12 CHAPTER

EMPIRICAL DATA COLLECTION AND ANALYSIS

Student Learning Outcomes

After studying this chapter, students will be able to:

- Explain that units are Standardized for better communication and collaboration. (Some examples may include: In the field of chemistry, the International System of Units (SDI is used to 'measure physical quantities such as mass, volume; and temperature: This standardized system ensures that chemists worldwide can use the same units to measure and communicate their results, facilitating communication and collaboration iri the field. Without standardized units it would be difficult for chemists fo compare their results with one another, and it would be challenging to develop consistent and accurate scientific models. For example, imagine if one Chemist measüred the mass of a substance in grams while another used bounces. The two measurements would be difficult to compare and combine, potentially leading to inaccurate or inconsistent results).
- Identify Si units for abstract and physical quantities (some examples include mass, time and amount of Matter.
- Apply the concept that units can be combined with terms for magnitude, especially kilo, deci and milli.
- Justify chemists use cm^3, g and s as more practical units when working with small amounts in

INTRODUCTION
LONG QUESTIONS

Q.1 What is science? What is international system of units? write its role in the development of science. (K.B+A.B)

Ans:

SCIENCE

Definition

Science is a systematic study of this world through observation and experimentation.

OR

Systematic study of nature based on observation, inference, prediction and experiment is called science.

Significance of Science

It is a method through which we make sense of this world in which we live. Scientific research is done in all the countries of the world.

Method of Scientific Research

Scientific research is done in all the countries of the world. But the way it is done is not identical everywhere. In order to make sure things are done-properly and carefully/ we need to share ideas and standardize our approach towards solving the problems.

Most usual problem faced by the scientific community

One of the most usual problem which is faced by the scientific community is the issue of unit. If scientists in one country are measuring lengths in metres and in another country in feet, then we will have to face problems in converting them. Comparing quantities in different units is not only confusing but the wastage of time as well.

INTERNATIONAL SYSTEM OF UNITS

Introduction

The world-wide commonly accepted system of units adopted in the eleventh general conference of weight and measures held in the Paris in 1960 is called international system of units commonly referred as SI units.

SOLUTION TO THE DIFFERENT UNITS TO MEASURE A QUANTITY, USED IN WORLD/ SIGNIFICANCE OF SI UNITS

For the reasons mentioned above scientists have agreed to adopt standard system of units. SI units have the following merits:

(i) Standard system and user-friendly units

It is a standard system of units and user-friendly units called Sl or System International Units.

(ii) Make Things Easier

Things become a lot easier when we use these units.

(iii) Makes communication easy worldwide

The adoption of Sl units is important in all branches of science because it makes communication easy worldwide.

(iv) Share Data Easily

It allows scientists to share data easily.

(v) Reduce The Number Of Conversions

Sl units are preferred because they reduce the number of conversions needed to coordinate information among the scientists.

(vi) Base of SI Units

Sl units use base 10, just like our number system. So, it is much easier to learn, remember and convert these units. These units are based on definite and precise standards.

(vii) Without Conversion Factors

Sl units are interrelated in such a way that one unit is derived from other units without conversion factors.

(viii) Used Almost Everywhere

Sl units are used almost everywhere in the world.

(ix) Use of single standard

It allows scientists to use a single standard in exchanging scientific data.

(x) Accuracy, consistency and universal understanding

This fact brings accuracy, consistency and universal understanding in scientific communication.

(xi) No confusion between scientists of different parts of the world

A measurement taken in part of the world can be easily understood and verified in another part without any confusion.

(xii) To Compare Results, Replicate Experiments

When scientists belonging to different countries and cultures collaborate on research, they need a common language to share their results. Using Sl units enables scientists to compare results, replicate experiments and take benefit of each other work.

Conclusion

In conclusion we can say that Sl units allow scientists to work together effectively, advancing the frontiers of our knowledge. All of this ensures safety, reliability, reproducibility and progress.

INTERESTING INFORMATION!

The following systems of units are commonly used in the world:

- Sl System
- CGS System
- MKS System

EXERCISE

1. What is the difference between reliable and reproducible results?

Ans: **DIFFERENTIATION**

Difference between reliable and reproducible results are as follows:

Reliable Results	Reproducible Results
Definition	
• *Reliable results are those results which are obtained when measured multiple times.*	• *Reproducible results are those results which can be attained by a different team, using the same method.*
Formation	
• If the same result can be consistently achieved by using the same methods under the same circumstances, the measurement is considered reliable.	• If another researcher uses the available data and obtains the same result, it is reproducible result.

