

GPAT

2027-28



PHARMACEUTICAL ANALYSIS

CLASS- 7



TIME- 8 : 30 P.M

ANALYTICAL ERRORS, ACCURACY & PRECISION

UPDATED QUESTIONS TILL GPAT 2026



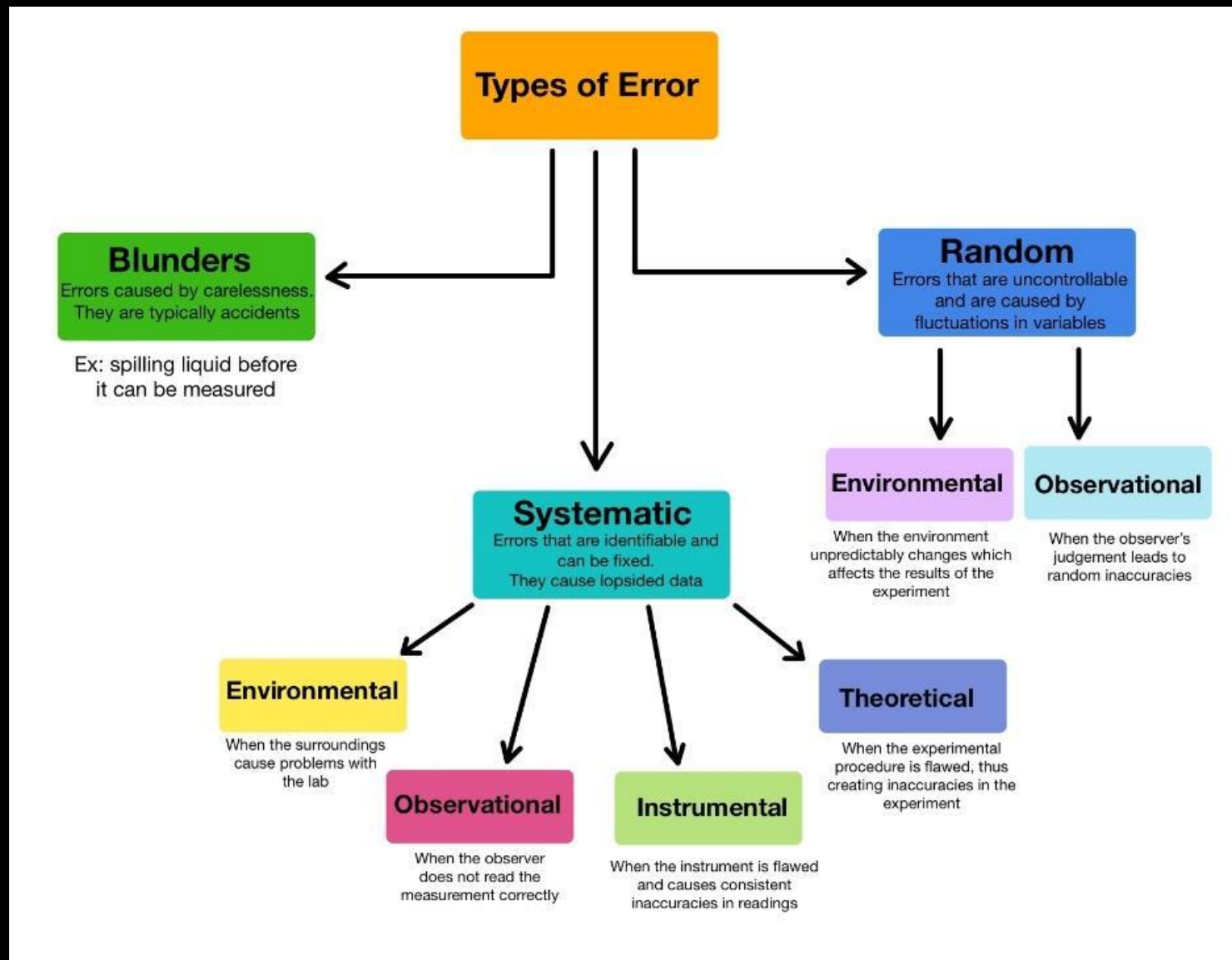
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Accuracy	Precision
The degree of closeness or agreement to the standard value is given by accuracy.	In a set, precision gives us the degree of deviation from each other.
Even in a set, accuracy is different for each component.	Where there's only a single reading, precision holds no meaning.
Accuracy is related to the closeness to a standard value .	Precision describes how close values are to one another .
Consistent accuracy is only possible when the set of readings is precise. An imprecise set cannot be consistently accurate.	It is possible for a set of values to be highly precise (without zero deviation, even), and yet, be far off from the true value.



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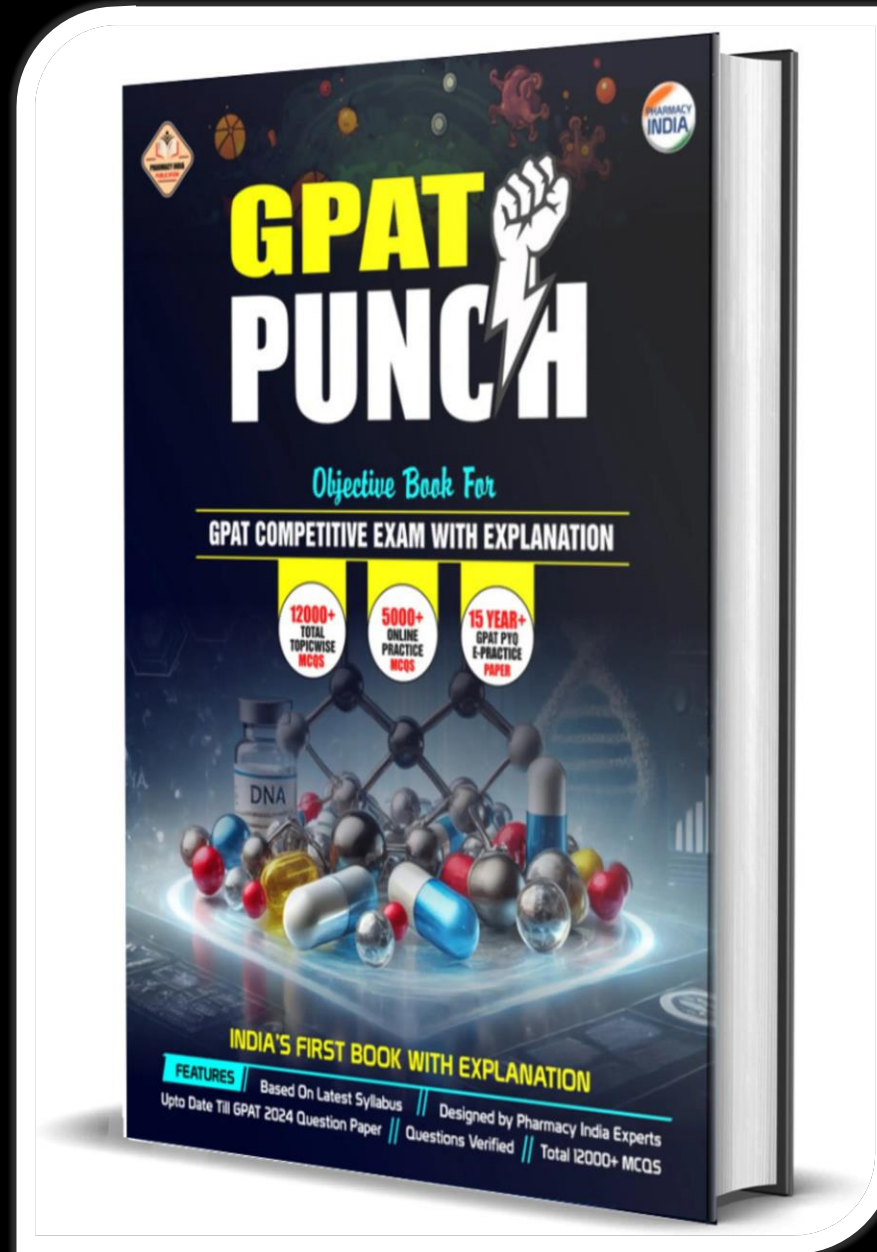
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01.

Match List I with List II. [GPAT-2022]

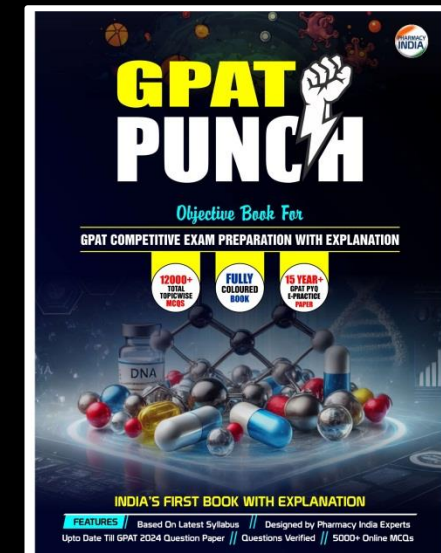
List I — Volumetric Solution	List II — Primary Standard
1. 0.1 M Iodine 2. 0.1 M Sodium thiosulphate 3. 0.1 M Sodium hydroxide 4. 0.1 M Perchloric acid	[P] Potassium iodate [Q] Potassium bromate [R] Potassium hydrogen phthalate [S] Arsenic trioxide [T] Potassium hydrogen phthalate

(a) 1-[S], 2-[Q], 3-[R], 4-[T]

(c) 1-[P], 2-[S], 3-[Q], 4-[R]

(b) 1-[S], 2-[Q], 3-[R], 4-[P]

(d) 1-[R], 2-[Q], 3-[S], 4-[P]



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01.

Match List I with List II. [GPAT-2022]

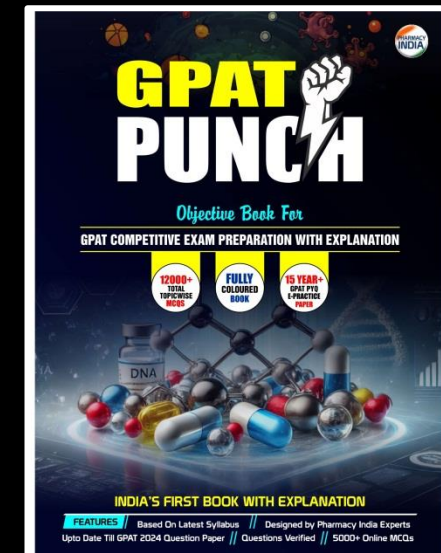
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(a) 1-[S], 2-[Q], 3-[R], 4-[T]

(c) 1-[P], 2-[S], 3-[Q], 4-[R]

(b) 1-[S], 2-[Q], 3-[R], 4-[P]

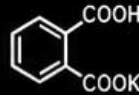
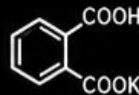
(d) 1-[R], 2-[Q], 3-[S], 4-[P]



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Standardization of Common Volumetric Solutions

Volumetric solutions are standardized using primary standards to determine their exact concentration.

VOLUMETRIC SOLUTION		PRIMARY STANDARD	
Iodine	→	Arsenic trioxide (As_2O_3)	
Sodium thiosulphate	→	Potassium bromate (KBrO_3)	
Sodium hydroxide	→	Potassium hydrogen phthalate (KHP)	
Perchloric acid	→	Potassium hydrogen phthalate (KHP)	



Primary standards help establish exact concentration.



Stable, pure reference substances are preferred.



Correct standardization **improves assay accuracy**.

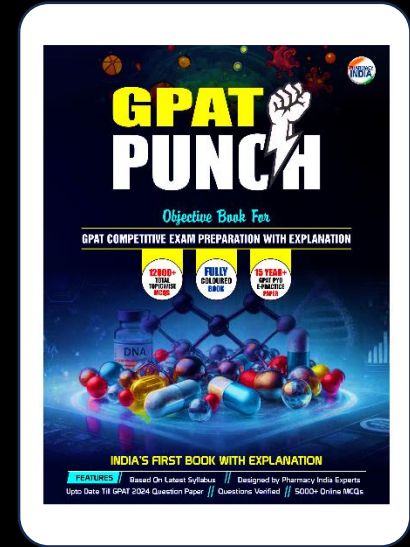




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02. Closeness of a measured value to the true value is known as: [GPAT-2020]

- (a) Accuracy
- (b) Deviation
- (c) Precision
- (d) Bias



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02.

Closeness of a measured value to the true value is

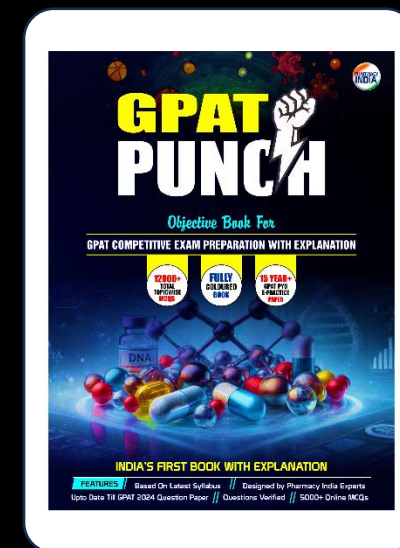
known as: [GPAT-2020]

(a) Accuracy

(b) Deviation

(c) Precision

(d) Bias



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Accuracy



Accuracy is the closeness of a measured value to the true value.



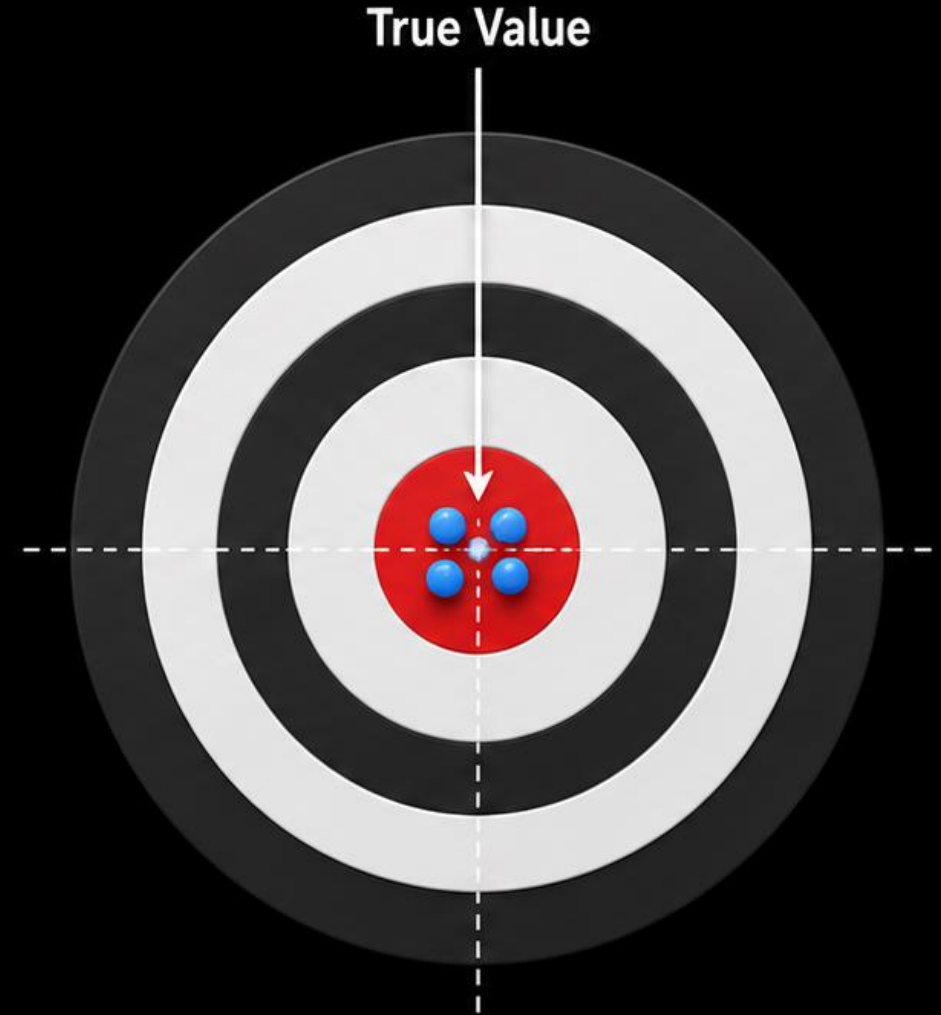
High accuracy means low error.



Bias lowers accuracy by shifting results away from the true value.



Accuracy tells how correct a result is.





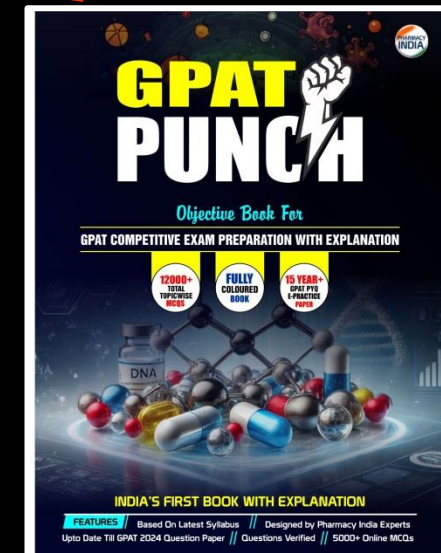
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03.

Permitted tolerance limit for a 100 mL Class B volumetric flask and 1000 mL Class B volumetric flask according to BS 1792 specifications respectively are: [GPAT-2019]

- (a) 0.15 and 0.80
- (b) 0.80 and 0.30
- (c) 1.00 and 10.00
- (d) 0.15 and 1.5



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03.

Permitted tolerance limit for a 100 mL Class B volumetric flask and 1000 mL Class B volumetric flask according to BS 1792 specifications respectively are: [GPAT-2019]

(a) 0.15 and 0.80

(b) 0.80 and 0.30

(c) 1.00 and 10.00

(d) 0.15 and 1.5



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Tolerance Limits in Class B Volumetric Flasks



100 mL Class B flask: ± 0.15 mL.



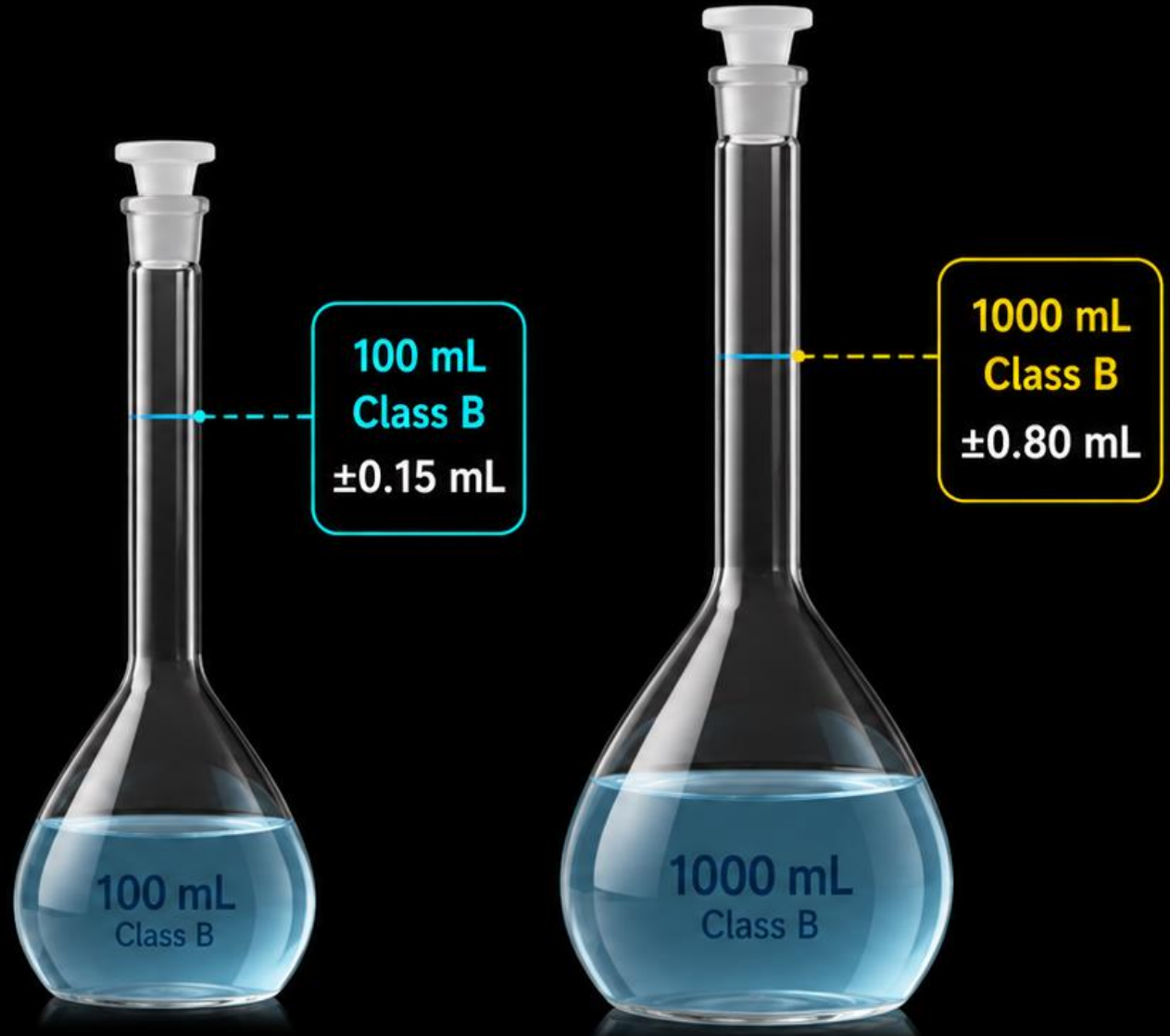
1000 mL Class B flask: ± 0.80 mL.



