UNIT 12

Empirical Data Collection and Analysis

Descriptive Questions

Q.1 (Ex. Q.4 (i)) What are our indigenous units of measurement of mass, volume and length? 092012001

Ans. Indigenous units of measurement can vary widely depending on the specific culture or region being discussed. Here are some common indigenous units of measurement for mass, volume, and length from various cultures:

Mass:

In many indigenous cultures, traditional units of mass might include items like "stone" or "pound." **For example,** in some cultures, a "stone" might be used to measure weight, which is equivalent to about 14 pounds.

Volume:

Volume measurements might involve containers or natural resources. **For example,** a "basket" or "cup" could be used to measure liquids or grains. The actual volume would depend on the size of the container used.

Length:

Length might be measured by using body parts or traditional items. **For example,** a "foot" or "hand" could be used, where a foot might refer to the length of an actual foot, and a hand could refer to the width of a hand, typically around 4 inches.

Q.2. (Ex. Q.4 (ii)) Elaborate difference between Accuracy and Precision. 092012002

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

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

Example: The volume of liquid is 26 cm^3. A student measures its volume three times and find the result as 27 cm^3. The student is not accurate because he has not calculated the exact result

ii. Precision: 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.

Dependence:

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

The exact mass of an object is 20 g. A student measures it and takes three readings as 17.3, 17.4 and 17.2. The student is considered as precise but not accurate. 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

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Q.3 (Ex. Q.4 (iii)) How can you avoid systematic errors in your measurements? 092012003

Ans. Systematic error:

Definition: When we use tools meant for measurement, we assume that they give correct results. However, these tools may not always be right. In fact, they have errors that naturally occur and these errors are called systematic errors.

How to avoid?

Systematic errors may be removed by adding or subtracting a constant adjustment given to each measurement. Systematic error affect the accuracy of the measurement. All measuring instruments contribute to systematic error e.g. pipette, burette and measuring cylinder may deliver the volume slightly different from the one indicated by their graduation.

Q.4 (Ex. Q.4 (iv)) How do taking measurements in SI units ensure safety and reliability? 092012004

Ans. 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 meters 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.

SI Unit:

Scientists have agreed to adopt standard and user-friendly units called SI or System International Units. Things become a lot easier when we use these units.

Advantage of SI Unit:

The adoption of SI units is important in all branches of science. It has following advantages:

- It makes communication easy worldwide.
- It allows scientists to share data easily.
- SI units are preferred because they reduce the number of conversions needed to coordinate information among the scientists.
- SI 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. SI units are interrelated in such a way that one unit is derived from other units without conversion factors.
- SI units are used almost everywhere in the world. It allows scientists to use a single standard in exchanging scientific data. This fact brings accuracy, consistency and universal understanding in scientific communication.
- A measurement taken in part of the world can be easily understood and verified in another part without any confusion.

Q.5 (Ex. Q.4 (v)) Can a student be both inaccurate and imprecise in his measurements? 092012005

Ans. Precision is independent of accuracy. A student may be accurate but not precise and vice versa. Lets supposethe exact mass of an object is 20 g. A student measures it and

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takes three readings as 17.3, 17.4 and 17.2. The student is considered as precise but not accurate. 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.

Investigative Questions

Q.1. (Ex. Q.5 (i)) Elaborate the importance of using SI units in space exploration.

092012006

Ans. Using SI units in space exploration is crucial for several reasons:

Standardization: Space missions often involve collaboration among various countries and organizations. By using SI units, scientists and engineers ensure that everyone is on the same page regarding measurements. This standardization helps avoid misunderstandings that could arise from using different measurement systems, which is vital when dealing with complex technologies and systems.

Precision and Accuracy: SI units are based on decimal systems, which make calculations more straightforward and reduces the risk of errors. In space exploration, where precision is critical for navigation, communication, and data analysis, using a consistent and precise measurement system is essential.

For example, distances in space are often measured in kilometers or meters, which allows for accurate calculations when plotting trajectories or determining the positions of spacecraft.

International Collaboration: Space exploration is a global endeavor with many missions involving multiple countries. Using SI units facilitates international cooperation by providing a common framework for scientific communication. This is especially important in joint missions, such as the International Space Station, where teams from different nations work together.

Data Comparison and Sharing: The use of SI units allows for easier comparison of data collected from different missions. When data is reported in a standardized format, researchers can effectively analyze and share findings across various studies, enhancing the overall understanding of space Phenomenon.