2. How Sl units have brought harmony in the scientific community?

Ans: **Sl UNITS HAVE BROUGHT HARMONY**

Sl units allow scientists to work together effectively, advancing the frontiers of our knowledge. In this way Sl units have brought harmony in the scientific community. All of this ensures safety, reliability, reproducibility and progress.

SHORT QUESTIONS

Q.1 What is science? What is significance of science?

Ans: **SCIENCE**

Definition

Science is a systematic study of this world through observation and experimentation.

OR

Systematic study of nature based on observation, inference, prediction and experiment is called science.

Significance of Science

It is a method through which we make sense of this world in which we live. Scientific research is done in all the countries of the world.

Q.2 What is base of SI Units?

Ans: **BASE OF SI UNITS**

Sl units use base 10, just like our number system. So, it is much easier to learn, remember and convert these units. These units are based on definite and precise standards.

MULTIPLE CHOICE QUESTIONS

1. What is base of SI Units?

(A) Base 2 (B) Base 10

(C) Base 5 (D) Base 8

2. SI unit of length is:

(A) Metre (B) Feet

(C) Centimetre (D) Millimetre

12.1 SI UNITS IN CHEMISTRY

LONG QUESTIONS

Q.1. What are physical quantities? Write down their types.

(K.B) (LHR 2012, GRW 2013)

Ans: **PHYSICAL QUANTITIES**

Definition

All measureable quantities are called physical quantities.

Example

Length, time, mass, force, speed, volume, density etc.

Characteristics of physical quantities

A physical quantity possesses at least two characteristics in common.

- Numerical magnitude
- Unit in which it is measured

Example

It the length of the student 104cm then 104 is its numeric magnitude and centimeter is the unit of measurement.

TYPES OF PHYSICAL QUANTITIES

There are two types of physical quantities:

a. Base quantities
b. Derived quantities

BASE QUANTITIES

Definition

"Seven physical quantities which form the foundation for other physical quantities are called base quantities.

DERIVED QUANTITIES

Definition

"Those physical quantities which are expressed in term of base quantities"

Q.2 What are SI Units? Explain base units used in chemistry.

Ans: **SI UNITS**

Definition

The world-wide commonly accepted system of units adopted in the eleventh general conference of weight and measures held in the Paris in 1960 is called international system of units commonly referred as SI units.

SI UNITS IN CHEMISTRY

(A) BASE UNITS

There are seven base units in Sl system for physical quantities,

Base quantities, their SI units with symbol

Base quantities and there units are given below:

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
length	I	meter	m
Mass	m	Kilogram	kg
Time	t	Second	s
Electric current	I	Ampere	A
Intensity of light	L	Candela	cd
Temperature	T	Kelvin	K
Amount of substance	n	Mole	mol

Base units used in Chemistry

Out of seven base units we use five in Chemistry. These physical quantities are:

(i) Metre
(ii) Kilogram
(iii) Second
(iv) Kelvin
(v) Mole

1. METRE

It is the standard unit of length.

Symbol

Symbol m is used for meter.

Definition

Metre is the distance travel led by light in vacuum in about 300 millionth of a second.

Fig 12.1: Meter rod

12.1.2 Kilogram

2. KILOGRAM

It is the standard unit of mass.

Symbol

Its symbol is kg

Definition

A block is kept in France which is taken as a standard unit of mass. tt is also defined as the mass of 1000 cm^3 of water.

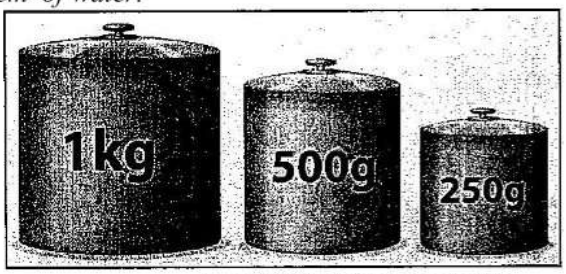

Fig 12.2: Different weights

3. **SECOND**

It is the standard unit of time

Symbol

Its symbol is s.

Definition

It is the time that elapses during 9,1921631,770 cycles of the radiation produced by the transition between two levels of the cesium-133 atom.

4. **KELVIN**

It is the standard unit of temperature.

Symbol

It is represented by the symbol k.

Definition

It is 273 rd of the thermodynamic temperature of the triple point of water. It is a point at which all the states of water exist at the same time.

5. **MOLE**

It is the base unit of the amount of pure substance.

Symbol

It is denoted by mol.

Definition

It is defined as having exactly 6.022 x 1 0^{23} particles of substance.

INTERESTING INFORMATION ABOUT SI UNITS
1. **Symbols are not changed in plural forms.**
2. **Use a space between units N m^{-2} not Nm^{-2}**

Q.3 What are derived quantities? Write down units of these quantities.