Tolerance means permissible volumetric error.



Class B glassware has wider tolerance than Class A.





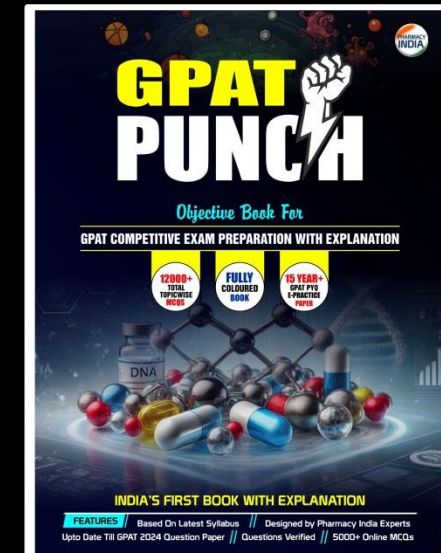
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04. What quantity of an indicator solution shall be added when quantity is not mentioned in an assay or test?

[GPAT-2018]

- (a) 0.1 mL
- (b) 0.05 mL
- (c) 0.2 mL
- (d) 0.5 mL



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04.

What quantity of an indicator solution shall be added when quantity is not mentioned in an assay or test?

[GPAT-2018]

(a) 0.1 mL

(b) 0.05 mL

(c) 0.2 mL

(d) 0.5 mL



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Indicator Quantity



If not specified,
use **0.1 mL** indicator solution.



The indicator **helps detect the endpoint.**



Excess indicator **can disturb endpoint observation.**



Use only the **minimum amount**
needed for a **clear endpoint.**





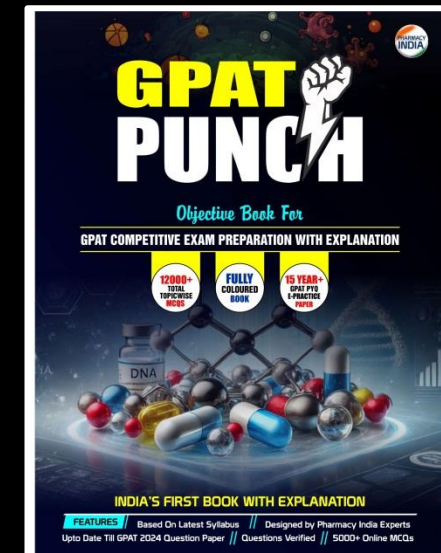
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05.

Which one of the following statements is NOT true? [GPAT-2010]

- (a) Accuracy expresses the correctness of measurement
- (b) Precision represents reproducibility of measurement
- (c) High degree of precision implies high degree of accuracy also
- (d) High degree of accuracy implies high degree of precision also



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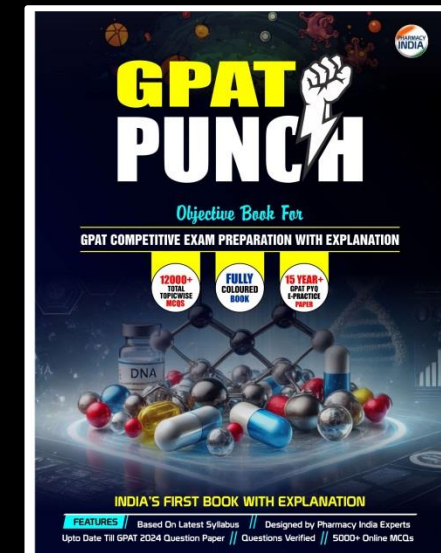
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05.

Which one of the following statements is NOT true? [GPAT-2010]

- (a) Accuracy expresses the correctness of measurement
- (b) Precision represents reproducibility of measurement
- (c) High degree of precision implies high degree of accuracy also
- (d) High degree of accuracy implies high degree of precision also



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Precision Does Not Always Mean Accuracy



Precision is closeness among repeated values.



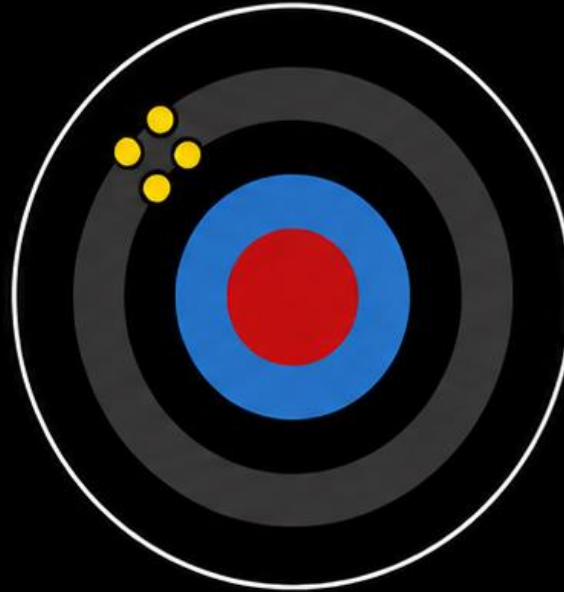
Accuracy is closeness to the true value.



Results may be precise yet still inaccurate.

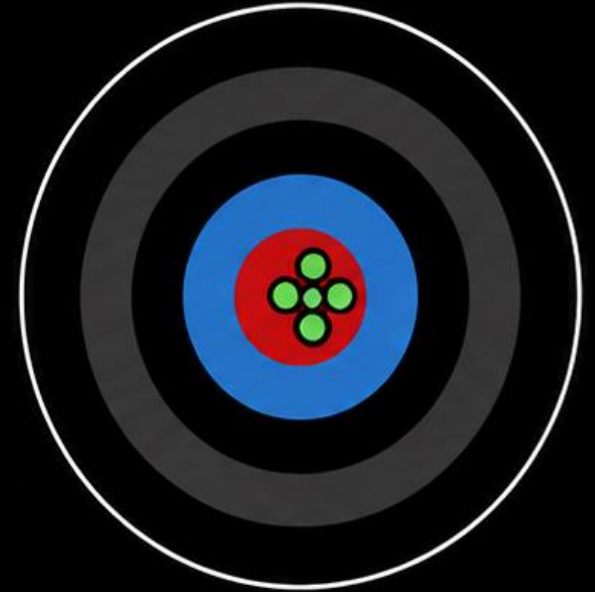


Reproducibility alone does not prove correctness.



PRECISE BUT INACCURATE

Tight grouping,
far from the true value.



ACCURATE AND PRECISE

Tight grouping,
at the true value.



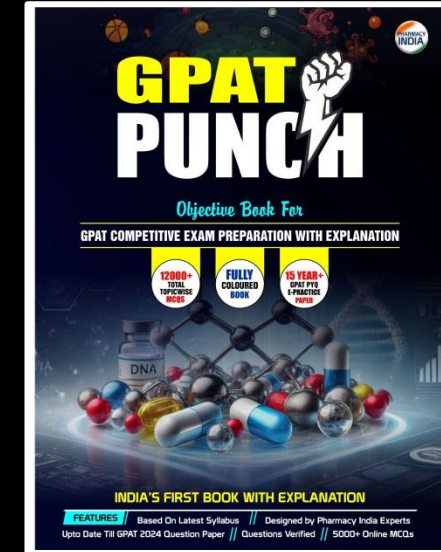
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06.

Which of the following is a measure of precision?

- (a) Standard deviation
- (b) Bias
- (c) Mean value
- (d) Percent error



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06. Which of the following is a measure of precision?

(a) Standard deviation

(b) Bias

(c) Mean value

(d) Percent error



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Standard Deviation

Standard deviation quantifies how much individual measurements vary around the mean.



Standard deviation

measures the scatter of repeated values.



Lower standard deviation

indicates better precision.



It is useful

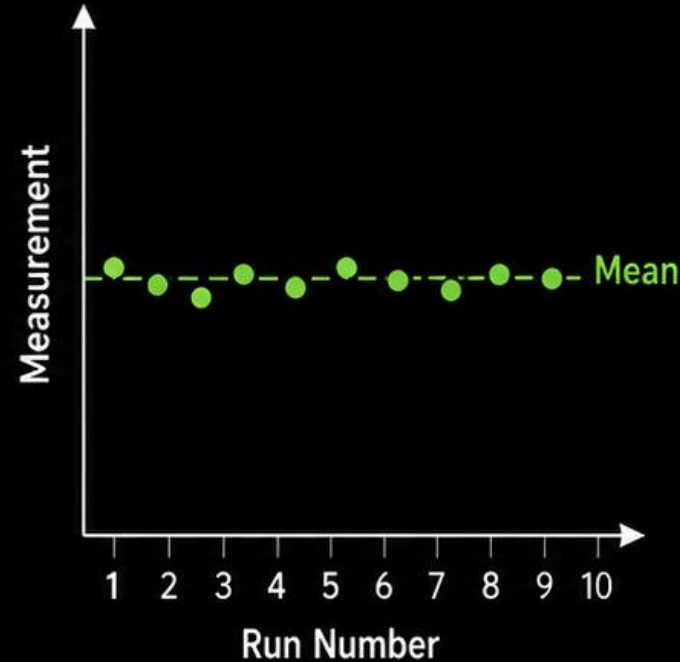
for judging reproducibility.



Smaller spread

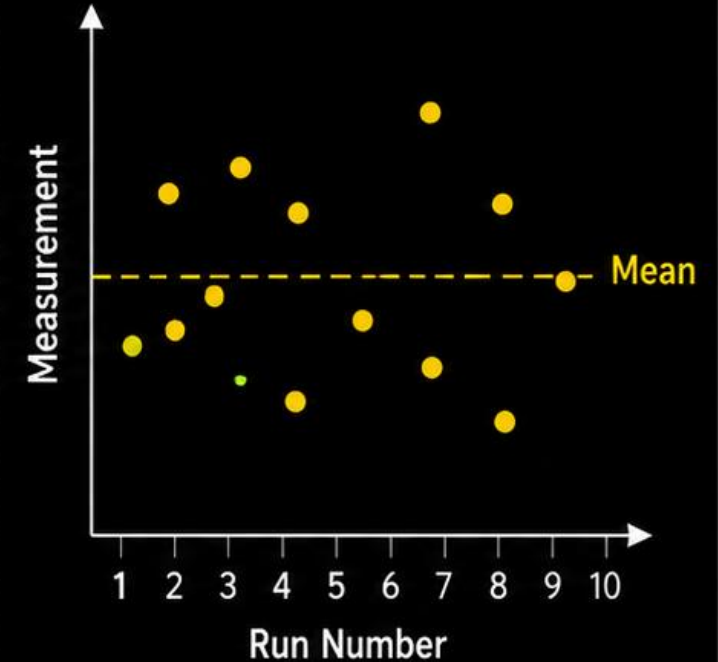
means greater consistency.

LOW STANDARD DEVIATION



Low SD = High Precision

HIGH STANDARD DEVIATION



High SD = Low Precision



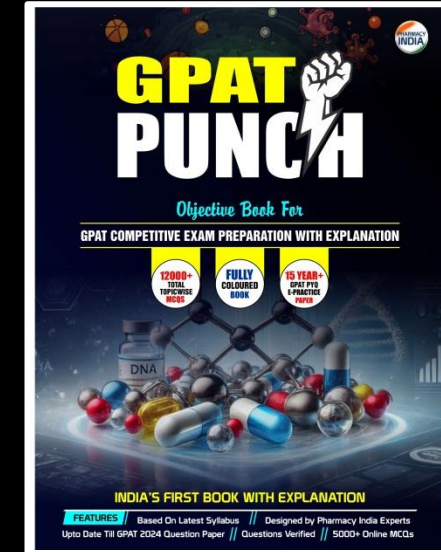
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07.

Which type of error affects the accuracy of measurements?

- (a) Random error
- (b) Systematic error
- (c) Gross error
- (d) All of the above



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07. Which type of error affects the accuracy of measurements?

- (a) Random error
- (b) Systematic error
- (c) Gross error
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How Errors Affect Accuracy



Systematic error produces bias in one direction.



Random error causes scatter around the true value.

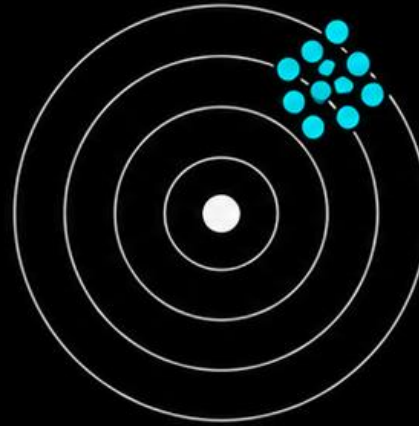


Gross error results from major mistakes or blunders.



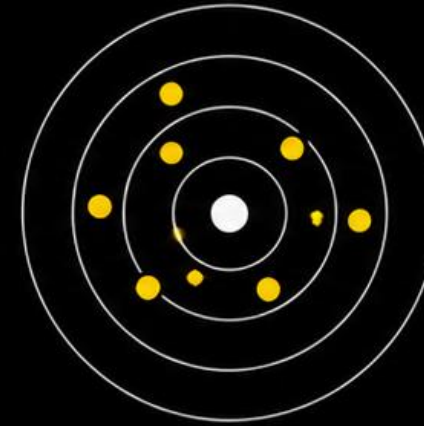
All of these can disturb analytical results.

Systematic Error (Bias)



Consistent offset from true value

Random Error (Scatter)



Results scattered around true value

Gross Error (Blunder)



Result far from true value

● True value ● Systematic error ● Random error ● Gross error



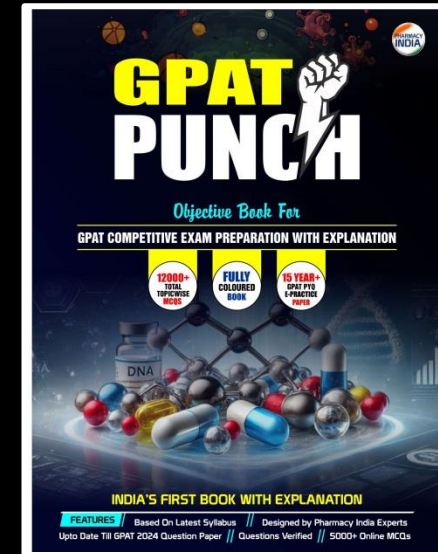
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08.

The term “bias” in analytical measurements refers to:

- (a) Random errors in the data
- (b) Consistent deviation from the true value
- (c) Fluctuations due to environmental conditions
- (d) High variability in repeated measurements



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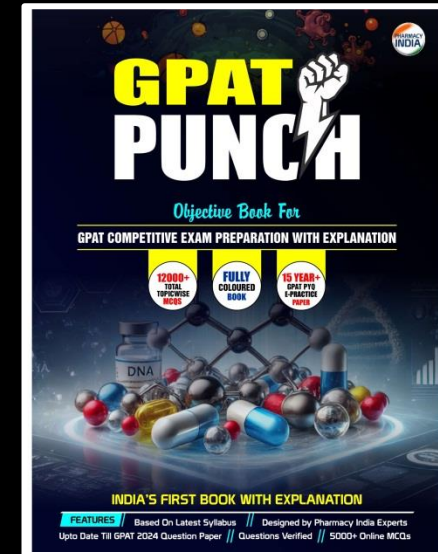
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- (a) Random errors in the data
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- (c) Fluctuations due to environmental conditions
- (d) High variability in repeated measurements



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Bias



Bias is a consistent deviation from the true value.



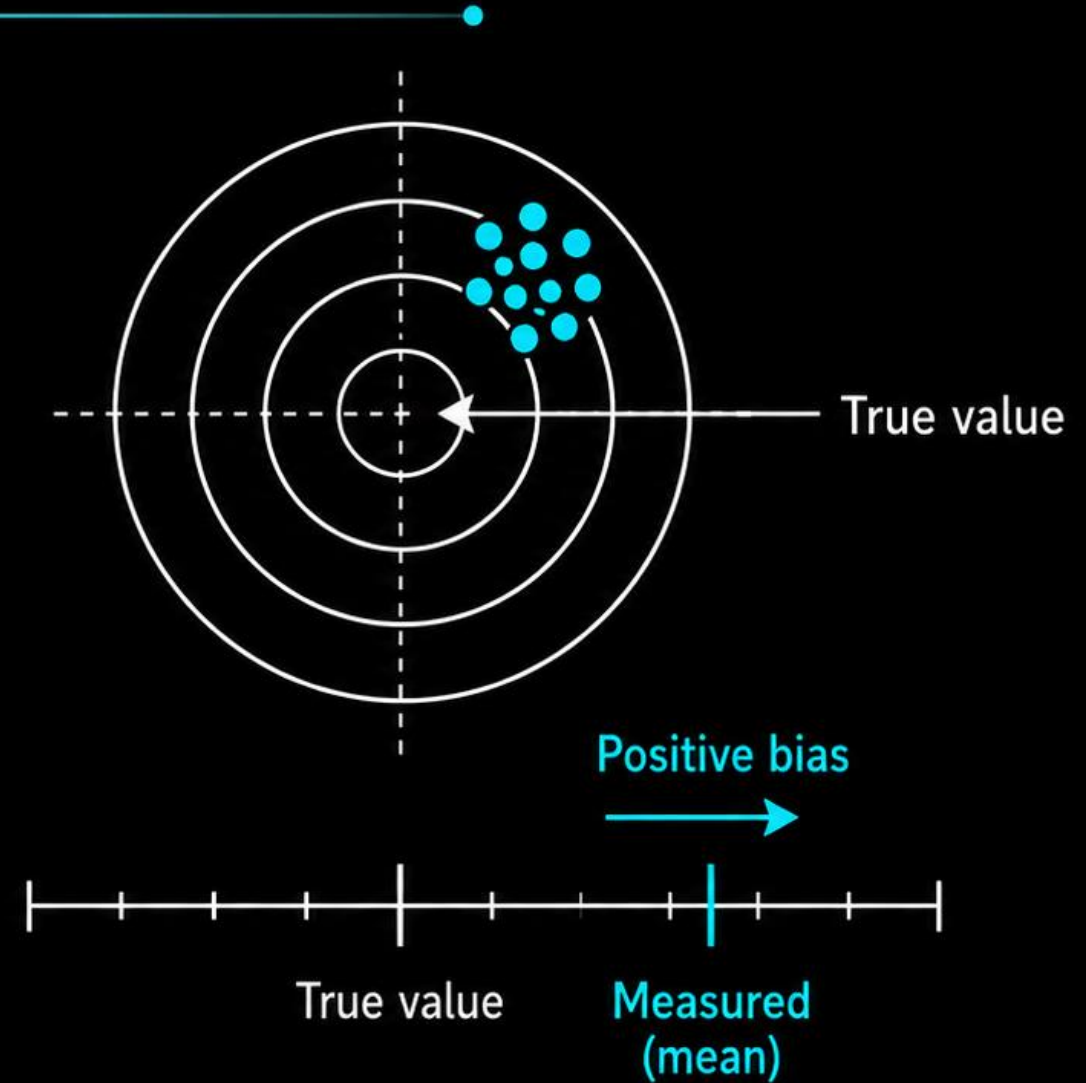
It is a **systematic error**.



Biased results are **shifted** in one direction.



Common causes include **method**, **instrument**, or **calibration error**.





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09.

Control determination is performed to:

- (a) Calibrate the instrument only
- (b) Check the performance of analytical method
- (c) Remove sample matrix interference
- (d) Determine reagent impurities



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09.

Control determination is performed to:

- (a) Calibrate the instrument only
- (b) Check the performance of analytical method**
- (c) Remove sample matrix interference
- (d) Determine reagent impurities



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Control Determination



A known standard is analyzed along with the sample.