Educational Consistency: SI units are taught in educational institutions worldwide, making them familiar to scientists and engineers entering the field. This consistency in education helps prepare future generations for careers in space exploration and related fields.

SLO Based Additional Long Question

Q.1. Compare SI units with imperial system of units.

Ans.

092012007

Measurement	SI Units	Imperial Units	Comparison
Length	Meter (m), Centimetre (cm)	Inch (in), Foot, Yard	1m ≈ 39.37 in
Mass	Kg, g	Pound (ℓb), Ounce (oz)	1kg ≈ 2.2 ℓb
Volume	L, mL	fluid ounce (fℓoz), Gallon (gal)	K ≈ 33.8 fℓoz

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Temperature	K	Fahrenheit (°F)	F=(K-273.15)
Force	N	Pound - Force (ℓbf)	1N ≈ 0.2248(ℓbf)
Energy	J	BTU	1J ≈ 0.0009478(BTU)

Exercise Short Question

Q.1 What is consistency of results? 092012008

Ans. SI units are used almost everywhere in the world. It allows scientists to use a single standard in exchanging scientific data. This fact brings accuracy, consistency and universal understanding in scientific communication. A measurement taken in part of the world can be easily understood and verified in another part without any confusion.

Q.2 Why SI units are user friendly? 092012009

Ans. When scientists belonging to different countries and cultures collaborate on research, they need a common language to share their results. Using SI units enables scientists to compare results, replicate experiments and take benefit of each other work. That's why, SI units are user friendly.

Q.3 Does systematic error affect the accuracy? 092012010

Ans. Systematic error affect the accuracy of the measurement. All measuring instruments contribute to systematic error e.g. pipette, burette and measuring cylinder may deliver the volume slightly different from the one indicated by their graduation.

Q.4 What is reason behind a random error? 092012011

Ans. It is a type of error which a student commits during measurement is called a **random error**.

Reasons:

Random error causes one measurement to differ slightly from the next measurement. It comes from unpredictable changes during an experiment. The main reasons for random errors are limitations of instruments, environmental factors and slight variation in procedure.

For example, when taking a volume reading from a measuring cylinder, you may read the volume from a different angle each time. Measuring the mass of a sample on a balance may give you different values as the surrounding air affects the balance.

Q.5 Difference between Random Error and Systematic Error 092012012

Ans.

Systematic Error	Random Error
When we use tools meant for measurement we assume that they give correct results. However, these tools may not always be right. In fact they have errors that naturally occur and these errors are called systematic errors.	It is a type of error which a student commits during measurement is called a random error. Random error causes one measurement to differ slightly from the next measurement. It comes from unpredictable changes during an experiment. The main reasons for random errors are

Q.6 Which other systems of measurements are used apart from SI units? 092012013

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

i. SI System (International System of Units)
ii. CGS System (Centimeter–gram–second System of Units)
iii. MKS System (Meter–kilogram– second System of Units)
iv. Imperial (System of Units)

Q.7 Define meter. 092012014

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Ans. It is the standard unit of length. Symbol m is used for meter. Meter is the distance travelled by light in vacuum in about 300 millionth of a second.



Meter Rod

Q.8 Mention two benefits scientists get by using SI units. 092012015

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

SI units allow scientists to work together effectively, advancing the frontiers of our knowledge. All of this ensures safety, reliability, reproducibility and progress.

Practice Exercise Questions

Q.9 What is the difference between reliable and reproducible results? 092012016

Ans.

Reliable Results	Reproducible Results
Reliability refers to the consistency of results when the same experiment is repeated under the same conditions. If an experiment yields similar results every time it is conducted, it is considered reliable. This means that the measurement or observation is dependable and can be trusted to reflect what it is supposed to measure.	Reproducibility, refers to the ability of other researchers to obtain the same results when they conduct the same experiment independently, using the same methods and conditions. This is crucial for validating findings in science.
For example, if a scientist measures the boiling point of water multiple times and consistently gets 100°C at sea level, those results are reliable.	**For example,** if another scientist takes the original experiment's procedure and performs it in a different lab and still finds that water boils at 100°C, then the results are reproducible.

Q.10 How SI units have brought harmony in the scientific community? 092012017

Ans. SI units have brought harmony in the scientific community in several ways:

Universal Language: SI units serve as a universal language for scientists across the globe. By using a standardized system, researchers from different countries and disciplines can communicate their findings without confusion. This common ground fosters collaboration and understanding in a field that often involves complex data and measurements.