Ans:

DERIVED QUANTITIES

Definition

"Those physical quantities which are expressed in term of base quantities"

Derived quantities, their SI with symbol

Derived quantities and their units have been given below

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
Speed	v	metre per second	ms^{-1}
Acceleration	a	metre per second per second	ms^{-2}
Volume	V	cubic metre	ms^3
Force	F	newton	N or (kg ms^{-2})
Pressure	P	Pascal	Pa or (N m^{-2})
Density	ρ	Kilogramme per	kgm^{-3}

		cubic metre	
Charge	Q	Coulomb	C or (As)

Q.4 What is international system of units? Write its role in the development of science.

(K.B+A.B)

Ans:

INTERNATIONAL SYSTEM OF UNITS

Introduction

The world-wide commonly accepted system of units adopted in the eleventh general conference of weight and measures held in the Paris in 1960 is called international system of units commonly referred as SI.

Role of SI

The role of SI in the development of science is in under:

- This system produces uniformity in measurement all over the world
- It makes easy to exchange scientific and technical information
- It provides us system of prefixes that makes our calculation say.

Q.5 Differentiate between base and derived quantities?

Ans:

DIFFERENTIATION

Difference between base and derived units are as follow:

Base units	Derived units
Definition	
• The units describe base quantities are called base units	• The units used to measure derived quantities are called derived units
Formation	
• Each base quantity has its own SI unit, as defined by international system of units.	• Derived units are defined in the terms of base units and are obtained by multiplying or dividing one or more base units with each other
Numbers	
• Base units are seven in numbers	• Derived units are multiplies number
Example	
• Meter • Kilogram • Second • Ampere • Candela • Calvin • Mole	• Unit of area $(meter)^2$ • Unit of volume $(meter)^3$

Q.6 Identify the base quantities in the following:

(i) Speed (ii) Area (iii) Force (iv) Distance

Ans:

(i)

SPEED

Formula

Speed = distance / time

Units

Ms^{-1}

Base quantities involved

- Length

- Time

(ii) **AREA**

Formula

Area = length × width

Unit

m^2

Base quantities involved

- Length

(iii) **FORCE**

Formula

$$F = ma \ldots(i)$$

$$a = \frac{change\ in\ velocity}{time} \ldots(ii)$$

$$velocity = \frac{displacement}{time}$$

putting in eq. (ii)

$$a = \frac{displacement}{time}$$

putting in eq. (i)

$$F = \frac{Mass \times Displacement}{(time)2}$$

Units

$F = (kg\ ms^{-2})$

Base quantities involved

- Mass
- Length
- Time

(iv) **DISTANCE**

Distance is a length of a path that is a base quantity.

Q.7 Identify the following as base or derive quantity: density, force, mass, speed, time, length, temperature and volume.

Ans: **BASE AND DERIVED QUANITITIES**

Base quantities

Derived quantities

Q.8 Express $1m^3$ = _____L. (K.B)

Solution:

$$1m = 10\ dm$$

Taking cube on both sides

$$(1m^3) = (10dm^3)$$

$$1m^3 = 1000dm^3$$

As,

$$1L = 1dm^3$$

Hence

$$1m^3 = 1000\ L$$

SHORT QUESTIONS

Q.1 What is international system of units? Write its role in the development of science. (K.B+A.B)

Ans: **INTERNATIONAL SYSTEM OF UNITS**

Introduction

The world-wide commonly accepted system of units adopted in the eleventh general conference of weight and measures held in the Paris in 1960 is called international system of units commonly referred as SI.

Role of SI

The role of SI in the development of science is in under:

- This system produces uniformity in measurement all over the world
- It makes easy to exchange scientific and technical information
- It provides us system of prefixes that makes our calculation say.

Q.2 What are derived quantities? Write down units of these quantities.

Ans:

DERIVED QUANTITIES

Definition

"Those physical quantities which are expressed in term of base quantities"

Derived quantities, their SI with symbol

Derived quantities and their units have been given below

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
Speed	v	metre per second	ms^{-1}
Acceleration	a	metre per second per second	ms^{-2}
Volume	V	cubic metre	ms^{3}
Force	F	newton	N or ($kg\ ms^{-2}$)
Pressure	P	Pascal	Pa or ($N\ m^{-2}$)
Density	ρ	Kilogramme per cubic metre	kgm^{-3}
Charge	Q	Coulomb	C or (As)

Q.3 What are SI Units? Explain base units and derived units used in chemistry.