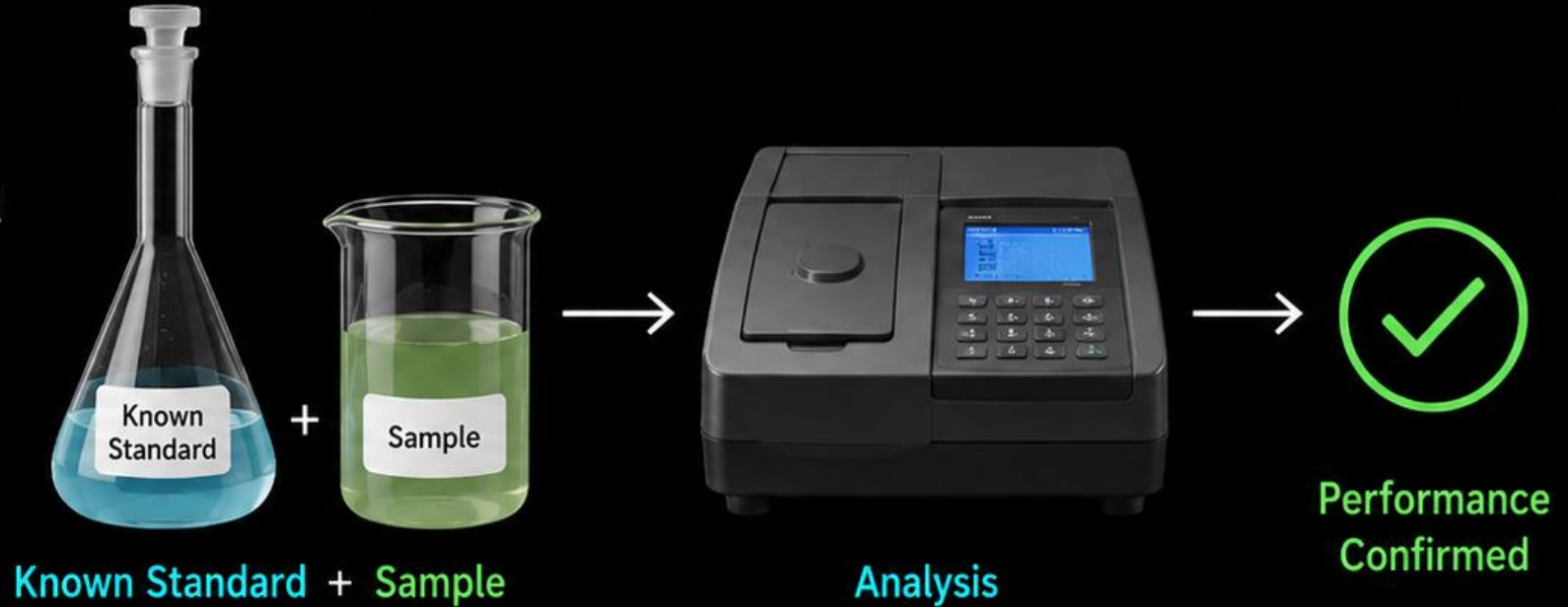
It checks whether the analytical method is performing properly.



It improves confidence in the result.



It serves as an important quality-control step.





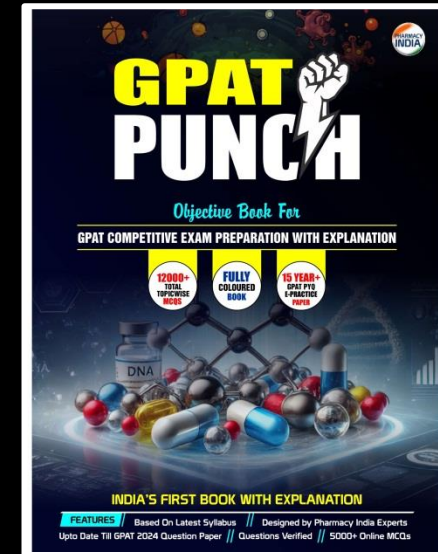
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10.

Absolute error is calculated as:

- (a) True value – observed value
- (b) Observed value – true value
- (c) Observed value $\times$ true value
- (d) Standard deviation $\div$ mean



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10.

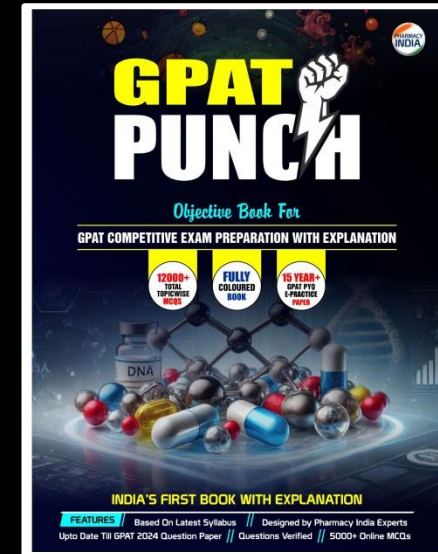
Absolute error is calculated as:

(a) True value – observed value

(b) Observed value – true value

(c) Observed value $\times$ true value

(d) Standard deviation $\div$ mean



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ABSOLUTE ERROR

$$\text{Absolute Error} = \text{Observed Value} - \text{True Value}$$

Formula

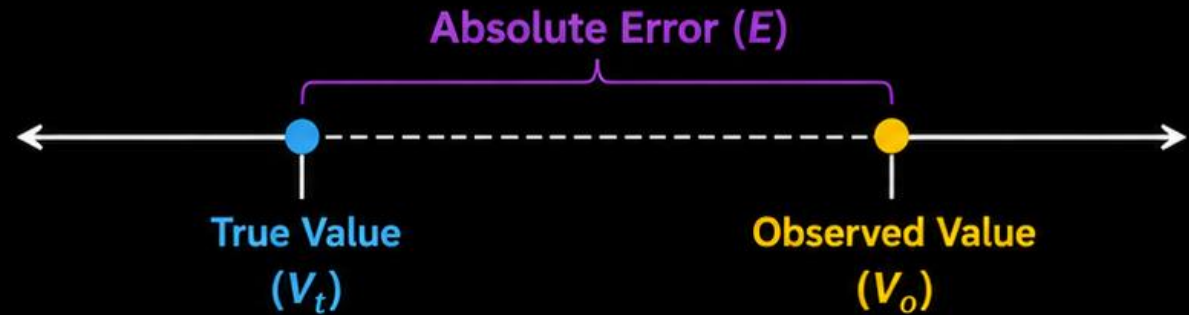
$$E = |V_o - V_t|$$

E = Absolute error

V_o = Observed (measured) value

V_t = True (actual) value

Visual Representation



**CORRECT
ANSWER**

(b) Observed value – true value

$$E = |V_o - V_t|$$

EXAMPLE

True value (V_t) = 25.0

Observed value (V_o) = 23.7

$$\begin{aligned} \text{Absolute error, } E &= |23.7 - 25.0| \\ &= |-1.3| = 1.3 \end{aligned}$$



Absolute error represents the **magnitude** of the difference between the observed value and the true value, **regardless of direction**.



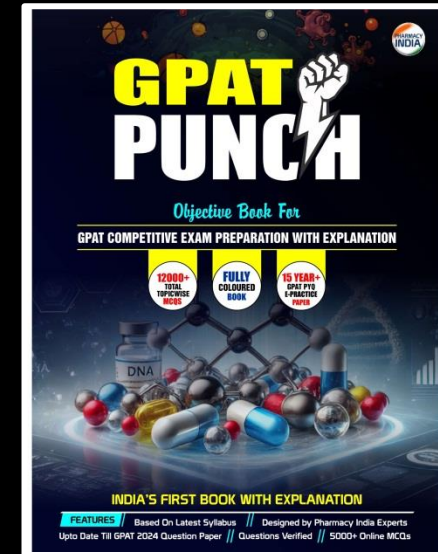
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11.

The arithmetic mean of replicate analytical results is used to represent:

- (a) The most probable value of the data
- (b) The largest observed value
- (c) The smallest observed value
- (d) The random error only



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11.

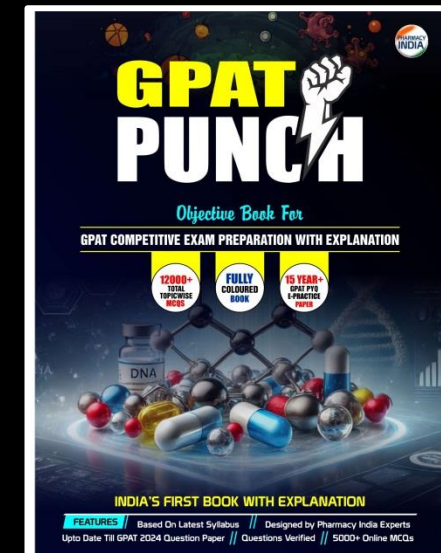
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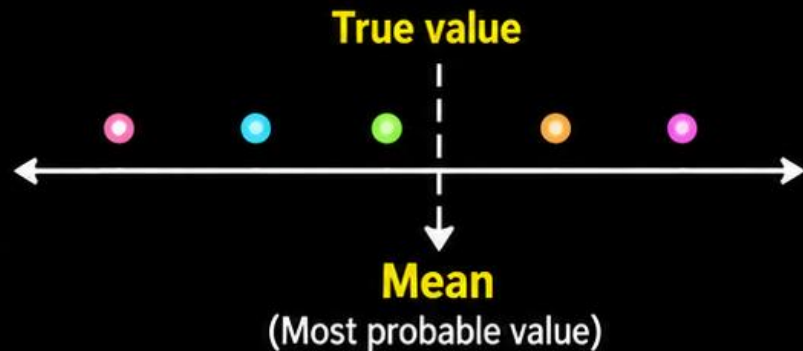


ARITHMETIC MEAN



✓ **Correct answer:** The most probable value of the data

REPLICATE RESULTS CLUSTER AROUND THE TRUE VALUE



ARITHMETIC MEAN (AVERAGE)

$$\bar{X} = \frac{\text{Sum of all observations}}{\text{Number of observations}}$$



$$\text{Mean } (\bar{X}) = \frac{99.6 + 100.2 + 99.8 + 100.1 + 99.9}{5} = 99.92 \text{ mg/L}$$



EXPLANATION

- ✓ Replicate analytical results vary because of **random error**.
- ✓ The arithmetic mean averages all observations and gives the **best estimate of the true value**.
- ✓ Therefore, the mean represents the **most probable value** of the data.



MEAN LIES NEAR THE CENTER
BEST ESTIMATE



EXAMPLE

- Replicate results: 99.6, 100.2, 99.8, 100.1, 99.9
- Mean = **99.92 mg/L**
- Average value lies near the true value



Arithmetic mean = best estimate of the true value

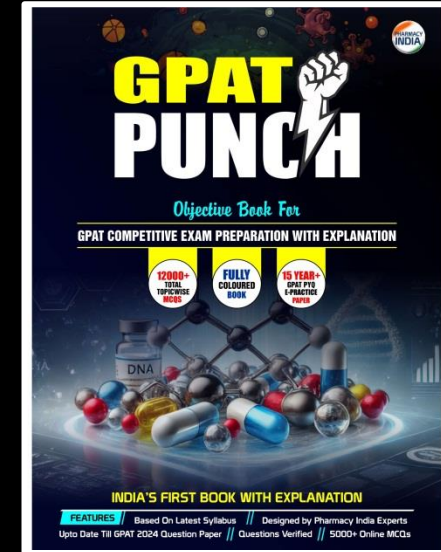




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12. Analyst consistently reads burette 0.05 mL higher. This is:

- (a) Random personal error
- (b) Systematic personal error
- (c) Method error
- (d) Instrumental error



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12.

Analyst consistently reads burette 0.05 mL higher. This is:

(a) Random personal error

(b) Systematic personal error

(c) Method error

(d) Instrumental error



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Systematic Personal Error



True reading
22.50 mL

Analyst reads
22.55 mL

Consistently reads
+0.05 mL
higher each time



A consistent **burette misreading** is a personal error.



Because it happens in the **same direction**, it is **systematic**.



It introduces **bias** into the result.



It is often caused by **analyst habit** or **reading technique**.



Systematic personal errors are **predictable** and **do not average out**. They must be **recognized** and **eliminated** to ensure accurate results.

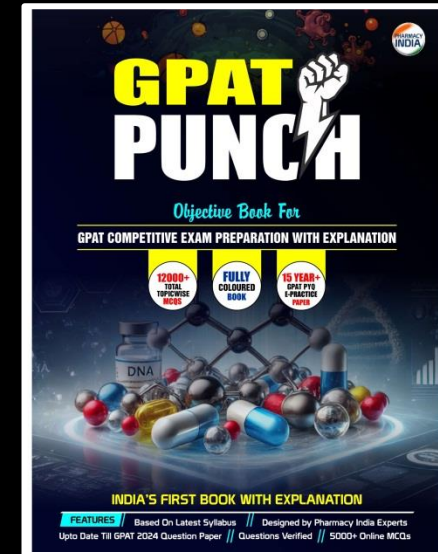


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13. Colour blindness during endpoint detection causes:

- (a) Random error
- (b) Instrumental error
- (c) Method error
- (d) Personal error



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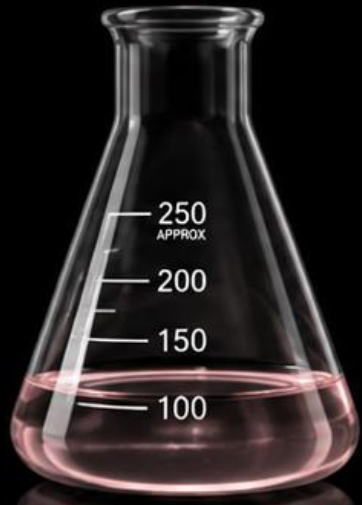
13. **Colour blindness during endpoint detection causes:**

- (a) Random error
- (b) Instrumental error
- (c) Method error
- (d) Personal error**



Colour Blindness and Endpoint Detection

NORMAL VISION
(Correct Endpoint)



✓ Faint **pink** endpoint clearly observed

COLOUR BLINDNESS
(Missed Endpoint)



✗ Pink not perceived, titration continues



The endpoint appears **pink** in normal vision but may appear **colorless** or **different** to a colour-blind analyst.

01



Colour blindness can cause **wrong endpoint** judgement.

02



This error arises from **analyst limitation**.

03



It is classified as a **personal error**.

04



Incorrect endpoint detection can affect **analytical results**.



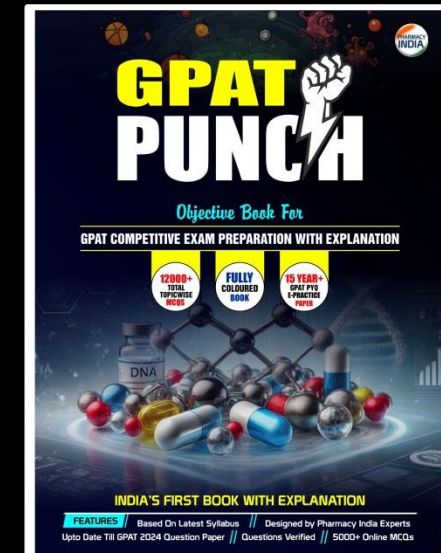
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14.

Draft near analytical balance causes fluctuating readings. This introduces:

- (a) Systematic error
- (b) Random error
- (c) Proportional error
- (d) Constant error



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14. Draft near analytical balance causes fluctuating readings. This introduces:

- (a) Systematic error**
- (b) Random error**
- (c) Proportional error**
- (d) Constant error**



Draft Near Analytical Balance



Fluctuating Balance Readings



0.10023 g
0.10031 g
0.10018 g
0.10027 g
0.10015 g
0.10028 g
0.10021 g
...

1 Air draft causes **unstable** balance readings.

2 The variation is **unpredictable**.

3 This produces **random error**.

4 Random error mainly affects **precision**.



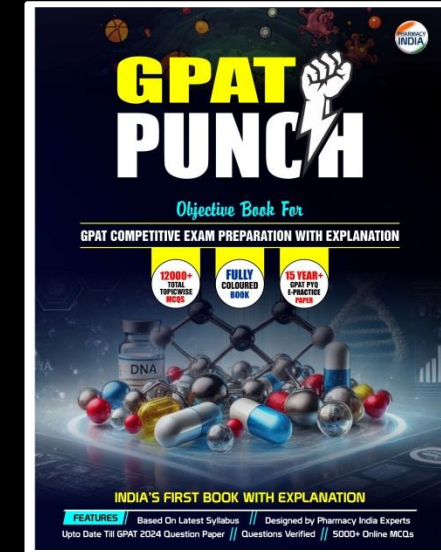


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15. If 10 mg sample has +0.1 mg error and 50 mg sample has +0.5 mg error, the error is:

- (a) Constant
- (b) Proportional
- (c) Gross
- (d) Random



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15. If 10 mg sample has +0.1 mg error and 50 mg sample has +0.5 mg error, the error is:

(a) Constant

(b) Proportional

(c) Gross

(d) Random



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Proportional Error

Example	True Amount (Actual)	Observed Amount (Measured)	Error (Observed – Actual)	Percentage Error [(Error / Actual) × 100]
①	10 mg	10.1 mg	+0.1 mg	$(0.1 / 10) \times 100 = 1\%$
②	50 mg	50.5 mg	+0.5 mg	$(0.5 / 50) \times 100 = 1\%$



- 1 Proportional error changes with **sample size**.
- 2 The error **increases** or **decreases** in proportion to the amount measured.
- 3 In both examples, the **percentage error** is the same.
- 4 This is **not** a constant error.



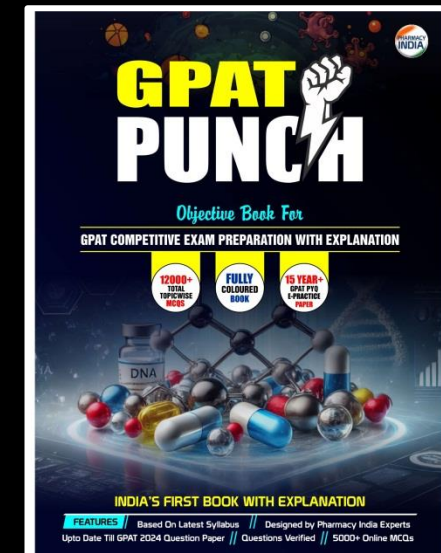
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16.

Which action reduces systematic error?

- (a) More replicate analysis
- (b) Calibration of instruments
- (c) Calculating median
- (d) Rejecting outliers



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16.

Which action reduces systematic error?

(a) More replicate analysis

(b) Calibration of instruments

(c) Calculating median

(d) Rejecting outliers



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Calibration Reduces Systematic Error



Calibration checks the instrument against a **known standard**.



It helps **detect** and **correct bias**.



It reduces **systematic instrumental error**.



Replication alone **cannot remove systematic error**.

BEFORE CALIBRATION

Instrument has bias



Known Standard
True Value = 100.0



Bias = +10.0
Systematic Error Present



AFTER CALIBRATION

Instrument aligned with standard



Known Standard
True Value = 100.0



Bias $\approx$ 0.0
Systematic Error Minimized



Calibration aligns instrument readings with true values, ensuring **accuracy** and **reliability** of results.



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17.