Consistency in Research: The use of SI units ensures that measurements are consistent and comparable. When scientists report their results in SI units, it allows others to replicate experiments and validate findings accurately. This consistency is crucial for building on previous research and advancing scientific knowledge.

Q.11 A student weighs a given substance three times, and each time he

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gets the reading 5.2g. 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? 092012018

Ans. The student's work is precise but not accurate.

Explanation:

Precision refers to the closeness of repeated measurements to each other. In this case, the student consistently got a reading of 5.2 grams each time he weighed the substance, indicating precision.

Accuracy, refers to the closeness of a measurement to the true value. Since the true weight of the substance is five grams and the student consistently measured 5.2 grams, the measurements are not accurate. Therefore, the student's work is precise (consistent readings of 5.2 grams) but not accurate (the measured value is not close to the true weight of five grams).

Q.14 How will you avoid systematic and random errors? 092012019

Ans. Systematic errors may be removed by adding or subtracting a constant adjustment given to each measurement. Systematic error affects the accuracy of the measurement.

Random error: We can remove random error by:

- Take multiple Measurements.
- Use more precise instruments.
- Calibrate instruments regularly.

SLO Based Additional Short Question

Introduction

Q.12 Why was there a need to develop the SI units system? 092012020

Ans. 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 meters 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.

For the reasons mentioned above scientists have agreed to adopt standard and user-friendly units called SI or System International Units. Things become a lot easier when we use these units.

Q.13 What are the advantages of SI unit system? 092012021

Ans. SI units are used almost everywhere in the world. It allows scientists to use a single standard in exchanging scientific data. This fact brings accuracy, consistency and universal understanding in scientific communication. A measurement taken in part of the world can be easily understood and verified in another part without any confusion.

SI Units in Chemistry

Q.15 How many S.I units are used in Chemistry? Write their names. 092012023

Ans. There are seven base units in SI system for physical quantities out of which we use five in Chemistry. These physical quantities are length, time, amount of substance, mass and temperature.

Quantity	Unit
Length	Meter (m)
Time	Second (s)
Amount of substance	Mole (mol)

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substance	
Mass	Kilogram (kg)
Temperature	Kelvin (K)

Kilogram

Q.16 What do you know about 'Kilogram'? 092012025

Ans. Its symbol is (kg) and it is the standard unit of mass. A block is kept in France which is taken as a standard unit of mass. It is also defined as the mass of 1000 cm^3 of water.

Second

Q.17 What do you know about 'Second'? 092012026

Ans. It is the standard unit of time with a symbol (s). it is the time that elapses during 9,192,631,770 cycles of the radiation produced by the transition between two levels of the cesium-133 atom.

Kelvin

Q.18 What do you know about 'Kelvin'? 092012027

Ans. It is represented by (K) and it is the standard unit of temperature. It is 1/273rd 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.

Mole

Q.19 What do you know about 'Mole'? 092012028

Ans. It is the base unit of the amount of pure substance and it is denoted by mol. It is defined as having exactly 6.022×10^2 particles of substance.

SI Units in Chemistry

Q.20 Define SI (system international) units. 09201202

Ans. 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 all 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 SI units.

Q.21 What are derived units? Give examples. 09201203

Ans. Mathematically, these are derived from base units.

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

Quantity	Unit
Volume	Cubic meter (m^3)
Density	kg per cubic meter (kgm^{-3})
Area	Square meter (m^2)

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

Specific Quantities used in chemistry

Quantity	Unit
Force	Newton/N ($kg.ms^{-2}$)
Pressure	Pascal/Pa (Nm^{-2})
Energy	Joule/J (Nm)

Q.22 What is the advantage of use of prefixes? 092012031

Ans. Since the SI system of units is a metric system, it is based around the number 10 for convenience. 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. These SI prefixes

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

Q.23 Why is the gram (unit) used in Chemistry instead of Kilogram for measuring Molar mass? 092012032

Ans. 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. 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. Using grams provides more manageable numbers for calculation and prevents the need for excessively large or small values.