Ans:

SI UNITS

Definition

The world-wide commonly accepted system of units adopted in the eleventh general conference of weight and measures held in the Paris in 1960 is called international system of units commonly referred as SI units.

Q.4 What is meant by kelvin?

Ans:

KELVIN

It is the standard unit of temperature.

Symbol

It is represented by the symbol k.

Definition

It is 273 rd of the thermodynamic temperature of the triple point of water. It is a point at which all the states of water exist at the same time.

Q.5 What are base units used in chemistry?

Ans:

BASE UNITS USED IN CHEMISTRY

Out of seven base units we use five in Chemistry. These physical quantities are:

(i) Metre
(ii) Kilogram
(iii) Second
(iv) Kelvin
(v) Mole

MULTIPLE CHOICE QUESTIONS

1. The international system of units is abbreviated as:

(A) IS
(B) SI
(C) Both a&b
(D) none

2. The SI unit of intensity of light is:

(A) Newton
(B) Kilogram
(C) Kelvin
(D) Candela

3. **SI unit of electric charge is:**
(A) Ampere
(B) Kelvin
(C) Pascal
(D) Coulomb

4. **Amount of substance in terms of numbers is measures:**
(A) Gram
(B) Kilogram
(C) Newton
(D) Mole

5. **1L =?**
(A) $10dm^3$
(B) $100dm^3$
(C) $1dm^3$
(D) $1000dm^3$

6. **1000 ml =?**
(A) $10dm^3$
(B) $100dm^3$
(C) $1dm^3$
(D) $1000dm^3$

7. **SI unit of pressure is:**
(A) Pa
(B) Nm^2
(C) Nm^{-2}
(D) Both a & c

12.2 SI UNITS IN CHEMISTRY

LONG QUESTIONS

Q.1 Why there is a need of SI units? Explain base units and derived units used in chemistry.

Ans: **NEED OF SI UNITS**

Definition

Chemistry involves taking measurements, analyzing results and sharing it with others. You may be working anywhere in the world, you need a consistent way to communicate measurements like mass, volume, temperature, amount and time. To make sure that all of us can understand each other, scientists all over the world use a common system of units called Sl units.

(A) BASE UNITS

There are seven base units in Sl system for physical quantities,

Base quantities, their SI units with symbol

Base quantities and there units are given below:

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
length	I	meter	m
Mass	m	Kilogram	kg
Time	t	Second	s
Electric current	I	Ampere	A

Intensity of light	L	Candela	cd
Temperature	T	Kelvin	K
Amount of substance	n	Mole	mol

Base units used in Chemistry

Out of seven base units we use five in Chemistry. These physical quantities are:

(i) Length
(ii) Time
(iii) amount of substance
(iv) mass
(v) Temperature

(B) DERIVED UNITS

Apart from these base units, there are other quantities that are mathematically derived from base units. These units are called derived units.

Examples

Examples of the derived units used in chemistry are given in the following table (12.2).

Table (12.2) **Derived quantities, their SI Units with symbol**

Derived quantities and their units have been given below

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
Volume	V	cubic metre	ms^3
Density	ρ	Kilogramme per cubic metre	kgm^{-3}
Area	A	Square metre	m^2

SPECIFIC QUANTITIES USED IN CHEMISTRY AND THEIR UNITS

In addition to derived units, there are other specific quantities commonly used in chemistry.

Table (12.3) Specific Quantities used in chemistry

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
Force	F	newton	N or ($kg\ ms^{-2}$)
Pressure	P	Pascal	Pa or ($N\ m^{-2}$)
Energy	E	Joule	J or (Nm)

OTHER ERIVED UNITS USED IN CHEMISTRTY

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
Charge	Q	Coulomb	C or (As)

Q.2 What are the prefixes used in chemistry?

Ans:

PREFIXES USED IN CHEMISTRY

Since the Sl system of units is a metric system, it is based around the number 10 for convenience.

Significance of Prefixes

A set unit of prefixes has been developed which indicates whether the unit is a multiple or a fraction of the base ten. It allows the reduction of zeros of a very small number or a very large number.

Symbols of Prefixes

These Sl prefixes also have a set of symbols that precede the unit symbol.

Table (12.4) Prefixes used with SI units

Symbol	Prefixes	
Mega	M	10^{6}
Kilo	k	10^{3}
Deci	d	10^{-1}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	u	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}

Q.3 What is the significance of use of different units in chemistry?

Ans: **SIGNIFICANCE OF DIFFERENT UNITS IN CHEMISTRY**

Significance of use of different units in chemistry is as follows:

(a) Measurement of Mass

SI Unit

SI unit of mass is kilogram.

Why we use gram, commonly, to measure the mass?