Primary standard for standardizing NaOH is:

- (a) Sodium carbonate
- (b) Potassium hydrogen phthalate
- (c) Potassium dichromate
- (d) Silver nitrate



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17. Primary standard for standardizing NaOH is:

(a) Sodium carbonate

(b) Potassium hydrogen phthalate

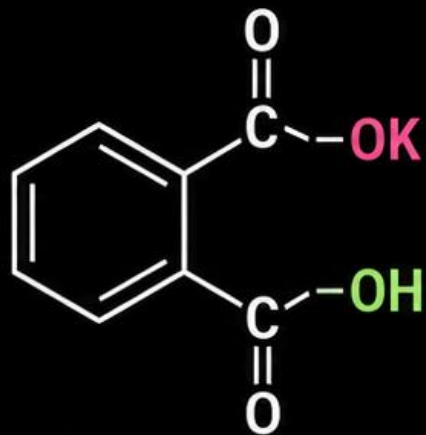
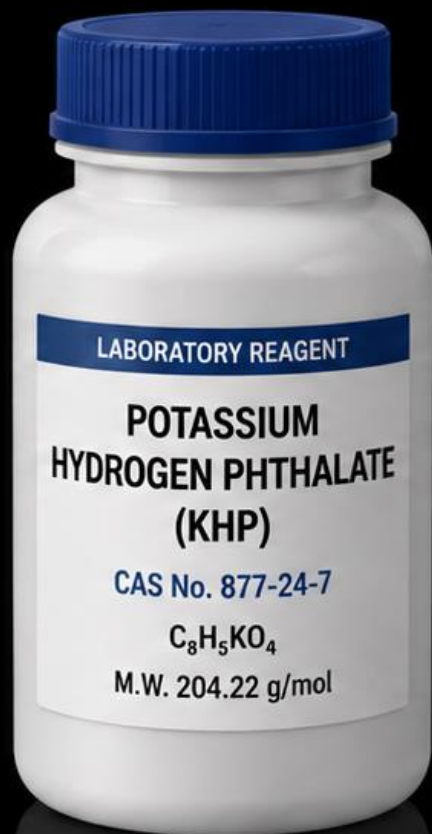
(c) Potassium dichromate

(d) Silver nitrate



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Potassium Hydrogen Phthalate (KHP)

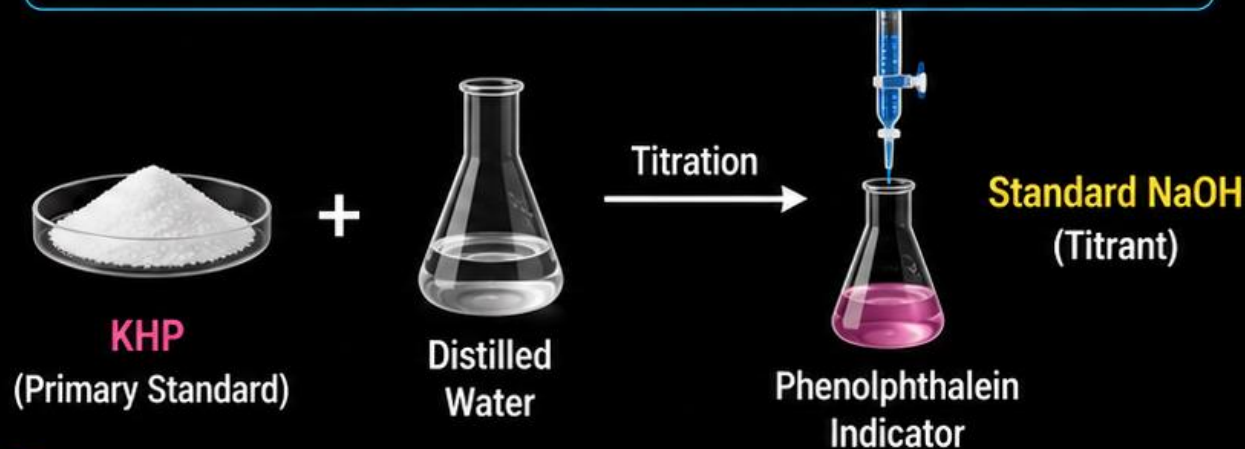


Potassium Hydrogen Phthalate
(KHP)

M.W. 204.22 g/mol

Monoprotic acid

KHP is used to **standardize sodium hydroxide**.



1. KHP is used to **standardize sodium hydroxide**.



2. It is **pure, stable**, and **non-hygroscopic**.



3. Its high purity allows **accurate weighing**.



4. Therefore, it is a **suitable primary standard**.



KHP (Potassium Hydrogen Phthalate) — a reliable primary standard for accurate **NaOH** standardization.



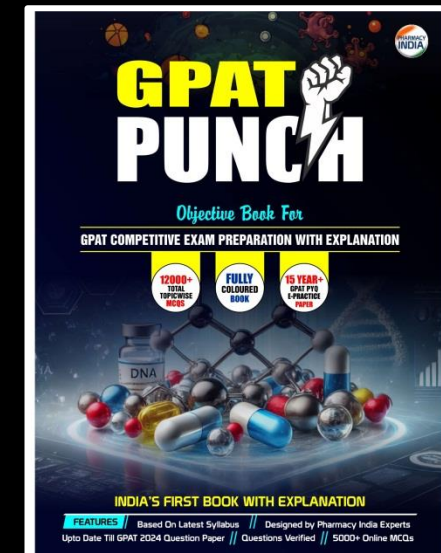
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18.

Reproducibility refers to precision obtained by:

- (a) Same analyst on same day
- (b) Different analysts in different laboratories
- (c) Comparison with true value
- (d) Small changes in method parameters



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18. Reproducibility refers to precision obtained by:

(a) Same analyst on same day

(b) Different analysts in different laboratories

(c) Comparison with true value

(d) Small changes in method parameters



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Reproducibility



Reproducibility is **precision** under changed conditions.



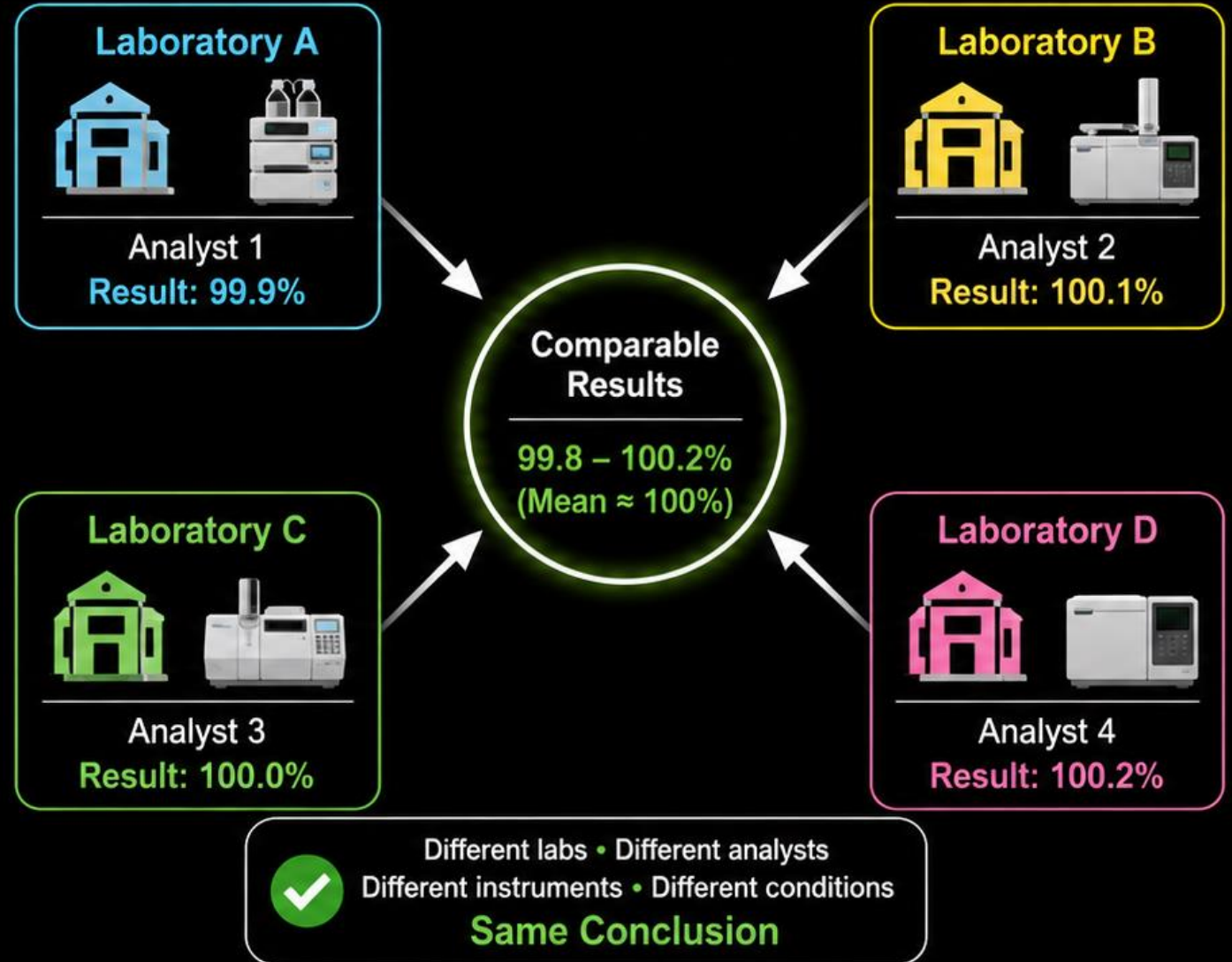
It involves **different analysts** or different laboratories.



It reflects **inter-laboratory agreement**.



It is **broader** than **repeatability**.





19. **Interfering substance in sample causes:**

- (a) Instrumental error
- (b) Personal error
- (c) Method error
- (d) Random error



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19. Interfering substance in sample causes:

(a) Instrumental error

(b) Personal error

(c) Method error

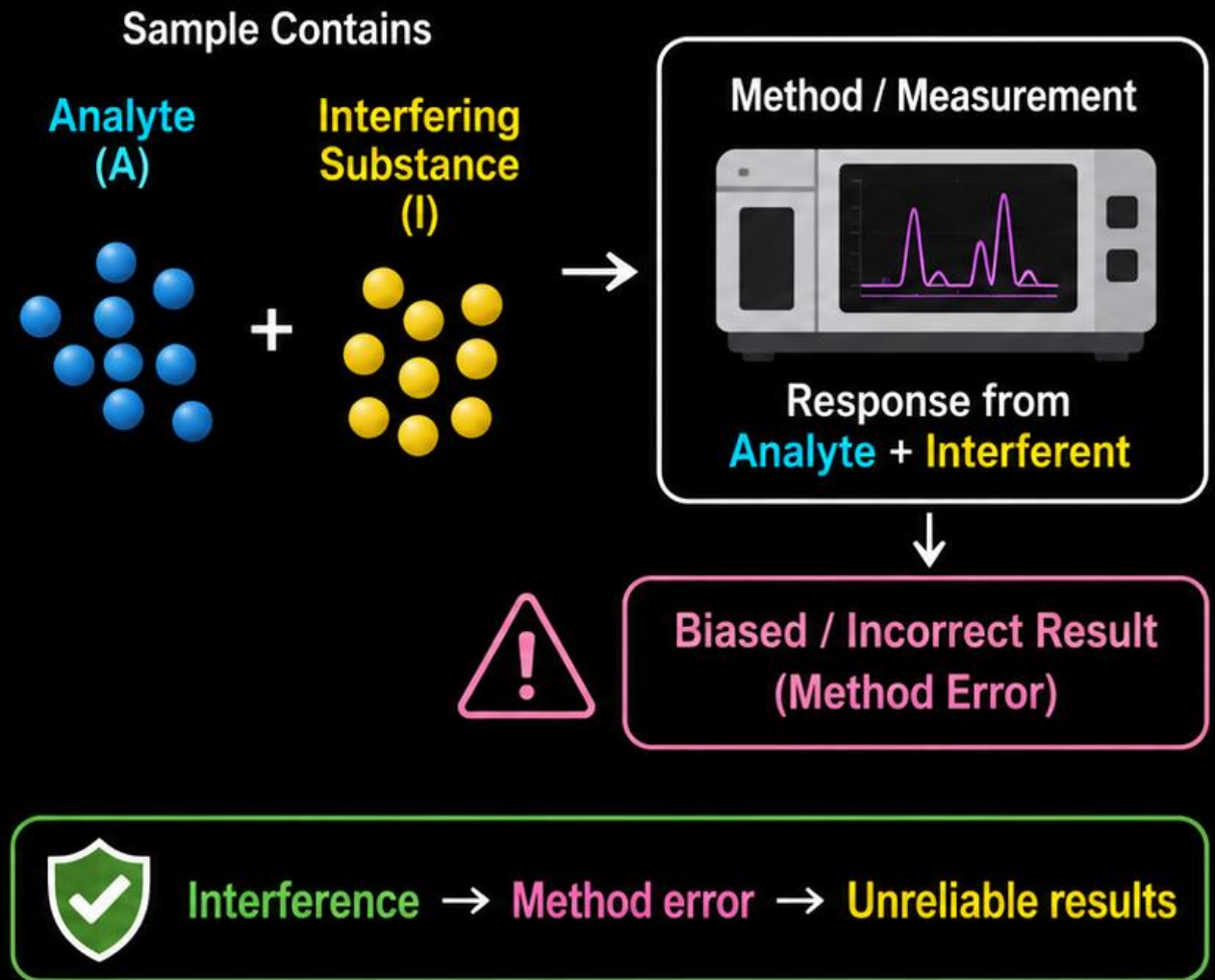
(d) Random error



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Interfering Substance in the Sample

- 1 An **interfering substance** can cause **method error**.
- 2 The method **fails to distinguish analyte** from interferent.
- 3 This reduces **specificity** of the analysis.
- 4 It often produces **systematic error**.



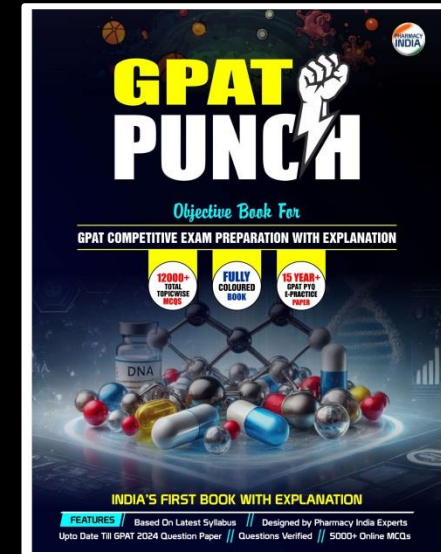


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20. Which of the following is an instrumental error?

- (a) Incorrect calibration of balance
- (b) Misreading the burette meniscus
- (c) Using wrong indicator
- (d) Spilling the sample



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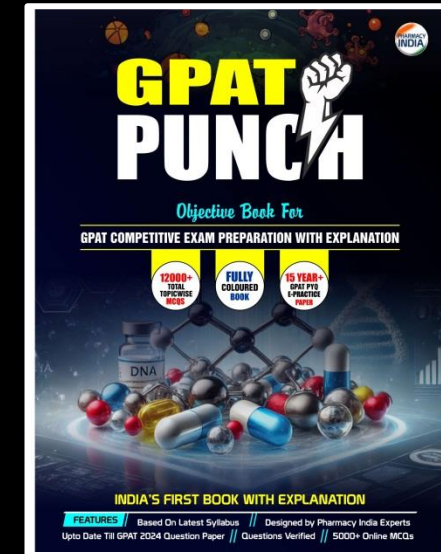


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20. Which of the following is an instrumental error?

- (a) Incorrect calibration of balance
- (b) Misreading the burette meniscus
- (c) Using wrong indicator
- (d) Spilling the sample



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INSTRUMENTAL ERROR



Incorrect calibration of a balance

1



Instrumental error arises from a **faulty** or **improperly calibrated** instrument.

2



If a balance is **not calibrated** correctly, it gives **inaccurate** weight readings even when the analyst works properly.

3



The error comes from the **instrument itself**, not from sample handling or observation.



CALIBRATION STATUS



ACTUAL WEIGHT



100.00 mg

INDICATED READING



WRONG READING



Example: A 100 mg sample may display a wrong value because the balance is miscalibrated.



SOURCE OF ERROR:
THE INSTRUMENT



CALIBRATE
REGULARLY



VERIFY WITH
STANDARD WEIGHTS





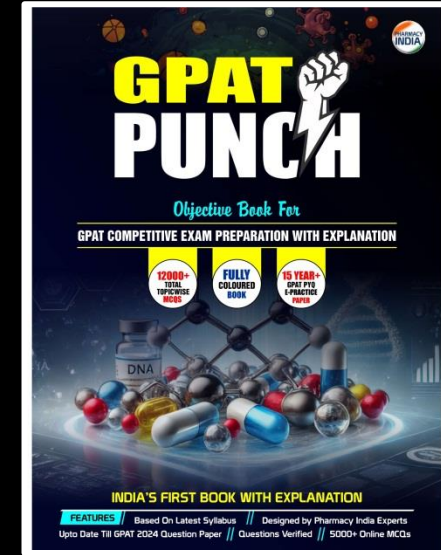
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21.

Bias is a quantitative measure of:

- (a) Ruggedness
- (b) Precision
- (c) Accuracy
- (d) Linearity



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21.

Bias is a quantitative measure of:

(a) Ruggedness

(b) Precision

(c) Accuracy

(d) Linearity



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Bias and Accuracy



Bias is the difference between the **mean result** and the **true value**.



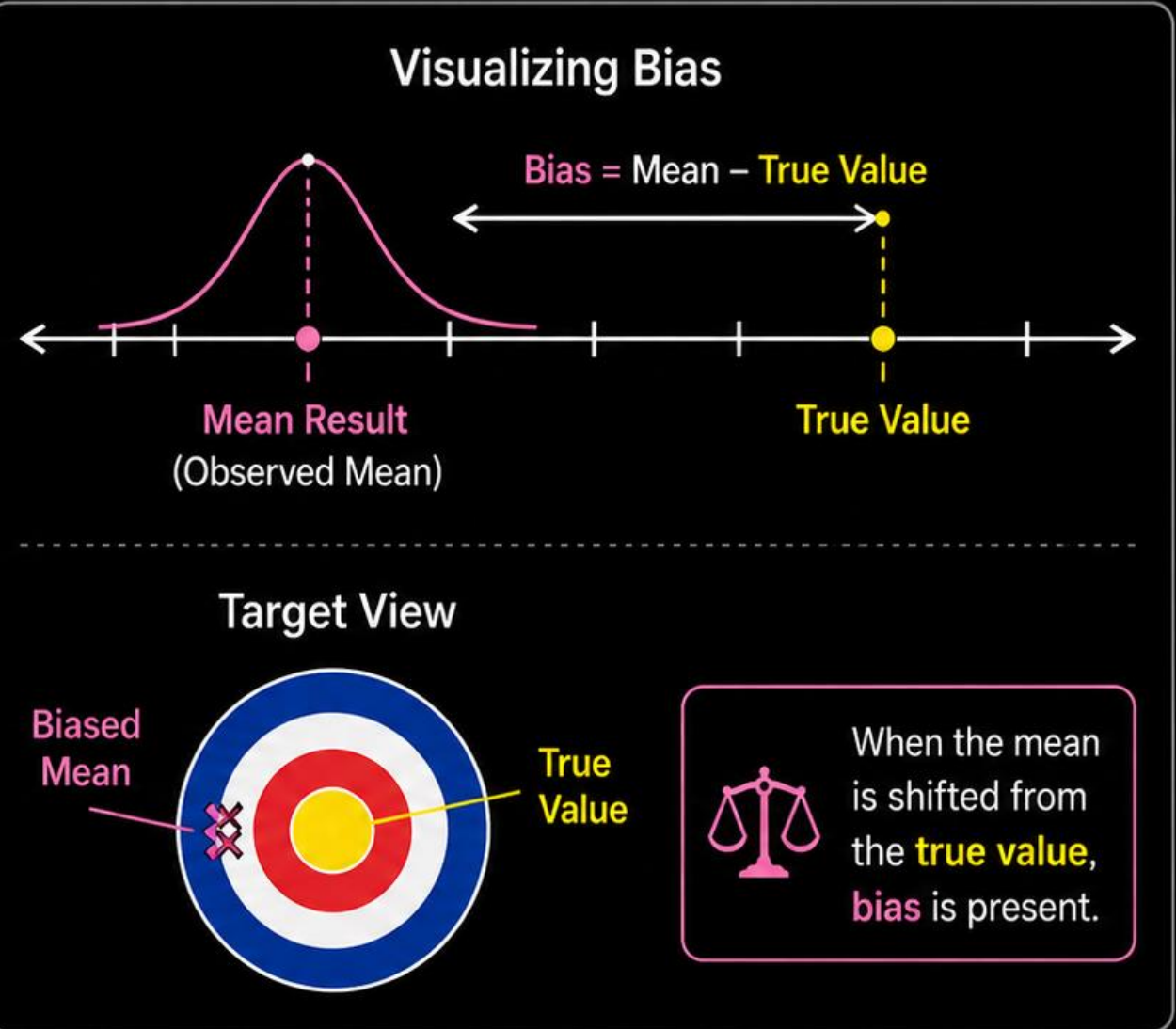
It is a **quantitative** measure related to **accuracy**.



Bias indicates **systematic error**.



Lower bias means **better accuracy**.



Bias is the difference between the **mean result** and the **true value**. | Lower bias leads to **higher accuracy**.



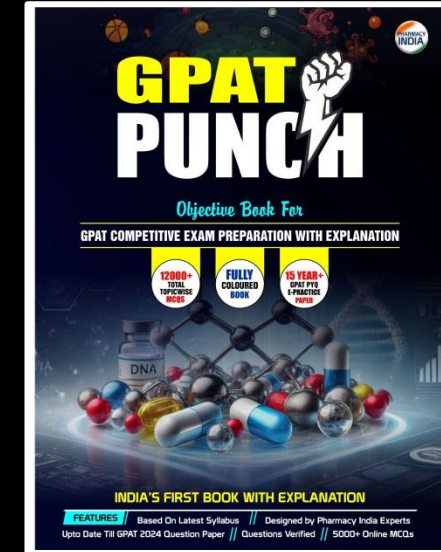
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22.

Forgetting to subtract blank value causes:

- (a) Constant systematic error
- (b) Proportional systematic error
- (c) Random error
- (d) Gross personal error



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22.

Forgetting to subtract blank value causes:

(a) Constant systematic error

(b) Proportional systematic error

(c) Random error

(d) Gross personal error



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Blank Correction



Blank correction removes **background signal** from reagents or the procedure to reveal the **true sample signal**.



A **blank value** represents a fixed **background** contribution from reagents or the procedure.