Q.24 Why Celsius scale is often used to measure temperature in Chemistry rather than Kelvin? 092012033

Ans. Celsius scale is most often used to measure temperature in Chemistry rather than Kelvin because it is more convenient to use it. Celsius scale has 100 divisions in total which makes it more compatible with the base ten format of SI system. Another reason is that it is easier to convert temperature on Celsius scale into Kelvin scale.

Q.25 Why is there unit of volume in Chemistry used as cubic centimeter instead of cubic meter? 092012034

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

Q.26 What are the two rules to write a symbol of an element? 092012035

Ans. i. Symbols are not changed in plural forms.

ii. Uses a space between units $N\ m^{-2}$ not Nm^{-2}

Tools and Techniques to Manage Accuracy and Precision

Q.27 Define error. 092012036

Ans. Every measurement carries a level of uncertainty which is known as error. An error may be defined as the difference between the measured value and the actual value.

For 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

Q.28 Why an error occur in the measurement? 092012037

Ans. An error may occur due to two factors:

i. The limitation of the measuring instrument.

ii. The skill of the student making the measurement.

Q.29 What is the difference between precision and accuracy? 092012038

Ans.

Precision	Accuracy
The closeness of two or more measurements to each other is called precision. **e.g.** If you weigh a given substance five times and every time you get 3.2Kg reading, then your measurement is precise.	Accuracy measures how close results are to the true or known value. **e.g.** Volume of liquid is $26cm^3$. A student measures its volume three times and find the result as $27cm^3$. The student is not accurate but if it measures $26cm^3$ then it would be accurate.

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	limitations of instruments environmental factors and slight variation in procedure.

Constructed Response Questions

Q.1 (Ex. Q.3 (i)) Compare the units in SI system with those in MKS system. 092012039

Ans. The SI system and the MKS system are both metric systems used for measuring physical quantities, but they have some differences in their units.

SI System:

In the SI (International System of Units), the base units are:

i. Meter (m) for length
ii. Kilogram (kg) for mass
iii. Second (s) for time
iv. Ampere (A) for electric current
v. Kelvin (K) for temperature
vi. Mole (mol) for the amount of substance
vii. Candela (cd) for luminous intensity

MKS System:

The MKS system is a subset of the SI system, where MKS stands for Meter, Kilogram, and Second. It primarily focuses on these three units:

i. Meter (m) for length
ii. Kilogram (kg) for mass
iii. Second (s) for time

Q.2 (Ex. Q.3 (ii)) What are five basic SI units which are used in chemistry? 092012040

Ans. There are seven base units in SI system for physical quantities out of which we use five in chemistry. These physical quantities are length, time, amount of substance, mass & temperature.

Basic Quantity	Basic Unit
Length	Meter (m)
Time	Second (s)
Amount of substance	Mole (mol)
Mass	Kilogram (Kg)
Temperature	Kelvin(K)

Q.3 (Ex. Q.3 (iii)) Explain the three units derived for the basic SI units. 092012041

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

Quantity	Unit
Volume	Cubic meter (m^3)
Density	kg per cubic meter (kgm^{-3})
Area	Square meter (m^2)

Q.4 (Ex. Q.3 (iv)) Explain why do we prefer to use smaller units of mass and volume in chemistry. 092012042

Ans. Mass: 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.

Volume:

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

Q.5 (Ex. Q.3 (v)) What difficulties we expect to encounter if we use different units of measurement in daily life? 092012043

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Ans. If scientists in one country are measuring lengths in meters 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.

For the reasons mentioned above scientists have agreed to adopt standard and user-friendly units called SI or System International Units. Things become a lot easier when we use these units.

Multiple Choice Questions (Exercise)

Tick (✓) the correct answer.

1. **Which of the following pairs of quantities may be measured in the same unit?** 092012044
   (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?** 092012045
   (a) Kilojoules (b) Mega joules
   (c) Calorie (d) Joule

3. **What prefix is used for 10^{-12}?** 092012046
   (a) Mega (b) Pico
   (c) Giga (d) Tessa

4. **In SI unit of pressure is expressed in:** 092012047
   (a) Newton per meter
   (b) Newton per meter square
   (c) Joule (d) Pascal

5. **Which symbol is used for kilogram in SI units?** 092012048
   (a)K (b) k
   (c) Kgm (d) kg

6. **What does a mole represent?** 092012049
   (a) Number (b) Mass
   (c)Volume (d) Length

7. **Which unit of volume should usually be used in chemistry?** 092012050
   (a) Milliliter (b) Liter
   (b) Cubic centimeter (d) Cubic meter