(i) In Chemistry, we measure the masses of the reactants in grams. It is essential because the unit of measurement of molar mass consists of grams per mole. Therefore, given a mass measured in grams as well as a corresponding molar mass, enables us to find the mole of a substance.

(ii) Moreover, in Chemistry the quantities involved in the laboratory are likely to be small. The choice of gram rather than kg is therefore sensible and normal.

(iii) Using grams provides more manageable numbers for calculation and prevents the need for excessively large or small values,

(b) Measurement of Temperature

SI Unit

SI unit of temperature is kelvin.

Why we use Celsius scale, commonly, to measure the temperature?

(i) Celsius scale is most often used to measure temperature in Chemistry rather than Kelvin because it is more convenient to use it.

(ii) Celsius scale has 100 divisions in total which makes it more compatible with the base ten format of Sl system.

(iii) Another reason is that it is easier to convert temperature on Celsius scale into Kelvin scale

(c) Measurement of Volume

SI Unit

SI unit of volume is cubic meter m^3.

Why we use cubic centimeter (cm^3), commonly, to measure the volume?

(i) The unit of measurement of volume in Chemistry is cubic centimeter instead of cubic meter because it is easy to measure and calculate with it and it is precise.

(ii) In laboratory we usually measure smaller volumes of liquid which are more manageable in cubic centimeter rather than cubic meter.

SHORT QUESTIONS

Q.1 What derived units used in chemistry?

Ans: **DERIVED UNITS**

DERIVED UNITS

Apart from these base units, there are other quantities that are mathematically derived from base units. These units are called derived units.

Examples

Examples of the derived units used in chemistry are given in the following table.

Derived quantities, their SI Units with symbol

Derived quantities and their units have been given below

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
Volume	V	cubic metre	m^3
Density	ρ	Kilogramme per cubic metre	kgm^{-3}
Area	A	Square metre	m^2

Q.2 Why we use cubic centimeter (cm^3), commonly, to measure the volume?

Ans: **WHY WE USE CUBIC CENTIMETER (CM^3), COMMONLY?**

(i) The unit of measurement of volume in Chemistry is cubic centimeter instead of cubic meter because it is easy to measure and calculate with it and it is precise.

(ii) In laboratory we usually measure smaller volumes of liquid which are more manageable in cubic centimeter rather than cubic meter.

Q.3 Why we use Celsius scale, commonly, to measure the temperature?

Ans: **WHY WE USE CELSIUS SCALE, COMMONLY?**

(i) Celsius scale is most often used to measure temperature in Chemistry rather than Kelvin because it is more convenient to use it.

(ii) Celsius scale has 100 divisions in total which makes it more compatible with the base ten format of Sl system.

Another reason is that it is easier to convert temperature on Celsius scale into Kelvin scale**?**

MULTIPLE CHOICE QUESTIONS

1. What is the number of divisions on Celsius scale?

(A) 30 (B) 100

(C) 50 (D) 10

2. SI unit of mass is:

(A) Centigram (B) Metre

(C) Milligram (D)Kilogram

3. What is the SI Unit of volume?

(A) m^3 (B) cm^3

(C) mm^3 (D) Litre

12.3 TOOLS AND TECHNIQUES TO MANAGE ACCURACY AND PRECISION

LONG QUESTIONS

Q.1 What is the significance of tools and techniques to manage Accuracy and Precision in the field of chemistry?

OR

Explain the types of errors.

Ans: **SIGNIFICANCE OF TOOLS AND TECHNIQUES**

Significance of Measurement

Measurement is the foundation for all experiments in science. Every measurement carries a level of uncertainty which is known as error.

Error

An error may be defined as the difference between the measured value and the actual value.

Example

If two students use the same tool or instrument for measurement, it is not necessary that both of them get similar results. The difference between the measurements is called an error.

Causes of Error

An error may occur due to two factors:

- the limitation of the measuring instrument
- the skill of the student making the measurement.

Significance of Tools for Measurement

When we use tools meant for measurement, we assume that they give correct results. However, these tools may not always be right.

Errors in Tools

In fact, they have errors that naturally occur and these errors are called systematic errors.

TYPES OF ERRORS

1. Systematic Errors
2. Random Error

1. Systematic Error

These are the errors that naturally occur are called systematic errors.

Removal of Systematic Errors

Systematic errors may be removed by adding or subtracting a constant adjustment given to each measurement.

Importance of Systematic Error

Systematic error affects the accuracy of the measurement.

Systematic errors in measuring instruments

All measuring instruments contribute to systematic error.

Examples

Pipette, burette and measuring cylinder may deliver the volume slightly different from the one indicated by their graduation.

2. Random Error

Another type of error which a student commits during measurement is called a random error.