If the blank is **not subtracted**, the same extra amount is added to **every result**.



This produces a constant **systematic error** (positive bias).



Correct **blank subtraction** removes the bias and **improves accuracy**.

SAMPLE RESULT
(Includes signal + blank)



Measured value
(Signal + Blank)

BLANK VALUE
(Background only)



Background from
reagents / procedure

CORRECTED RESULT
(True sample signal)



True value
(Background removed)



Blank correction **eliminates constant background bias**, **reduces systematic error**, and brings results closer to the true value—**improving accuracy**.



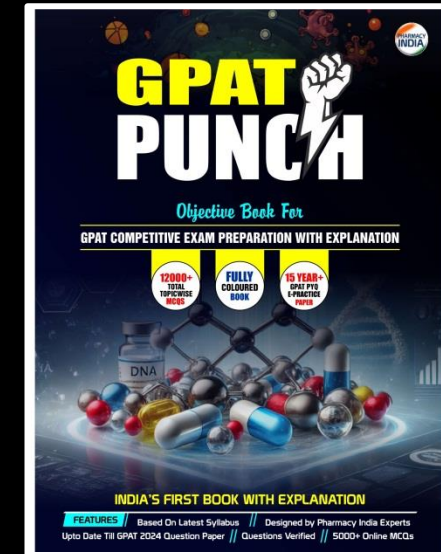
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23.

Which is a secondary standard?

- (a) Potassium dichromate
- (b) Anhydrous sodium carbonate
- (c) Sodium hydroxide
- (d) Oxalic acid



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23.

Which is a secondary standard?

- (a) Potassium dichromate
- (b) Anhydrous sodium carbonate
- (c) Sodium hydroxide**
- (d) Oxalic acid



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Secondary Standard: Sodium Hydroxide



Sodium hydroxide (NaOH) is a **secondary standard**.



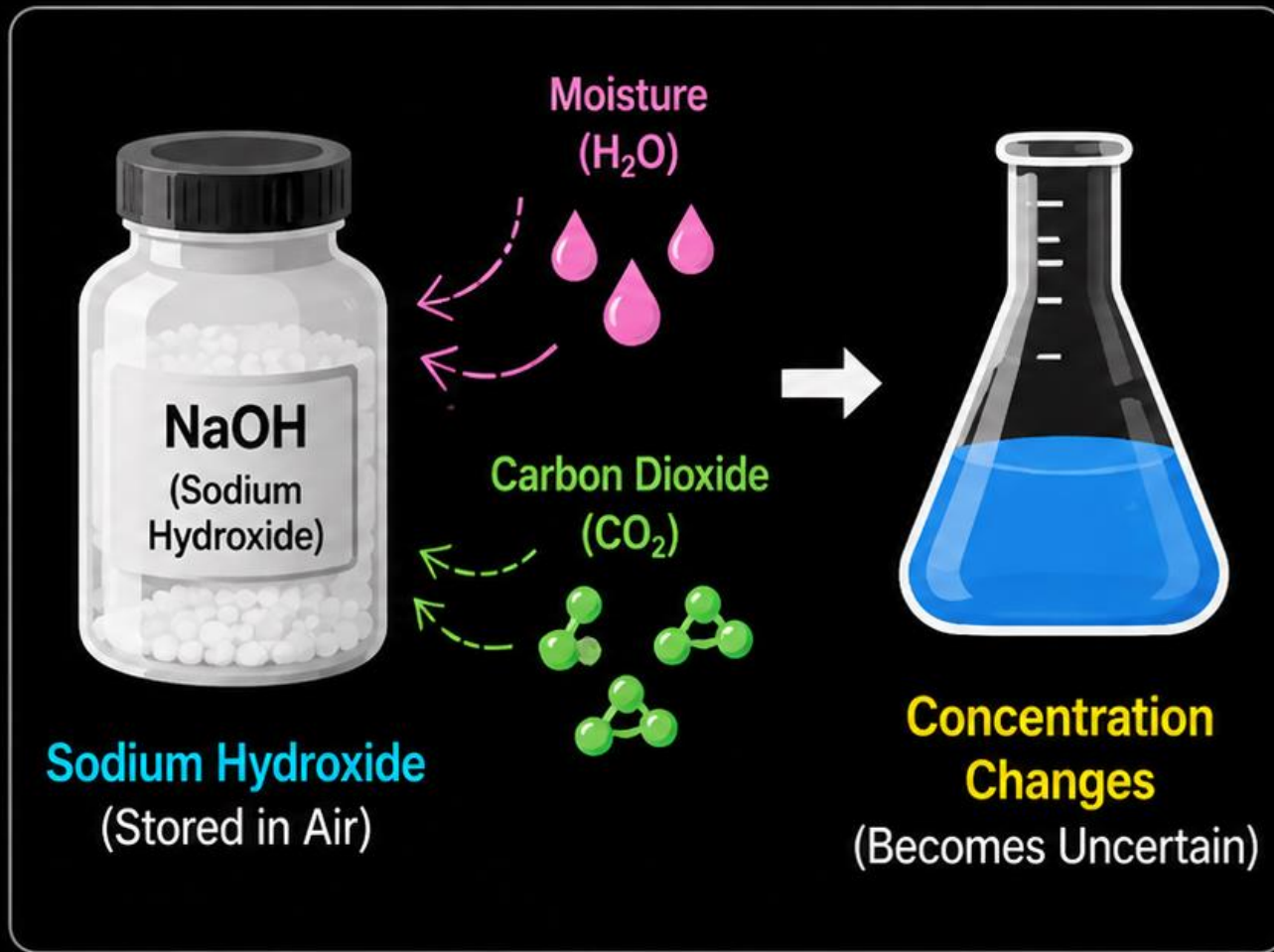
It absorbs **moisture (H₂O)** and **carbon dioxide (CO₂)** from air.



Its exact concentration **changes** during **storage**.



Therefore it **cannot** be used accurately without **standardization**.



Sodium hydroxide is a **secondary standard**.

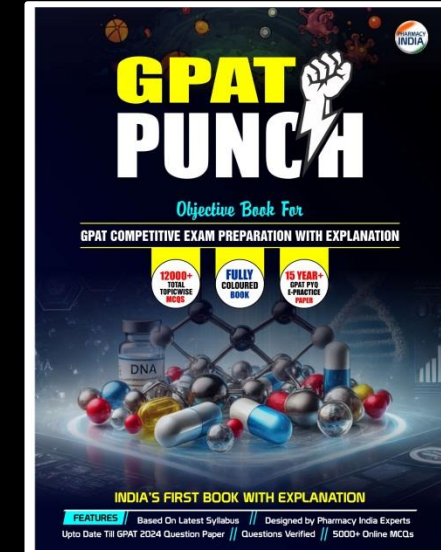
It must be **standardized** before use.



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24. Difference between largest and smallest value is:

- (a) Standard deviation
- (b) Variance
- (c) Mean deviation
- (d) Range



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24. Difference between largest and smallest value is:

(a) Standard deviation

(b) Variance

(c) Mean deviation

(d) Range



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Range



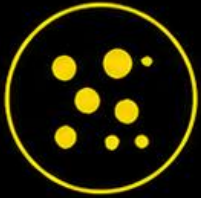
Range is the difference between the **largest** and the **smallest** value.



It is a **simple** measure of **spread**.



It gives a **quick estimate** of **precision** or **variability**.



Larger range means more **scattered** data.



Range provides a **fast, easy** way to understand how **spread out** the data is.

— **Data Set (Example)** —

12, 18, 20, 25, 28, 34, 41



$$\begin{aligned}\text{Range} &= \text{Highest Value} - \text{Lowest Value} \\ &= 41 - 12 = 29\end{aligned}$$

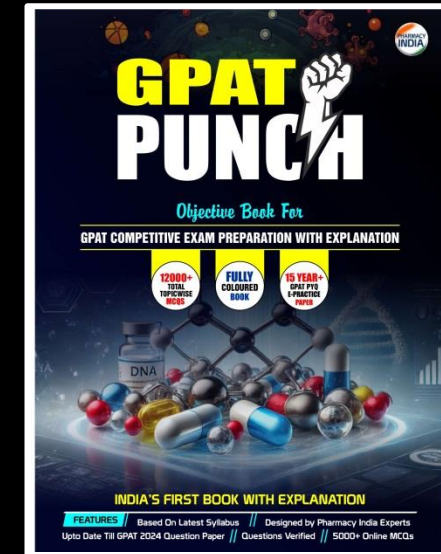


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25. Result 15.67% among 14.92%, 14.91%, 14.88% is due to:

- (a) Systematic error
- (b) Random error
- (c) Gross error
- (d) Proportional error



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25. Result 15.67% among 14.92%, 14.91%, 14.88% is due to:

- (a) Systematic error
- (b) Random error
- (c) Gross error**
- (d) Proportional error



Gross Error



An **isolated value** like 15.67% among results around 14.9% is an **outlier**.



This usually indicates **gross error** caused by a **mistake, blunder, or accident**.



Gross errors produce **abnormal unreliable** results.



Such data should be **investigated** before acceptance.

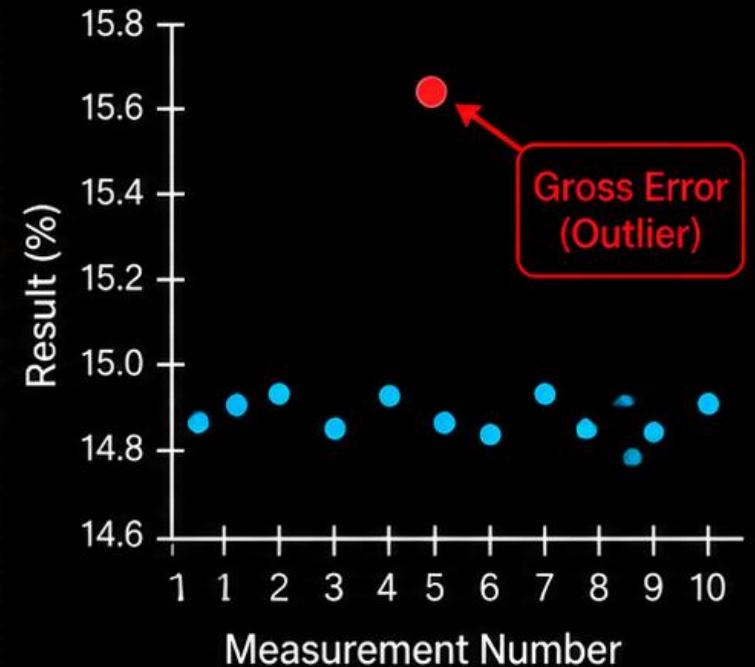


Gross error produces an **isolated, extreme result** that is inconsistent with the rest of the data. **Investigate** the cause and **do not accept** such data without **verification**.

Data Example (%)

14.91
14.88
14.93
14.90
14.87
14.92
15.67
14.89
14.94
14.90

Scatter Plot





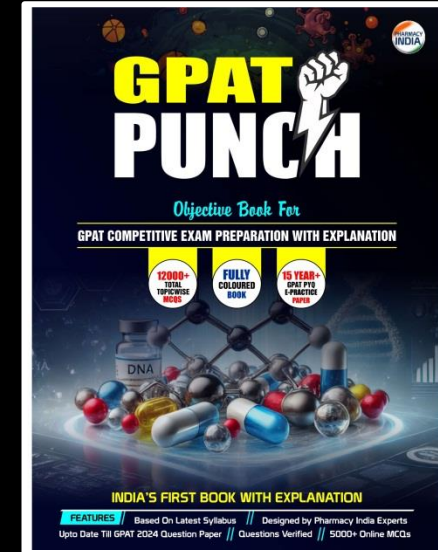
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26.

Error affecting accuracy but not necessarily precision is:

- (a) Random error
- (b) Systematic error
- (c) Gross error
- (d) Indeterminate error



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26. Error affecting accuracy but not necessarily precision is:

(a) Random error

(b) Systematic error

(c) Gross error

(d) Indeterminate error



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Systematic Error and Accuracy



Systematic error shifts results **consistently** in **one direction**.



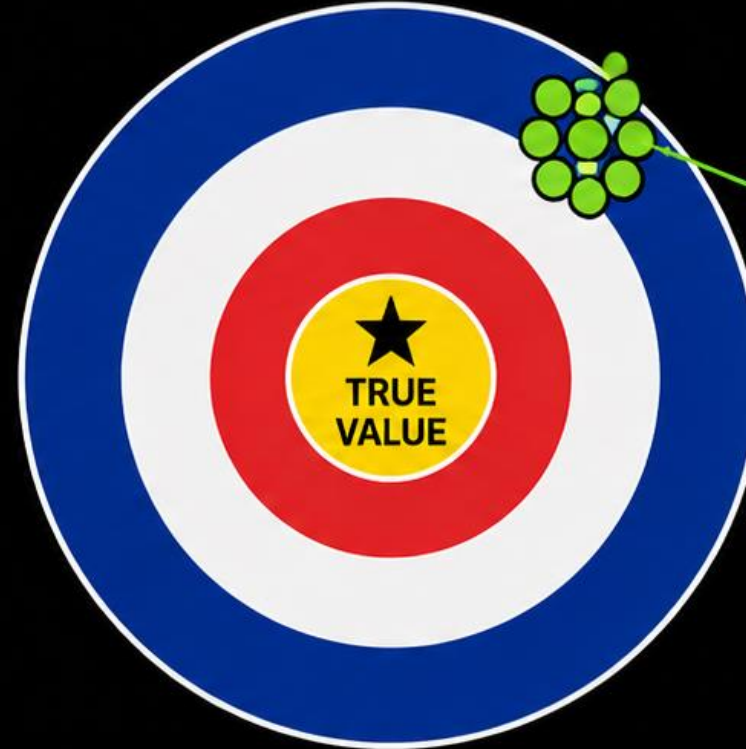
It mainly affects **accuracy** (closeness to the true value).



Results may still be **closely grouped**, so **precision** can remain good.



Therefore, **accuracy** can be **poor** even when **precision** looks good.



Closely grouped results, but **consistently shifted** away from the **true value**.



ACCURACY

Poor



PRECISION

Good



Systematic error biases results without increasing scatter—**accuracy** suffers, **precision** may remain high.



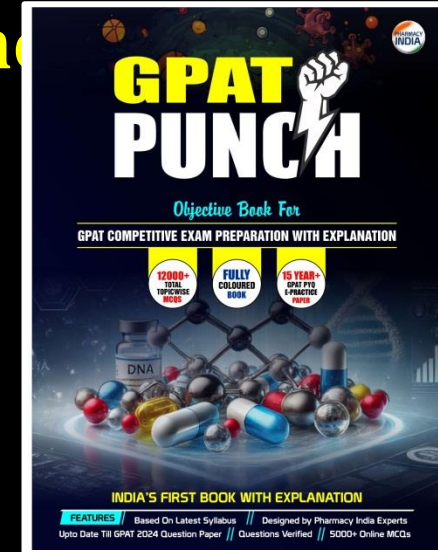
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27.

Ability of method to detect small concentration difference

- (a) Accuracy
- (b) Precision
- (c) Sensitivity
- (d) Selectivity



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27.

Ability of method to detect small concentration difference is:

(a) Accuracy

(b) Precision

(c) Sensitivity

(d) Selectivity



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Sensitivity



Sensitivity is the ability of a method to detect **small concentration differences**.



Higher sensitivity means small changes in concentration produce a **noticeable change in response**.



Sensitivity is related to the **slope** of the calibration curve.



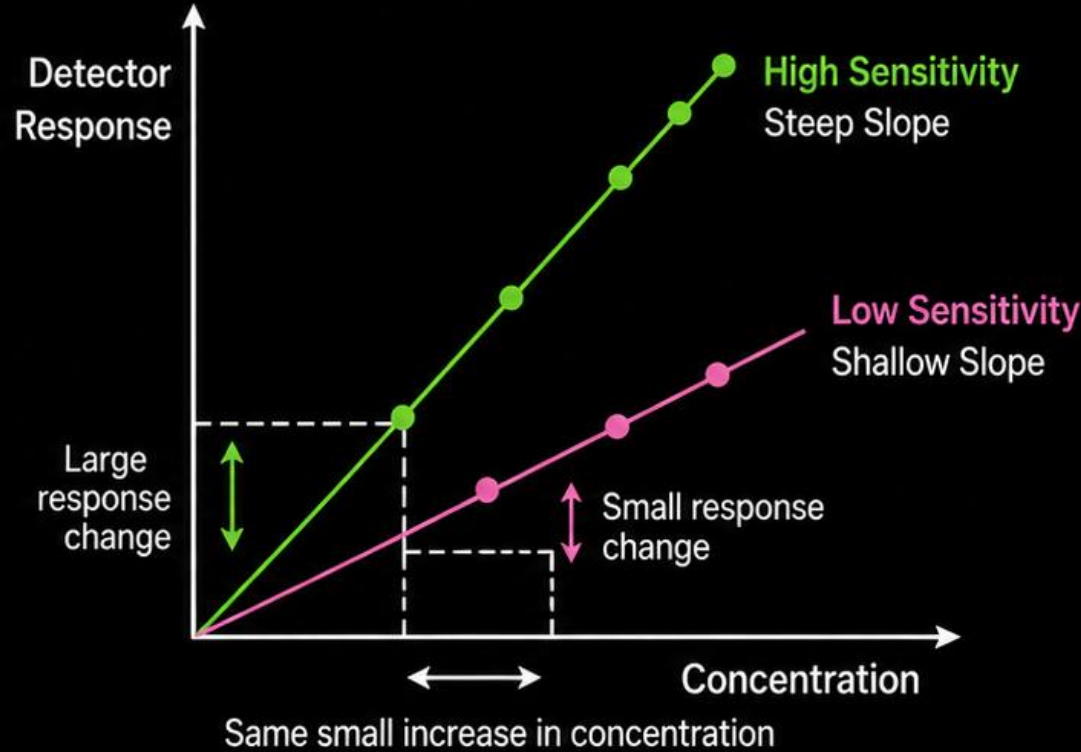
More sensitive methods have **steeper slopes** and **lower limits of detection**.



Sensitivity determines how well a method can **detect** and **respond** to small changes in concentration—a key factor for detecting **trace levels** reliably.

Calibration Curve

Detector Response vs. Concentration



High Sensitivity
Small concentration difference → Large response difference



Low Sensitivity
Small concentration difference → Small response difference

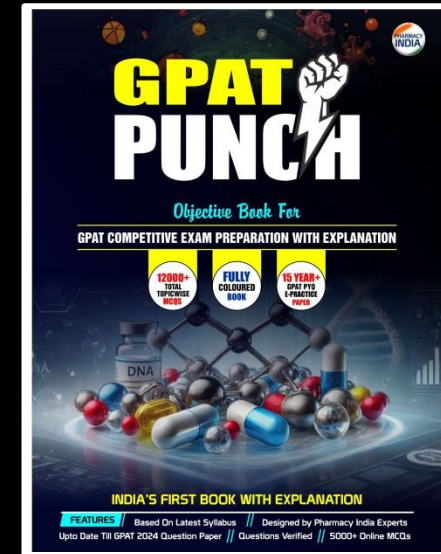


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28. Error due to physical or chemical properties of analytical system is:

- (a) Personal error
- (b) Method error
- (c) Operational error
- (d) Random error



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28. Error due to physical or chemical properties of analytical system is:

(a) Personal error

(b) Method error

(c) Operational error

(d) Random error



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Method Error



Method error arises from **physical or chemical limitations** of the analytical procedure.



Common causes: **incomplete reaction**, **side reaction**, or **poor selectivity**.



Method error is **inherent in the method**, not the analyst.