8. **Express 0.000840 in scientific notation:** 092012051
   (a) 8.40×10^{3} (b) 7.40×10^{4}
   (c) 8.40×10^{-4} (d) 7.4×10

9. **In SI units prefix Nano me equal to:** 092012052
   (a) 10^{-9} (b) 10^{-3}
   (c)10^{-11} (d) 10^{-12}

10. **65°C is equivalent to:** 092012053
    (a) 85°F (b) 120°F
    (c) 149°F (d) - 85°F

SLO Based Additional MCQ's

Introduction

11. **To change SI units by factors of ten into smaller or bigger units they use:** 092012054
    (a) Prefixes (b) Symbols
    (c) Abbreviation (d) Ratio

12. **The standard form of 38000000000 is:** 092012055
    (a) 3.8×10^{8} (b) 3.8×10^{9}
    (c) 3.8×10^{10} (d) 3.8×10^{11}

13. **The standard form of 0.00000000034 is:** 092012056
    (a) 3.4×10^{-8} (b) 3.4×10^{-9}
    (c) 3.4×10^{-10} (d) 3.4×10^{-11}

14. **The eleventh general conference was held in Paris in:** 092012057
    (a) 1959 (b) 1961

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(c) 1660 (d) 1960

15. The number 0.00580 in scientific notation is: 092012058

(a) 5.80×10^{5} (b) 5.80×10^{-4}

(c) 5.80×10^{-3} (d) 5.80×10^{-2}

12.1.3 Second

16. An interval of 200 ps equivalent to: 092012059

(a) 0.2s (b) 0.02s

(c) $2 \times 10^{-10} s$ (d) $2 \times 10^{-6} s$

SI Units in Chemistry

17. What is the volume of the liquid in this graduated cylinder? 092012060

(a) 23 (b) 24

(c) 25 (d) 22



18. How many cubic centimeters (cm^3) are there in 1 decimeter cube ($1\ dm^3$): 092012061

(a) 100 cm^3 (b) 1000 cm^3

(c) 10 cm^3 (d) 1 cm^3

19. A distance of 1 kilometer means? 092012062

(a) 100 cm (b) 1000 cm

(c) 10 cm (d) 1000 m

20. In SI, the unit of mass is: 092012063

(a) kilogram (b) centimeter

(c) kelvin (d) millimeter

21. The number of base units in SI are: 092012064

(a)3 (b) 6

(c)7 (d) 9

22. Which one of the following unit is not a derived unit? 092012065

(a) Pascal (b) kilogram

(c) newton (d) watt

23. Amount of a substance in terms of numbers is measured in: 092012066

(a) gram (b) kilogram

(c) newton (d) mole

24. Which one of the following is the smallest quantity? 092012067

(a) 0.01g (b) 2mg

(c) 100μg (d) 5000ng

25. A measuring cylinder is used to measure. 092012068

(a) mass (b) area

(c) volume (d) level of liquid

26. 1micro(μ) = 092012069

(a) 10^{-3} (b) 10^{-6}

(c) 10^{-9} (d) 10^{-12}

27. One cubic meter is equal to. 092012070

(a)1001itre (b) 1000 liter

(c) 10000 liter (d) 1 liter 1000

28. The base quantity is: 092012071

(a) mass (b) volume

(c) torque (d) momentum

29. The scientific notation of number 0.00235 is expressed as: 092012072

(a) 2.3×10^{-4}

(b) 2.35×10^{-3}

(c) 0.235×10^{-2}

(d) 0.0235×10^{-1}

30. One tera is equal to: 092012073

(a) 10^{-12} (b) 10^{-18}

(c) 10^{12} (d) 10^{18}

Accuracy and Precision

31. The property of a measuring instrument to give the output very close to the actual value is termed as: 092012074

(a) Sensitivity (b) Accuracy

(c) Precision (d) Repeatability

32. In the measuring instruments, the degree of conformity and closeness to the true value is known as: 092012075

(a) precision (b) accuracy

(c) Sensitivity (d) Compatibility

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Answer Key

1	c	2	c	3	b	4	b	5	d
6	a	7	c	8	c	9	a	10	c
11	a	12	c	13	c	14	d	15	c
16	c	17	b	18	b	19	d	20	a
21	c	22	b	23	d	24	d	25	c
26	b	27	b	28	a	29	b	30	c
31	b	32	b						

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