Importance of Random Error

Random error causes one measurement to differ slightly from the next measurement.

Causes of Random Error

(i) It comes from unpredictable changes during an experiment.

(ii) The main reasons for random errors are:

- limitations of instruments
- environmental factors
- slight variation in procedure

Example

(i) Measuring the Volume

When taking a volume reading from a measuring cylinder, you may read the volume from a different angle each time.

(ii) Measuring the Mass

Measuring the mass of a sample on a balance may give you different values as the surrounding air affects the balance.

Importance of Random Error

A random error often determines the precision of the experiment.

Goal of an Experiment

The goal of any experiment is to obtain accurate and precise results.

SHORT QUESTIONS

Q.1 What is the significance of tools and techniques to manage Accuracy and Precision in the field of chemistry?

Ans: **SIGNIFICANCE OF TOOLS**

When we use tools meant for measurement, we assume that they give correct results. However, these tools may not always be right.

Q.2 What are causes of random error?

Ans: **CAUSES OF RANDOM ERROR**

It comes from unpredictable changes during an experiment.

The main reasons for random errors are:

- limitations of instruments
- environmental factors
- slight variation in procedure

MULTIPLE CHOICE QUESTIONS

1. How many types of errors are in measurement?

(A) 8 (B) 2
(C) 4 (D) 1

2. The errors that occur naturally are:

(A) Random errors (B) Both A & B
(C) Systematic errors (D) None of these

3. Errors in tools are:

(A) Random errors (B) Both A & B
(C) Systematic errors (D) None of these

12.4 ACCURACY AND PRECISION

LONG QUESTIONS

Q.1 Explain the precision and accuracy in detail. Also describe the relationship between precision and accuracy.

Ans: **PRECISION AND ACCURACY**

Accuracy and precision are both ways to measure the correctness of results. They are used interchangeable in everyday life.

ACCURACY

Definition

Accuracy measures how close results are to the true or known value.

Example

The volume of a liquid is 26 cm^3. A student measures its volume three times and find the result as 27cm^3.

The student is not accurate because he has not calculated the exact result.

PRECISION

Definition

The closeness of two or more measurements to each other is called precision.

Example

If you weigh a given substance five times and every time you get 3.2kg reading, then your measurement is precise but not necessarily accurate.

Relationship between Precision and Accuracy

Precision is independent of accuracy. A student may be accurate but not precise and vice versa.

Example

(i) Precise but not accurate result

The exact mass of an object is 20 g. A student measures it and takes three readings as 17.3, 1 7.4 and 17.2.
The student is considered as precise but not accurate.

(ii) **Accurate but not Precise result**

Similarly, another student measures the mass of the same object and gets readings as 19.8, 20.5 and 19.6.
The second student is the more accurate but not precise.

EXERCISE

1. A student weighs a given substance three times, and each time he gets the reading 52g. The true weight of the substance is however, 5.0g. Is the work done by the student
(i) precise and accurate
(ii) accurate but not precise
(iii). precise but not accurate?

Ans:
The work done by the student is precise but not accurate

1. How will you avoid systematic and random errors?

Ans: **REMOVAL OF SYSTEMATIC ERRORS**
Systematic errors may be removed by adding or subtracting a constant adjustment given to each measurement.
Removal of Random Errors
Random error can be removed by taking multiple measurements and calculating the average.

S

HORT QUESTIONS

Q.1 Define the term accuracy. Give an example.

Ans: **ACCURACY**

Definition
Accuracy measures how close results are to the true or known value.
Example
The volume of a liquid is 26 cm^3. A student measures its volume three times and find the result as 27cm^3.

Q.2 Define the term precision. Give an example.

Ans: **PRECISION**

Definition
The closeness of two or more measurements to each other is called precision.
Example
If you weigh a given substance five times and every time you get 3.2kg reading, then your measurement is precise but not necessarily accurate.

2. How will you avoid systematic and random errors?

Ans: **REMOVAL OF SYSTEMATIC ERRORS**
Systematic errors may be removed by adding or subtracting a constant adjustment given to each measurement.
Removal of Random Errors
Random error can be removed by taking multiple measurements and calculating average.