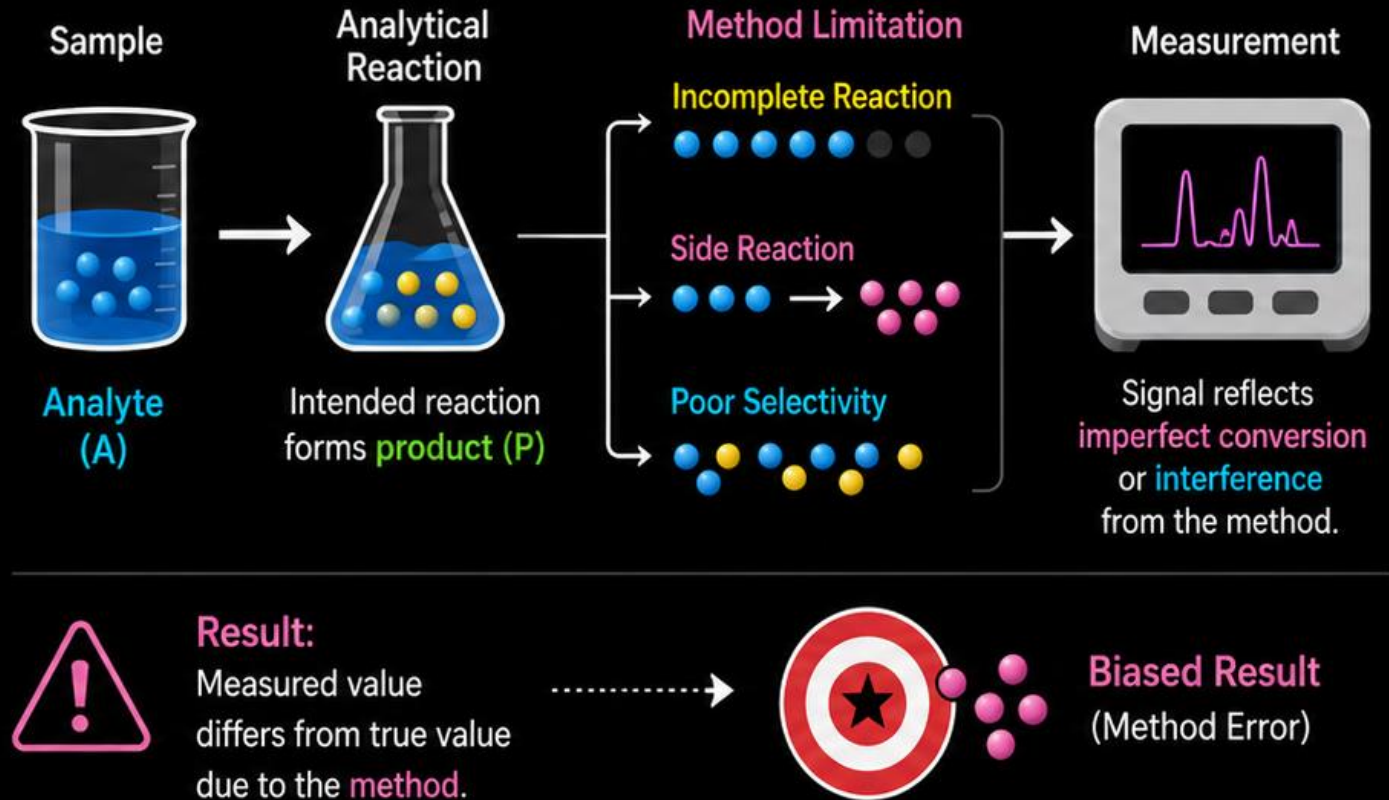


It can produce **biased** results.



Method error is **built into the procedure's chemistry or physics** and can create **biased** results, even when **performed perfectly**.

HOW METHOD ERROR OCCURS



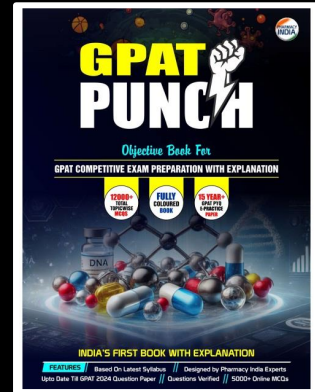


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29.

The median of analytical data is:

- (a) The most repeated value
- (b) The middle value after arranging data in order
- (c) The difference between maximum and minimum value
- (d) The square of standard deviation



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29.

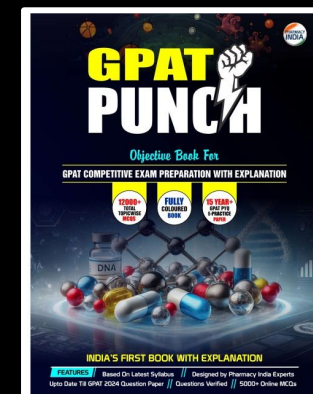
The median of analytical data is:

(a) The most repeated value

(b) The middle value after arranging data in order

(c) The difference between maximum and minimum value

(d) The square of standard deviation



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MEDIAN

— ● Central value in an ordered data set ● —



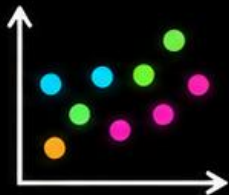
- 1 Arrange the values from lowest to highest, then choose the **middle value**.



- 2 Median is **less affected** by extreme values.



- 3 Useful when the data contains **outliers**.



Example 1: No Outliers

2 , 4 , 5 , 7 , 9

↑
middle value

Example 2: With an Outlier

2 , 4 , 5 , 7 , 50

↑ middle value ↑ outlier



Median focuses on the **center** of the data, **not the extremes**.



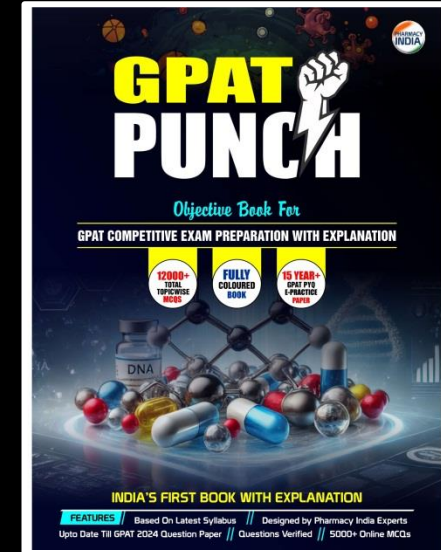
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30.

Variance is defined as:

- (a) Square of standard deviation
- (b) Square root of standard deviation
- (c) Mean divided by standard deviation
- (d) Difference between endpoint and equivalence point



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30.

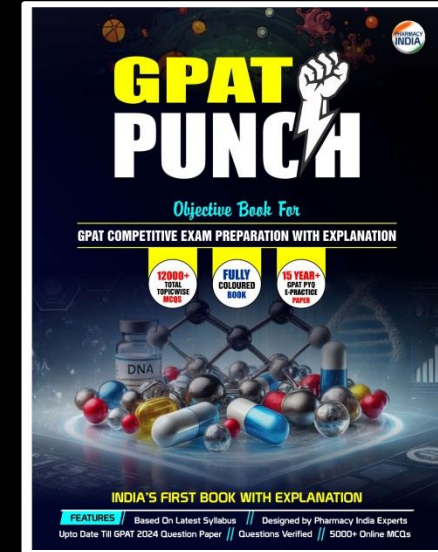
Variance is defined as:

(a) Square of standard deviation

(b) Square root of standard deviation

(c) Mean divided by standard deviation

(d) Difference between endpoint and equivalence point



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Variance is defined as:

Variance is the **square** of the **standard deviation**.

$$\text{Variance } (\sigma^2) = (\text{Standard Deviation})^2$$



Measures the average of the **squared deviations** from the **mean**.



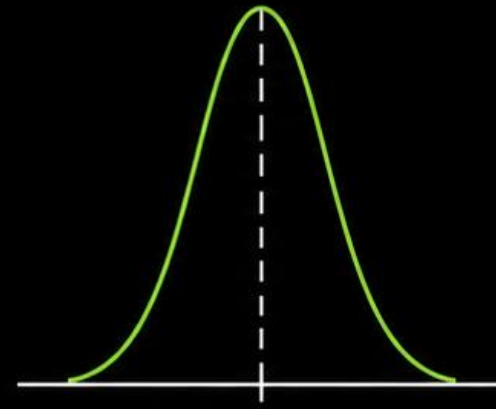
Higher variance means data points are more **spread out**.



Useful for understanding the **dispersion** of data.

Same Mean, Different Variance

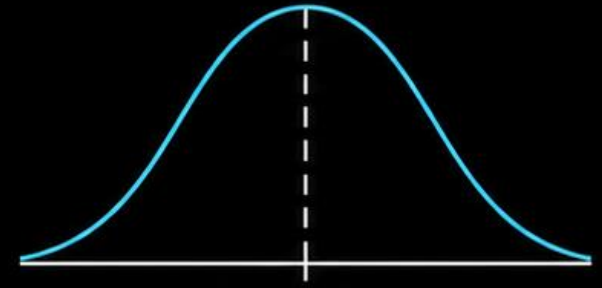
Low Variance



Mean (μ)

Data points are **closer** to the mean.

High Variance



Mean (μ)

Data points are more **spread out**.



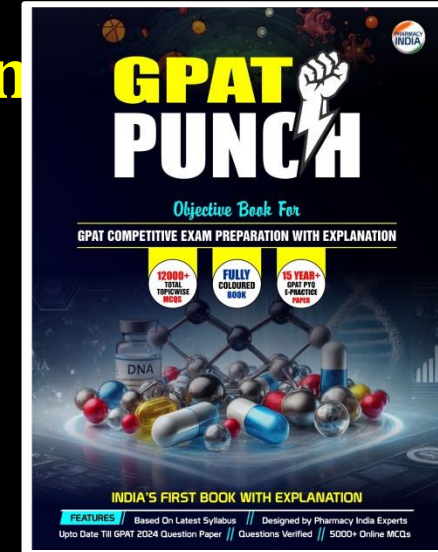
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31.

What type of error can be minimized by increasing the number of measurements?

- (a) Systematic error
- (b) Instrumental error
- (c) Random error
- (d) Gross error



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31. What type of error can be minimized by increasing the number of measurements?

- (a) Systematic error
- (b) Instrumental error
- (c) Random error**
- (d) Gross error

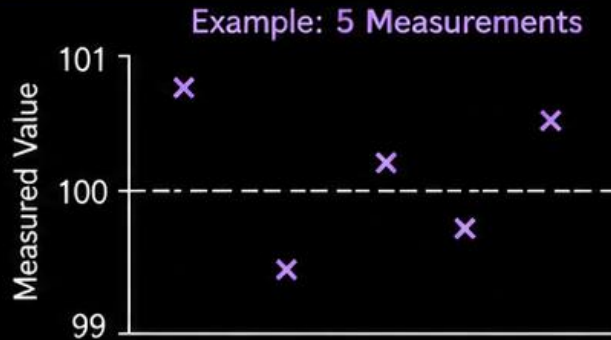


RANDOM ERROR CAN BE MINIMIZED BY INCREASING THE NUMBER OF MEASUREMENTS



Random error causes **unpredictable fluctuations** in individual measurements. Repeated measurements **average out** these fluctuations, improving **precision** (confidence in the mean).

FEW MEASUREMENTS → MORE SCATTER

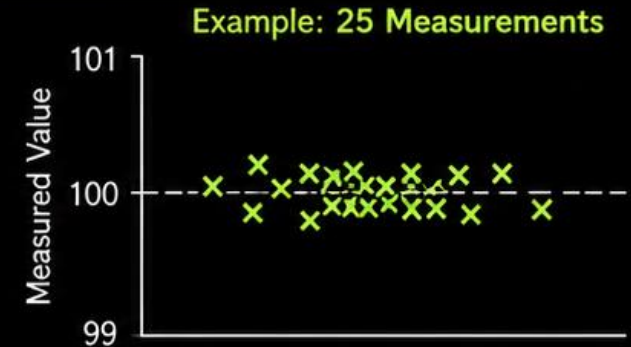
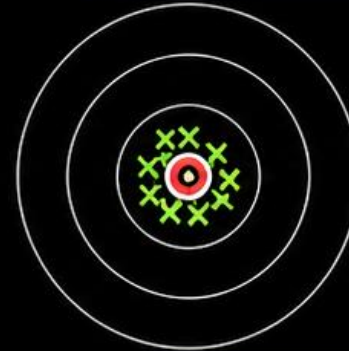


Large scatter around the true value.
Less precise mean → **lower confidence**.



Increase the
number of
repetitions

MANY MEASUREMENTS → LESS SCATTER



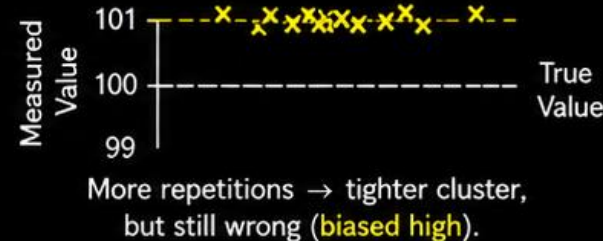
Smaller scatter around the true value.
More precise mean → **higher confidence**.



**REPETITION DOES
NOT REMOVE
SYSTEMATIC ERROR**

Systematic error shifts all results in the same direction (bias). Repeating measurements reduces **random error** but **does not** fix the bias.

Example: Positive Bias (+1.0)



Example: Negative Bias (-1.0)



Takeaway: More measurements → **random error decreases** → **precision increases** → **confidence in the mean improves**.



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32.

Precision in analytical measurement refers to:

- (a) Closeness of repeated measurements to each other
- (b) Closeness of measurements to the true value
- (c) Ability to detect small differences
- (d) Consistent errors in measurements



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32.

Precision in analytical measurement refers to:

- (a) Closeness of repeated measurements to each other**
- (b) Closeness of measurements to the true value**
- (c) Ability to detect small differences**
- (d) Consistent errors in measurements**

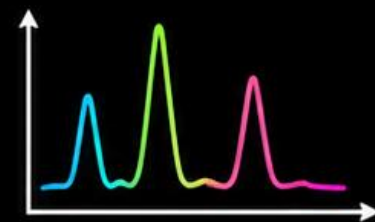


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PRECISION

— in Analytical Measurement —



DEFINITION

Precision means closeness of repeated measurements **to each other**.



WHAT IT REPRESENTS

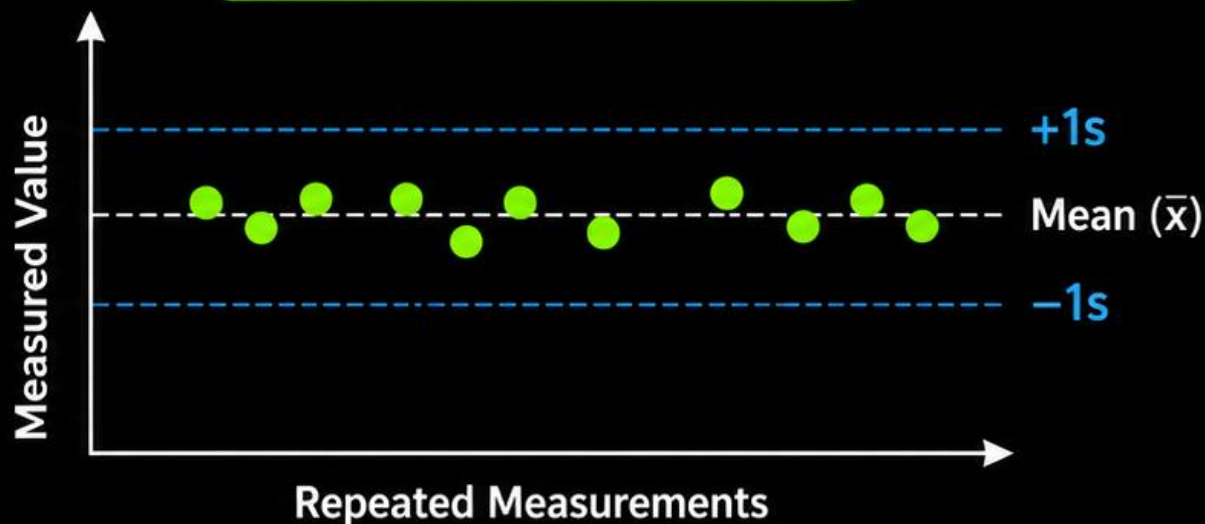
It represents **reproducibility** or **agreement** among repeated results.



HOW IT IS MEASURED

It is commonly measured by **standard deviation (s)**.

High Precision (Low Scatter)



Small Standard Deviation (s)

↓
Low scatter
High precision



$$\text{Standard Deviation (s)} = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}}$$



Precision is about **closeness among repeated values**, not closeness to the **true value**.



Key Takeaway: High precision = tight cluster of results (low s) regardless of how close they are to the true value.



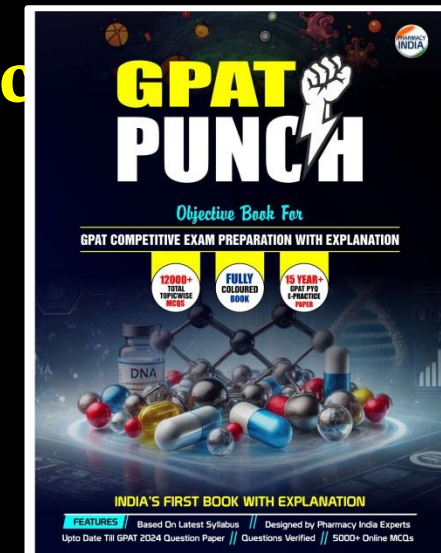
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33.

Anhydrous sodium carbonate is primary standard for acid-base titration because it is:

- (a) Weak base with high molecular weight only
- (b) Hygroscopic and reactive
- (c) Strong base only
- (d) Pure, stable and non-hygroscopic



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33.

Anhydrous sodium carbonate is primary standard for acids because it is:

- (a) Weak base with high molecular weight only
- (b) Hygroscopic and reactive
- (c) Strong base only
- (d) Pure, stable and non-hygroscopic**



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Anhydrous Sodium Carbonate as a Primary Standard



Pure composition



Stable during storage



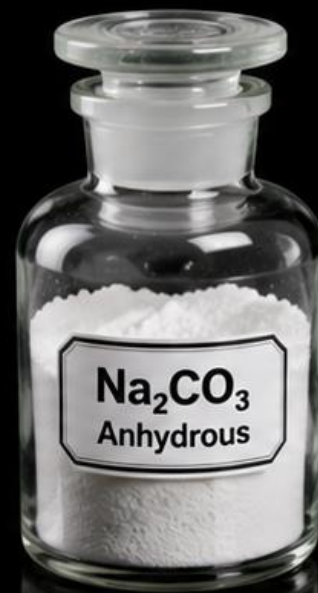
Non-hygroscopic



Can be **weighed** accurately



Suitable for
standardizing acids



Pure, stable, and non-hygroscopic substances
are **ideal primary standards**.



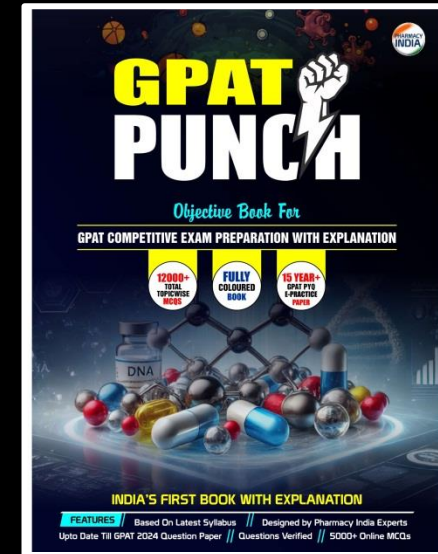
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34.

Which of the following best describes trueness?

- (a) Closeness of agreement between average value and true value
- (b) Closeness among repeated measurements
- (c) Ability to detect small concentration differences
- (d) Difference between maximum and minimum values



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34.

Which of the following best describes trueness?

- (a) Closeness of agreement between average value and true value
- (b) Closeness among repeated measurements
- (c) Ability to detect small concentration differences
- (d) Difference between maximum and minimum values



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TRUENESS

Trueness is the **closeness of agreement between the average (mean) value and the true value.**



What it means:

If the average of repeated measurements is close to the true (accepted) value, the results are considered to be **true (accurate)**.

Mathematically:

Trueness is high when

$$|\bar{X} - X_{true}| \text{ is small}$$

$\bar{X}$ = Average (mean) of measurements

X_{true} = True (accepted) value

VISUAL REPRESENTATION

High trueness
(Average close to true value)



Average $\approx$ True value

High trueness ✓

Low trueness
(Average far from true value)



Average $\neq$ True value

Low trueness ✗

Low trueness
(Average far and very scattered)



Average $\neq$ True value

Low trueness ✗



High trueness means **accurate** results.

It focuses on **accuracy** (closeness to the true value), not on **precision** (closeness among repeated measurements).



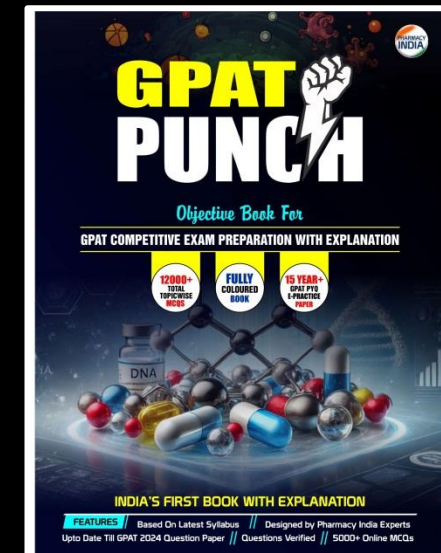
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35.

Titration error is:

- (a) Difference between titrant and analyte volume
- (b) Error in reading burette
- (c) Difference between endpoint and equivalence point
- (d) Error in primary standard concentration



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35.

Titration error is:

- (a) Difference between titrant and analyte volume
- (b) Error in reading burette
- (c) Difference between endpoint and equivalence point
- (d) Error in primary standard concentration



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TITRATION ERROR

Titration error is the **difference** between the **endpoint** and the **equivalence point**.



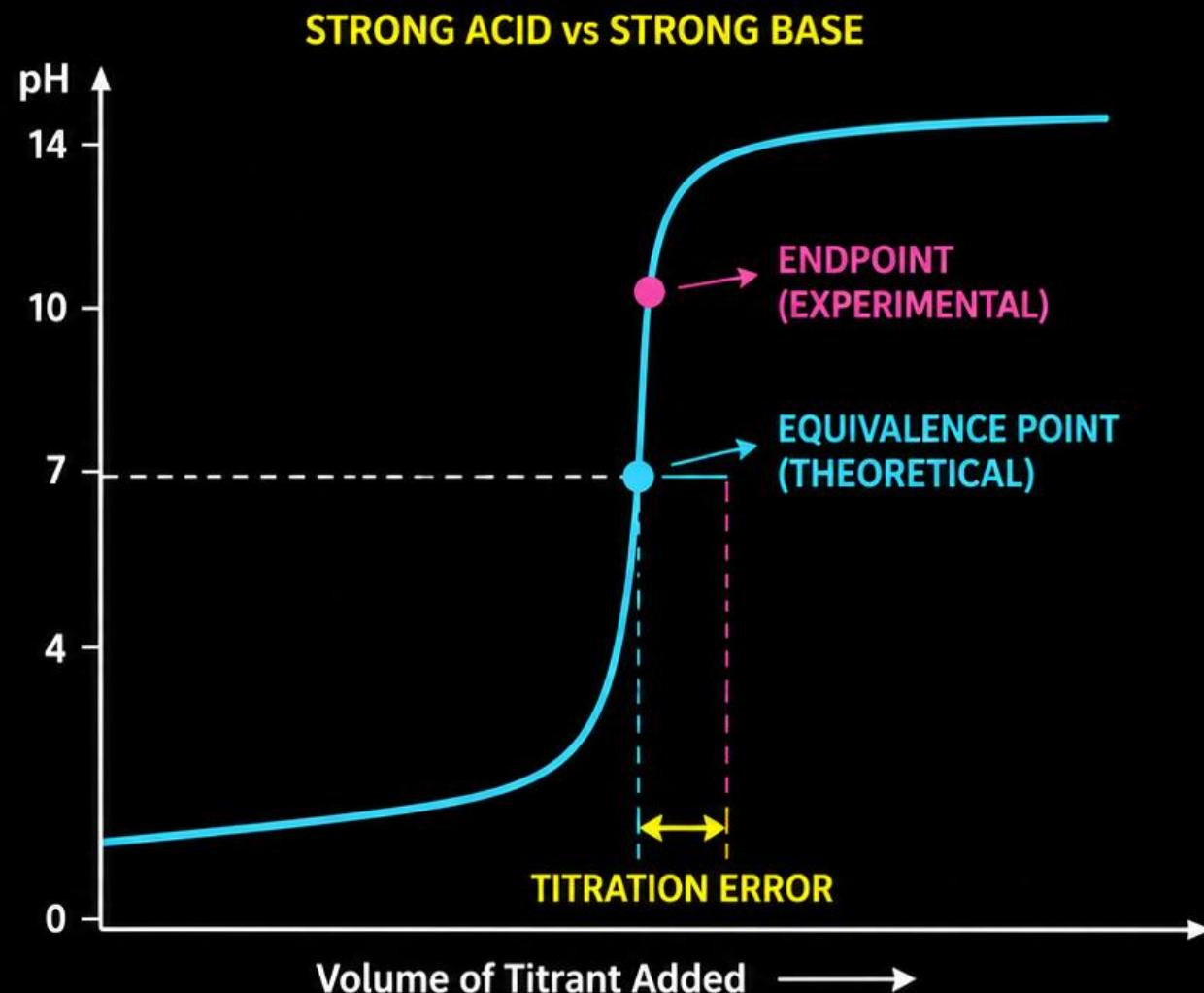
EQUIVALENCE POINT (THEORETICAL)

The stoichiometric point where moles of titrant added are exactly equivalent to the analyte.



ENDPOINT (EXPERIMENTAL)

The point at which the indicator changes color or the signal shows a change, observed in the experiment.



A **SMALLER DIFFERENCE** means better titration accuracy.

SMALL ERROR



High Accuracy



LARGE ERROR



Low Accuracy





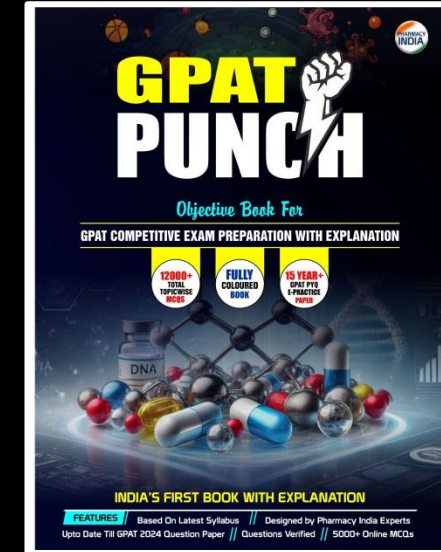
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36.

Mean value is 10.5%, true value is 10.0%. The difference 0.5% is:

- (a) Relative standard deviation
- (b) Absolute error or bias
- (c) Random error
- (d) Range



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36. Mean value is 10.5%, true value is 10.0%. The difference 0.5% is:

(a) Relative standard deviation

(b) Absolute error or bias

(c) Random error

(d) Range



ABSOLUTE ERROR (BIAS) FROM MEAN

$$\text{Absolute error} = \text{observed value} - \text{true value}$$

Observed (Mean)



10.5%

Observed value

True Value



10.0%

True value



CALCULATION

$$\begin{aligned}\text{Absolute error} &= \text{observed value} - \text{true value} \\ &= 10.5\% - 10.0\% \\ &= +0.5\%\end{aligned}$$

+0.5%
Bias



The **observed mean (10.5%)** is **+0.5% higher** than the **true value (10.0%)**.
→ This difference indicates **bias** in the result.



Positive bias (+) means the result is **higher** than the true value.

Negative bias (-) means the result is **lower** than the true value.



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37.

Sharp endpoint in titration depends mainly on:

- (a) Indicator concentration
- (b) Large change in property near equivalence point
- (c) Speed of titration
- (d) Primary standard choice



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37.

Sharp endpoint in titration depends mainly on:

(a) Indicator concentration

(b) Large change in property near equivalence point

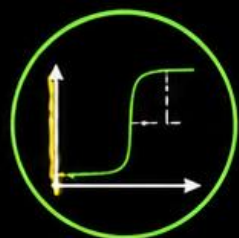
(c) Speed of titration

(d) Primary standard choice



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SHARP ENDPOINT IN TITRATION



1. LARGE CHANGE NEAR EQUIVALENCE POINT

A sharp endpoint depends mainly on a large change in property (pH, color, potential, etc.) near the equivalence point.



2. SUDDEN CHANGE IS EASY TO DETECT

A sudden color or pH change makes the endpoint obvious and easy to detect.



3. REDUCES TITRATION ERROR

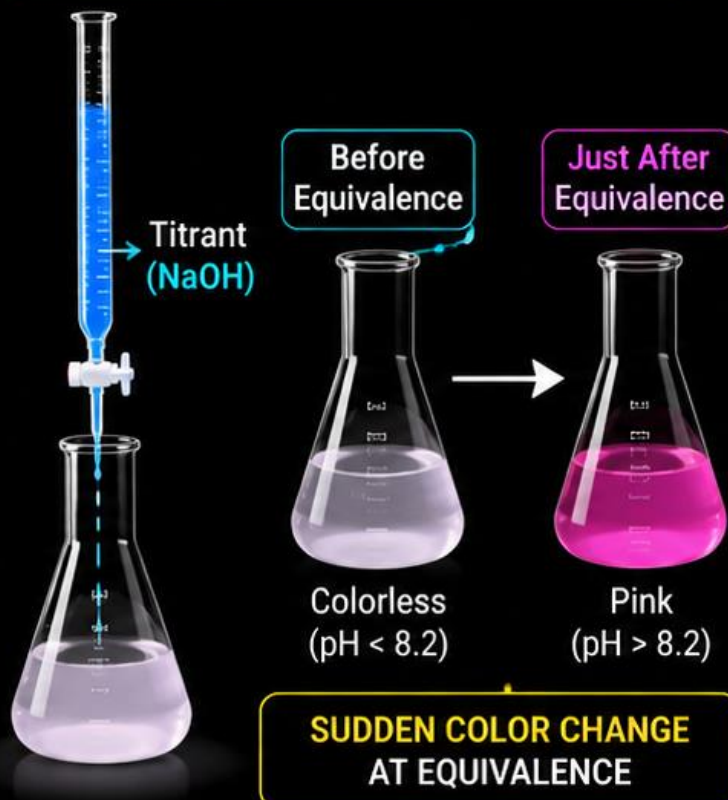
Clear detection of the endpoint minimizes overshooting or undershooting, giving accurate results.



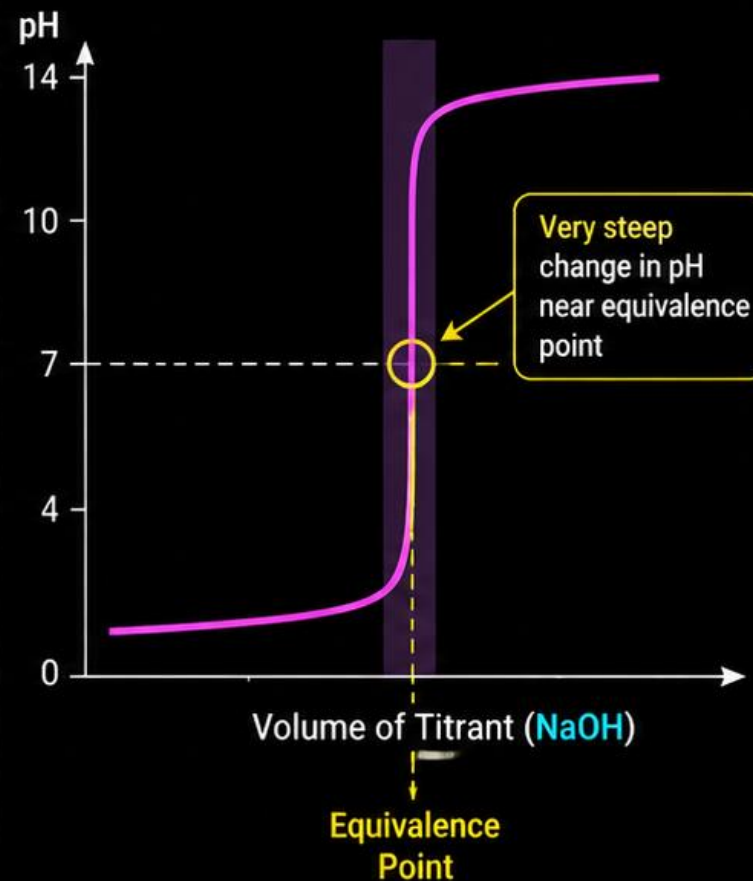
4. RELIABLE & REPRODUCIBLE

Sharp endpoints lead to consistent results across repeated titrations.

EXAMPLE: Strong Acid vs. Strong Base
(Phenolphthalein Indicator)



pH CURVE (Strong Acid vs. Strong Base)



KEY TAKEAWAY: A sharp endpoint arises from a **large change** in property near the equivalence point. A sudden **color** or **pH change** makes endpoint detection easier and **reduces titration error**.

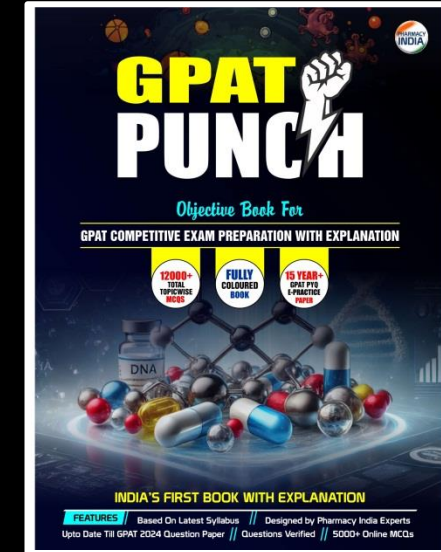


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38. Which error is unidirectional and reproducible?

- (a) Random error
- (b) Indeterminate error
- (c) Gross error
- (d) Systematic error



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38. Which error is unidirectional and reproducible?

- (a) Random error
- (b) Indeterminate error
- (c) Gross error
- (d) Systematic error**



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SYSTEMATIC ERROR

is **UNIDIRECTIONAL** and **REPRODUCIBLE**



Occurs in the **SAME DIRECTION** each time.



REPRODUCIBLE:
Repeated measurements are **CONSISTENT**.



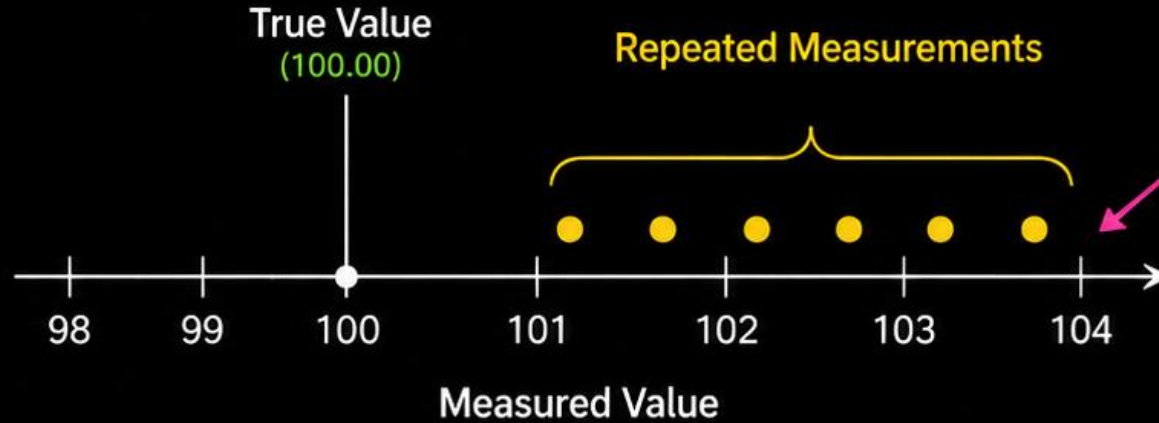
CAUSES BIAS:
Results are consistently shifted from the true value.



MAINLY AFFECTS **ACCURACY**, not precision.

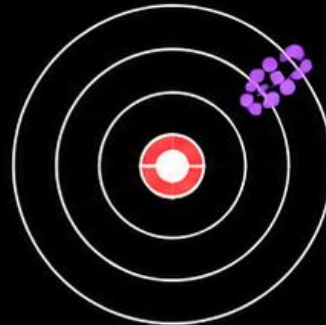


Systematic error is **UNIDIRECTIONAL** and **REPRODUCIBLE**, causing consistent **bias** and affecting **ACCURACY**.



All results are shifted to the **SAME SIDE** of the true value.

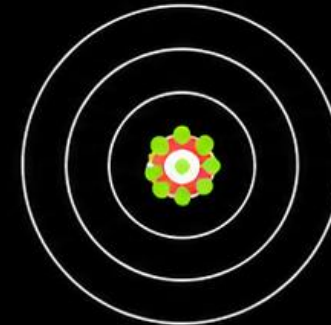
Precise but not accurate



High precision
(reproducible)

Low accuracy
(biased)

Precise and accurate



High precision
(reproducible)

High accuracy
(unbiased)

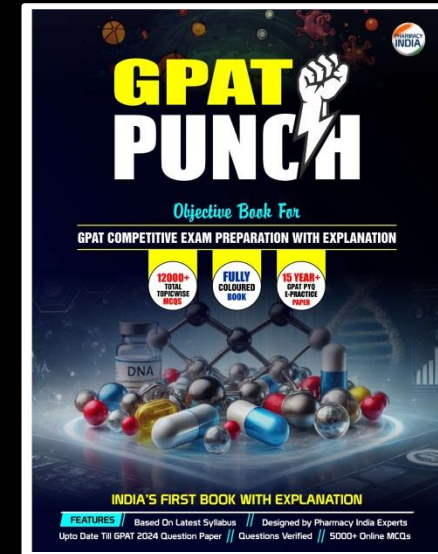
Bias → **Lower Accuracy**



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39. Balance calibration with certified weights minimizes:

- (a) Random weighing errors
- (b) Personal bias
- (c) Systematic instrumental error
- (d) Air buoyancy error only



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39. Balance calibration with certified weights minimizes:

- (a) Random weighing errors
- (b) Personal bias
- (c) Systematic instrumental error**
- (d) Air buoyancy error only



BALANCE CALIBRATION

WITH CERTIFIED WEIGHTS



CERTIFIED WEIGHTS



Traceable to national standards (e.g., NIST)



Known accurate mass values



CHECK ACCURACY

Place certified weights on the balance and compare the indicated mass.



CORRECTS SYSTEMATIC INSTRUMENTAL ERROR

Identifies and adjusts consistent deviations in measurements.



REDUCES INSTRUMENT BIAS

Aligns the balance response to true mass values.



**IMPROVES
ACCURACY
OF WEIGHING**



Good calibration
= Reliable results
you can trust.



1. PREPARE

Ensure balance is level, clean, and draft shield is closed.



2. CHECK

Weigh certified weights (low → high range).



3. CALIBRATE

Adjust balance settings to match true mass values.



4. VERIFY

Re-check weights to confirm accuracy across the range.



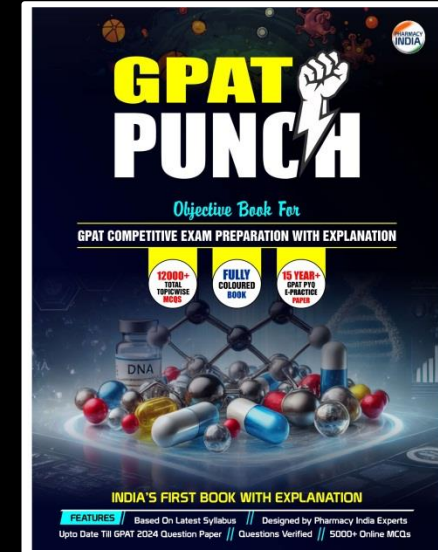
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40.

Primary standard for silver nitrate is:

- (a) Potassium chloride
- (b) Potassium hydrogen phthalate
- (c) Sodium hydroxide
- (d) Potassium permanganate



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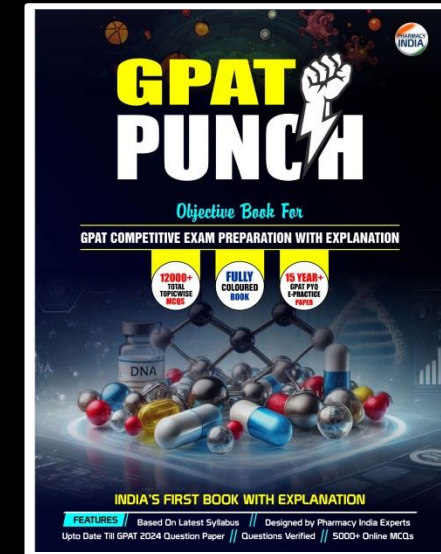


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40.

Primary standard for silver nitrate is:

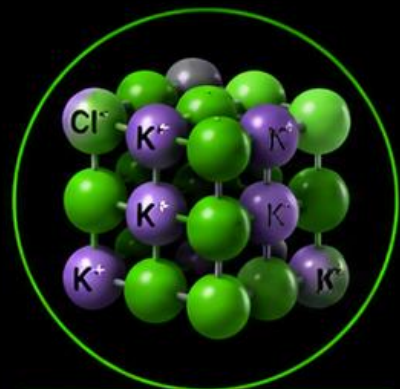
- (a) Potassium chloride**
- (b) Potassium hydrogen phthalate**
- (c) Sodium hydroxide**
- (d) Potassium permanganate**



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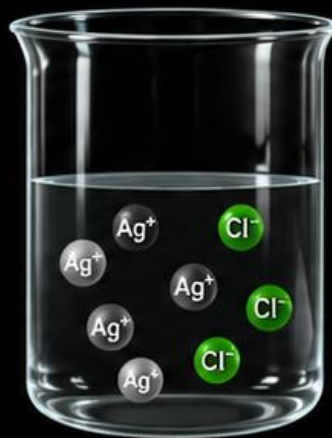
Why Potassium Chloride (KCl) is used as Primary Standard for Silver Nitrate

Potassium Chloride
KCl

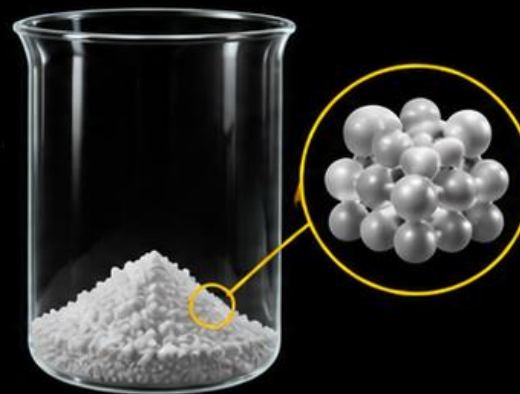


- ✓ Pure
- ✓ Stable
- ✓ Non-hygroscopic
- ✓ High molar mass

Silver Nitrate
AgNO₃



Silver Chloride
AgCl
(precipitate)



White precipitate
(Insoluble)



Primary Standard Requirements

- ✓ High purity
- ✓ Stability in air
- ✓ Non-hygroscopic
- ✓ High molar mass
- ✓ Readily available
- ✓ Easy to weigh



Therefore: **KCl** is used as a primary standard to standardize **AgNO₃** solution in **argentometric titrations**.