MULTIPLE CHOICE QUESTIONS

1. Express 0.000840 in scientific notation:
(A) 8.40×10^{-3} (B) 7.40×10^{4}
(C) 8.40×10^{-4} (D) 7.40×10^{-3}

2. In SI units prefix pico means:
(A) 10^{-9} (B) 10^{-6}

(C) 10^{-11} (D) 10^{-12}

3. Express 0.00840 in scientific notation:

(A) 8.40×10^{-3} (B) 7.40×10^{4}

(C) 8.40×10^{-4} (D) 7.40×10^{-3}

4. In SI units prefix micro means:

(A) 10^{-9} (B) 10^{-6}

(C) 10^{-11} (D) 10^{-12}

ANSWER KEY

MULTIPLE CHOICE QUESTIONS

INTRODUCTION

1	B	2	A				

12.1 SI UNITS IN CHEMISTRY

1	B	2	D	3	A	4	D	5	C
6	C	7	D						

12.2 SI UNITS IN CHEMISTRY

1	B	2	D	3	A

12.3 TOOLS AND TECHNIQUES TO MANAGE ACCURACY AND PRECISION

1	B	2	A	3	C

12.4 ACCURACY AND PRECISION

1	C	2	D	3	A	4	B

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. **Tick (v) the correct answer.**

1. 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

2. In which unit we usually measure the energy present in the food?

(A) Kilo joules (B) Mega joules
(C) Calorie (D) Joule

3. What prefix is used for 10^{-12}?

(Aa) Mega (B) Pico
(C) Giga (D) Tessa

4. **In Sl unit of pressure is expressed in**

(A) Newton per metre (B) Newton per metre square
(C) Joule (D) Pascal

5. Which symbol is used for kilogram in Sl units?

(A) K (B) k
(C) Kg m (D) kg

6. What does a mole represent?

(A) Number (B) Mass
(C) Volume (D) Length

7. Which unit of volume should usually be used in chemistry?

(A) Millilitre (B) Litre
(C) Cubic centimetre (D) Cubic metre

8. Express 0.000840 in scientific notation:

(A) 8.40×10^{-3} (B) 840×10^{-4}
(C) 8.40×10^{-4} (D) 84.0×10^{-5}

9. In SI units prefix nano means:

(A) 10^{-9} (B) 10^{-8}
(C) 10^{-11} (D) 10^{-12}

10. $65^{o}C$ is equivalent to:

(A) $208^{o}K$ (B) $338^{o}K$
(C) $403^{o}K$ (D) $300^{o}K$

ANSWER KEY

MULTIPLE CHOICE QUESTIONS

1	A	**2**	C	**3**	B	**4**	B	5	D
6	B	**7**	C	**8**	C	**9**	A	10	B

QUESTIONS FOR SHORT ANSWERS

2. Questions for Short Answers:

Q.1 What is consistency of results?

Ans: **CONSISTENCY OF RESULTS**

Consistency of results means that when a test, experiment, or measurement is repeated multiple times under similar conditions, the results produced are largely the same

Q.2 Why Sl units are user friendly?

Ans: **SI UNITS USER FRIENDLY**

The SI units are user friendly and important in science and technology because it **provides a consistent and comprehensive system of units** for all physical quantities.

Q.3 Does systematic error affect the accuracy?

Ans: **EFFECT OF SYSTEMATIC ERROR ON ACCURACY**

Yes, systematic error directly affects the accuracy of a measurement,

Q.4 What is reason behind a random error?

Ans: **REASON OF RANDOM ERROR**

Random errors in experimental measurements are caused by unknown and unpredictable changes in an experiment. These changes may occur in the measuring instruments or in the environmental conditions.

Q.5 What is the difference between precision and accuracy?

Ans: **DIFFERENTIATION**

The differences between precision and accuracy are as follows:

Precision	Accuracy
• *The closeness of two or more measurements to each other is called precision*	*Accuracy measures how close results are to the true or known value.* •
The volume of a liquid is 26 cm^3. A student measures its volume three times and find the result as 27cm^3. The student is not accurate because he has not calculated the exact result. •	The volume of a liquid is 26 cm^3. A student measures its volume three times and find the result as 27cm^3. The student is not accurate because he has not calculated the exact result. •

Q.6 Which other systems of measurements are used apart from Sl units?

Ans: **SYSTEMS APART FROM SI UNITS**

- CGS system
- FPS system
- MKS system

Q.7 Define metre.

Ans: **METRE**

It is the standard unit of length.

Symbol

Symbol m is used for meter.

Definition

Metre is the distance travel led by light in vacuum in about 300 millionth of a second.

Q.8 Mention two benefits scientists get by using Sl units.

Ans: **BENEFITS OF SI UNITS**

(i) Standard system and user-friendly units

It is a standard system of units and user-friendly units called Sl or System International Units.

(ii) Make Things Easier

Things become a lot easier when we use these units.

(iii) Makes communication easy worldwide

The adoption of Sl units is important in all branches of science because it makes communication easy worldwide.

(iv) Share Data Easily

It allows scientists to share data easily.

CONSTRUCTED RESPONSE QUESTIONS

3. Constructed Response Questions

Q.1 Compare the units in Sl system with those in MKS system?

Ans: **DIFFERENTIATION**

The differences between SI system and MKS system are as follows:

SI System	MKS System
Definition	
• "SI system" (International System of Units) is the modern, internationally standardized version of the metric system.	• The "metric system" is a broader term for a system of measurement based on the meter, gram, and liter.
Key Difference	
• SI unit for mass is the kilogram.	• The basic metric unit for mass is the gram.

Q.2 What are five basic Sl units which are used in chemistry?

(B) Ans: **BASE SI UNITS**

There are seven base units in Sl system for physical quantities. Out of seven, five used in chemistry are as follows.

Base quantities, their SI units with symbol

Base quantities and there units are given below:

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
length	I	meter	m
Mass	m	Kilogram	kg
Time	t	Second	s
Temperature	T	Kelvin	K
Amount of substance	n	Mole	mol

Q.3 Explain the three units derived for the basic Sl units.

Ans: **DERIVED SI UNITS**

Derived quantities and their units have been given below

Quantities		Units	
Name	**Symbol**	**Name**	**Symbol**
Volume	V	cubic metre	ms^3
Density	ρ	Kilogramme per cubic metre	kgm^{-3}

Area	A	Square metre	m^2

Q.4 Explain why do we prefer to use smaller units of mass and volume in chemistry.

Ans: **WHY TO USE SMALLER UNITS OF MASS AND VOLUME?**

In chemistry we mostly use small amounts of reactants. SI unit of mass is kilogram but we use smaller units of mass to make the calculations more accurate. Similarly, smaller unit of volume (mostly cm^3) is used for the measurements.

Q.5 What difficulties we expect to encounter if we use different units of measurement in Daily life.

Ans: **DIFFICULTIES DUE TO USE OF DIFFERENT UNITS**

If we use different units of measurement in daily life, the calculations become much more complex and incorrect.

DESCRIPTIVE QUESTIONS

4. Descriptive Questions

Q.1 What are our indigenous units of measurement of mass, volume and length?

Ans: Answer given on page # 312

Q.2 Compare Sl units with imperial system of units.

Ans: **COMPARISON**

The comparison between SI units and imperial system of units is as follows:

SI Units	Imperial System of Units
Definition	
• SI is considered more logical and universally used.	• The Imperial system is primarily used in the United States and is less standardized internationally.
Key Difference	
• SI unit for mass is the kilogram.	• The basic metric unit for mass is the gram.
Nature of Units	
• The SI Units is a decimal based system of measurement where units are related by powers of 10 and makes the conversions straightforward.	• The Imperial system uses a mix of units like inches, feet, pounds, and gallons, with no consistent decimal relationship between them which makes the conversions more complex.

Q.3 How can you avoid systematic errors in your measurements?

Ans: **AVOIDING SYSTEMATIC ERRORS**

- We can avoid systematic errors in measurements by the following methods: carefully calibrate your equipment regularly
- use proper techniques when taking measurements
- control environmental factors that could influence results
- use multiple methods or instruments to verify your findings or results

Q.4 How do taking measurements in Sl units ensure safety and reliability?

Ans: **SI UNITS ENSURE SAFETY AND RELIABILITY**

Taking measurements in SI units (International System of Units) ensures safety and reliability because it provides a standardized, globally recognized system of measurement, which eliminates confusion and ambiguity.

Q.5 Can a student be both inaccurate and imprecise in his measurements?

Ans: **BOTH INACCURATE AND IMPRECISE**

Yes, a student can be both inaccurate and imprecise in his measurements. this means their measurements are not only far from the true value (inaccurate) but also inconsistent with each other (imprecise).

INVESTIGATIVE QUESTIONS

5. **Investigative Question**

Q.1 Elaborate the importance of using Sl units in space exploration.

Ans: **IMPORTANCE OF USING SI UNITS IN SPACE EXPLORATION**

Using SI units in space exploration is much important because it ensures consistency and accuracy in measurements and has following advantages:

- precise calculations for navigation
- trajectory planning
- scientific experiments
- minimize the risk of errors due to unit conversion issues
- successful space missions

TERMS TO KNOW

Terms	Definitions
Significance of SI Units	The subject of chemistry needs a consistent way to measure and to communicate the quantities like mass, volume, temperature, amount and time. To make sure that al[of us can understand each other, scientists all over the world have adopted a common system of units which is based upon the metric system and it is called Sl units.
Base Units and Derived Units	There are seven base units and twenty-two derived units in Sl system but all these units are not used in chemistry. In chemistry we generally use five base units and three derived units.