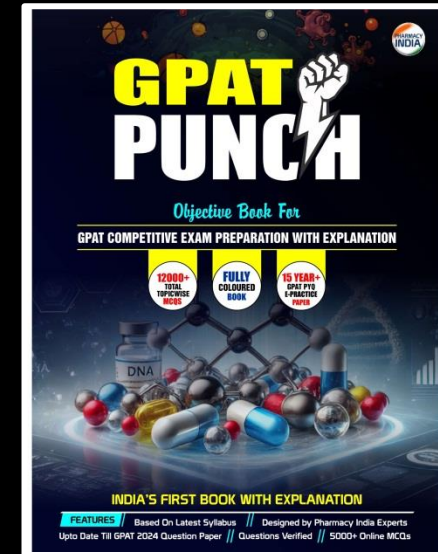
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41.

A constant error is best described as an error that:

- (a) Changes with sample size
- (b) Remains the same regardless of sample size
- (c) Occurs only due to random fluctuation
- (d) Occurs only in biological samples



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41.

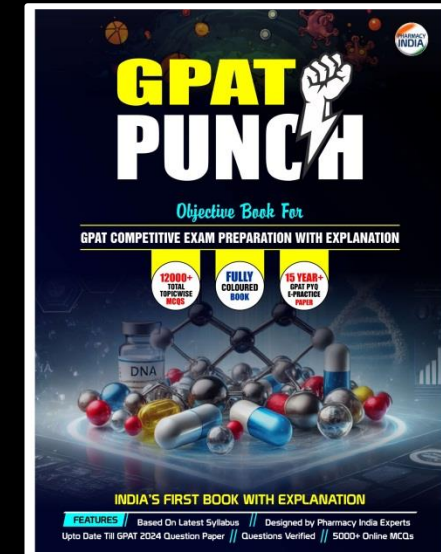
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(a) Changes with sample size

(b) Remains the same regardless of sample size

(c) Occurs only due to random fluctuation

(d) Occurs only in biological samples



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CONSTANT ERROR

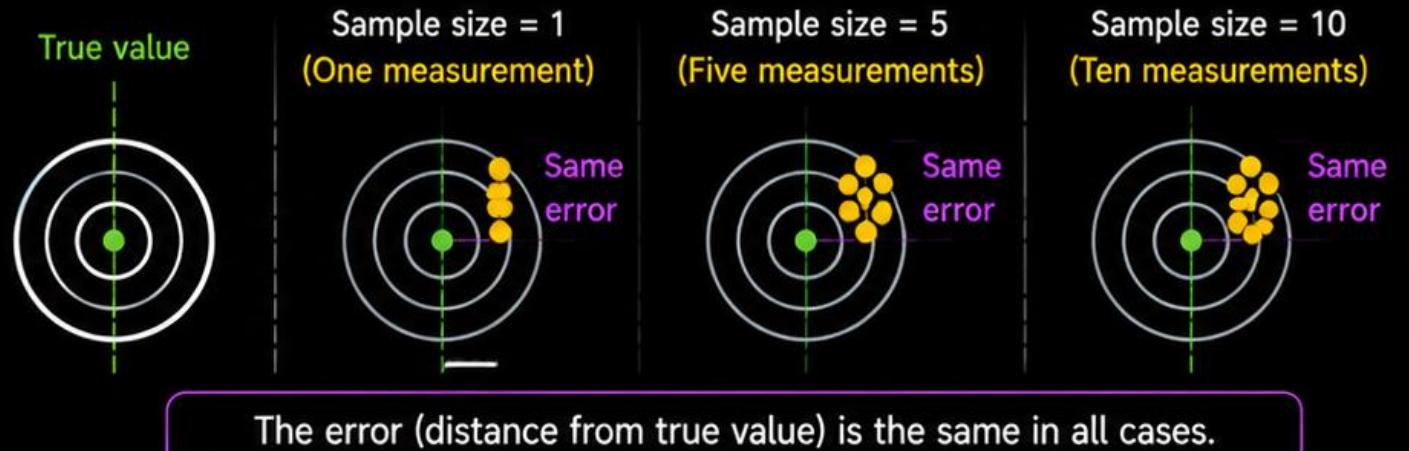
Constant error is an error that **remains the same regardless of sample size.**

WHAT IT MEANS



A **constant error** (**systematic error**) introduces a fixed bias in all measurements, shifting the results by the **same amount** in the **same direction**, no matter how many measurements (sample size) are taken.

VISUAL EXAMPLE



EXAMPLES



KEY TAKEAWAY

A constant error **stays constant**, independent of sample size.



A balance that is **not zeroed** → All measurements are off by the same amount.



A thermometer with a **calibration offset** → All readings are consistently high or low.



A volumetric flask **marked incorrectly** → All volumes are consistently higher or lower.



42.

Systematic error can be detected by:

- (a) Increasing sample size only**
- (b) Comparing results with standard reference material**
- (c) Ignoring outliers**
- (d) Using more decimal places**



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42.

Systematic error can be detected by:

- (a) Increasing sample size only
- (b) Comparing results with standard reference material**
- (c) Ignoring outliers
- (d) Using more decimal places



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DETECTING SYSTEMATIC ERROR WITH STANDARD REFERENCE MATERIAL



1. STANDARD REFERENCE MATERIAL (SRM)

Has a **CERTIFIED (KNOWN) VALUE** established with high confidence.



2. MEASURE AND COMPARE

Measure the SRM under the same conditions as unknown samples and compare to the **KNOWN VALUE**.



3. DIFFERENCE INDICATES BIAS

A consistent difference (bias) between measured and known value reveals **SYSTEMATIC ERROR**.

COMPARE TO REVEAL BIAS

KNOWN STANDARD VALUE
(Certified Value)



100.00
mg/L

BIAS
(DIFFERENCE)

+5.30
mg/L

OBSERVED MEASURED VALUE
(Your Measurement)



105.30
mg/L



CONSISTENT DIFFERENCE = BIAS
INDICATES **SYSTEMATIC ERROR**



COMPARISON WITH A STANDARD REFERENCE MATERIAL
HELPS **REVEAL SYSTEMATIC ERROR**.



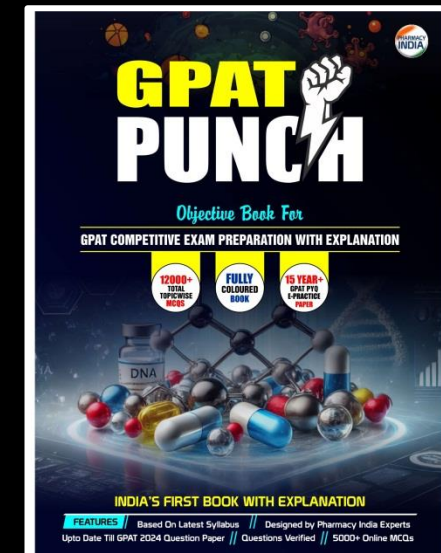
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43.

Which of the following reduces the effect of parallax error while reading a burette?

- (a) Reading the meniscus at eye level
- (b) Increasing titrant concentration
- (c) Using excess indicator
- (d) Heating the burette



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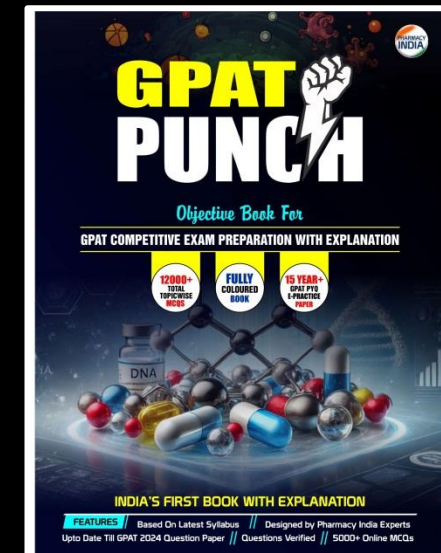
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- (a) Reading the meniscus at eye level
- (b) Increasing titrant concentration
- (c) Using excess indicator
- (d) Heating the burette



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Explanation:

Reading the meniscus at eye level reduces the effect of parallax error.



Parallax error occurs due to wrong viewing angle.

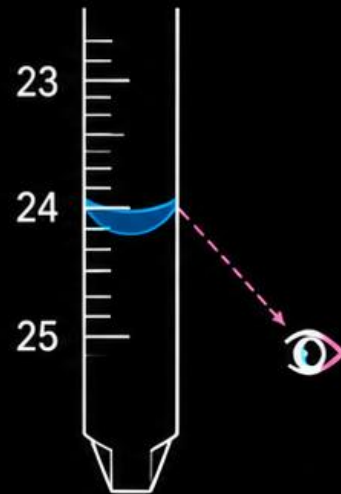


Eye-level reading gives correct meniscus observation.



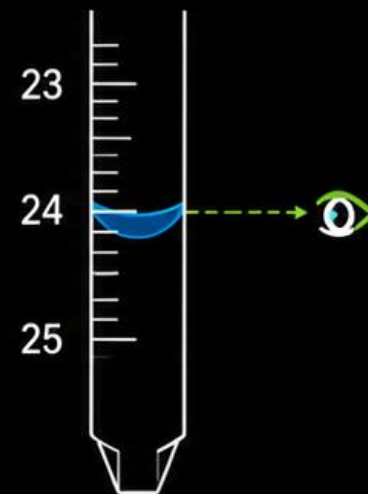
It reduces personal observational error.

Eye below



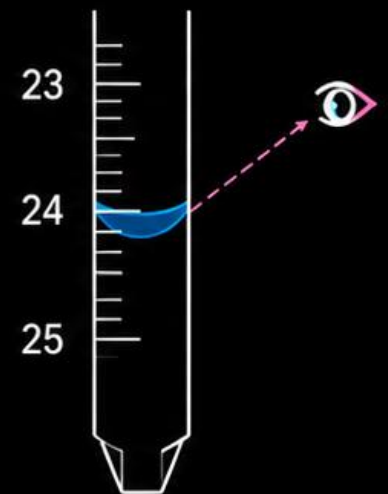
Reads higher than actual

Eye level



Correct reading
(No parallax error)

Eye above



Reads lower than actual



Always keep your eyes at the same level as the meniscus to get accurate and reliable readings.

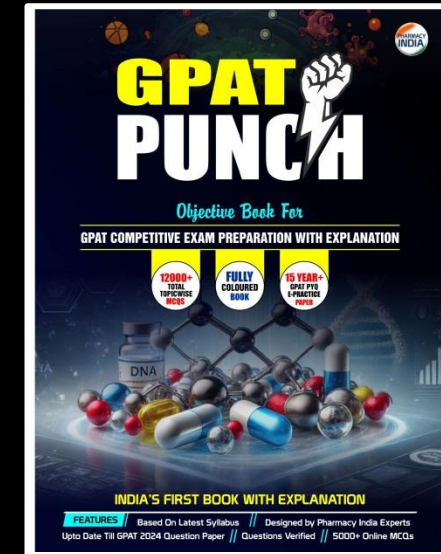


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44. Relative error is expressed as:

- (a) Error $\times$ true value
- (b) Absolute error divided by true value
- (c) True value divided by observed value
- (d) Mean divided by standard deviation



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44.

Relative error is expressed as:

(a) Error $\times$ true value

(b) Absolute error divided by true value

(c) True value divided by observed value

(d) Mean divided by standard deviation



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RELATIVE ERROR



NORMALIZES THE ERROR

It is the ratio of the **absolute error** to the **true value**.



OFTEN EXPRESSED AS A PERCENTAGE

Multiply by **100%** to express relative error in percent.



ENABLES FAIR COMPARISON

Helps **compare** the size of error between measurements with **different true values**.

FORMULA

$$\text{Relative error} = \frac{\text{Absolute error}}{\text{True value}}$$



Often expressed as a percentage:

$$\text{Relative error (\%)} = (\text{Absolute error} / \text{True value}) \times 100\%$$

EXAMPLE

True value = **50.0**

Measured value = **52.5**

$$\text{Absolute error} = |52.5 - 50.0| = 2.5$$

$$\text{Relative error} = \frac{2.5}{50.0} = 0.05$$

$$\text{Relative error} = 5\%$$



TAKEAWAY:

Relative error compares the **size of error** with the **true value**.



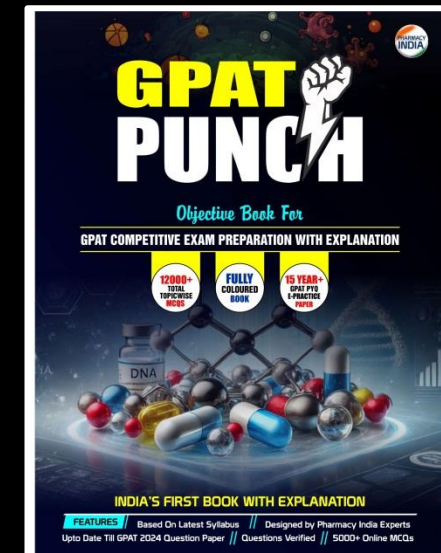
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45.

Coefficient of variation is also known as:

- (a) Absolute error
- (b) Relative standard deviation
- (c) Bias
- (d) Mean deviation



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45. Coefficient of variation is also known as:

(a) Absolute error

(b) Relative standard deviation

(c) Bias

(d) Mean deviation



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COEFFICIENT OF VARIATION (CV) = RELATIVE STANDARD DEVIATION (RSD)



CV is also known as
Relative Standard Deviation (RSD).



Calculated as:

$$\text{RSD} = \frac{\text{SD}}{\text{Mean}} \times 100$$

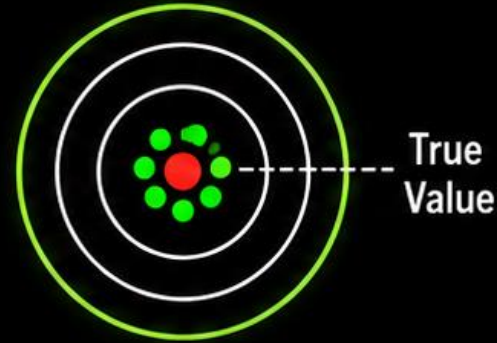


Expresses **precision** as a
percentage. Useful for **comparing**
variability between data sets.

LOW RSD
High Precision

⚡ VS ⚡

HIGH RSD
Low Precision



Results are close to
each other and close
to the **true value**.

RSD is LOW



Results are widely
scattered and may be
far from the **true value**.

RSD is HIGH



TAKEAWAY: RSD gives a **percentage view** of precision.



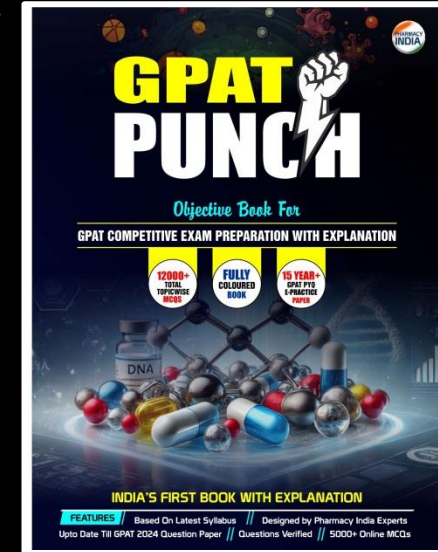
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46.

Which condition gives accurate but not precise results?

- (a) Results are close to true value but widely scattered
- (b) Results are close to each other but away from true value
- (c) Results are both scattered and away from true value
- (d) Results are close to each other and true value



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46.

Which condition gives accurate but not precise results?

(a) Results are close to true value but widely scattered

(b) Results are close to each other but away from true value

(c) Results are both scattered and away from true value

(d) Results are close to each other and true value



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ACCURATE BUT NOT PRECISE



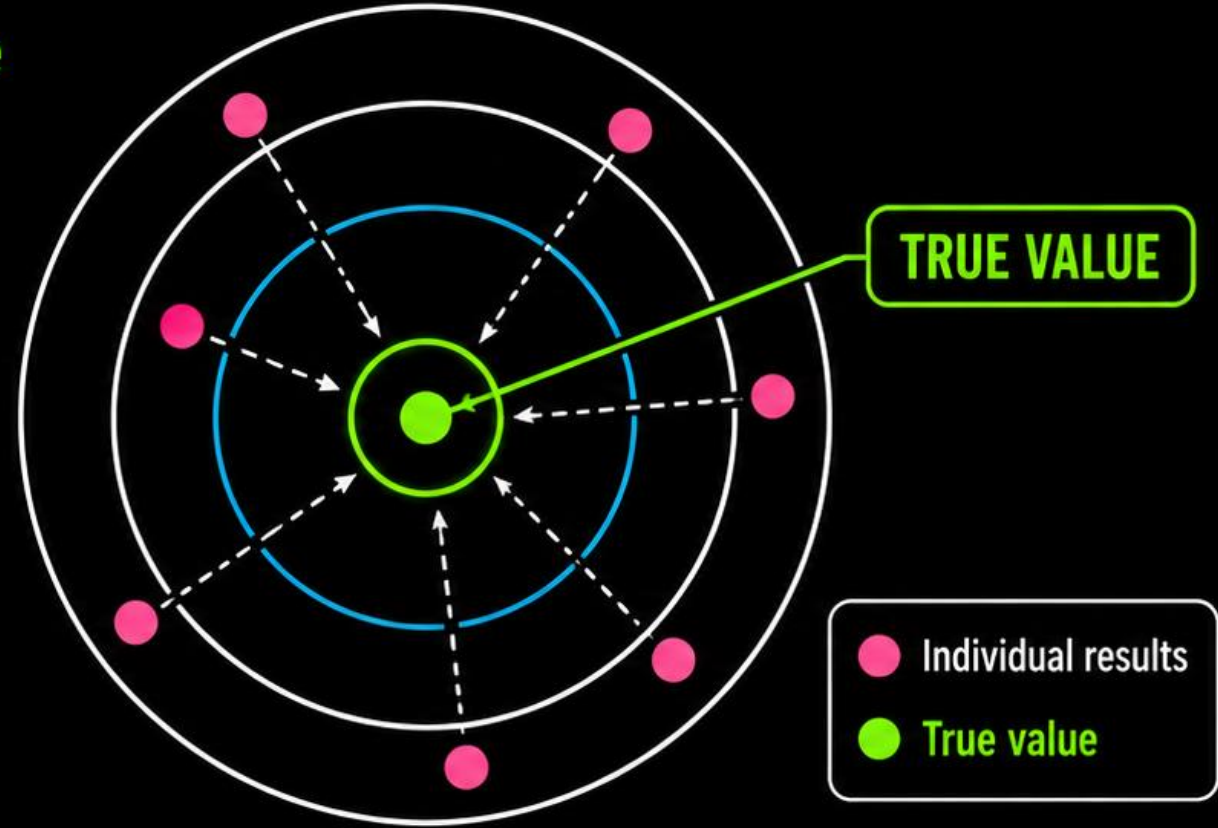
Results can be **close to the true value** overall but **widely scattered** individually.



The **average (mean)** of the results may be near the **true value**.



Poor agreement among values
→ poor **precision**.



TAKEAWAY: Accuracy may be **acceptable**, while **precision is poor**.



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47.

Which of the following is a gross error?

- (a) Slight fluctuation in temperature
- (b) Incorrect weighing due to spilling sample
- (c) Small variation in burette reading
- (d) Instrument drift during analysis



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47.

Which of the following is a gross error?

- (a) Slight fluctuation in temperature
- (b) Incorrect weighing due to spilling sample**
- (c) Small variation in burette reading
- (d) Instrument drift during analysis



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GROSS ERROR – SPILLING SAMPLE

DURING WEIGHING



MAJOR ACCIDENTAL MISTAKE

Occurs due to carelessness, mishandling, or loss of sample.



ABNORMAL RESULT

Spilling sample reduces the amount weighed → result is too low and inaccurate.



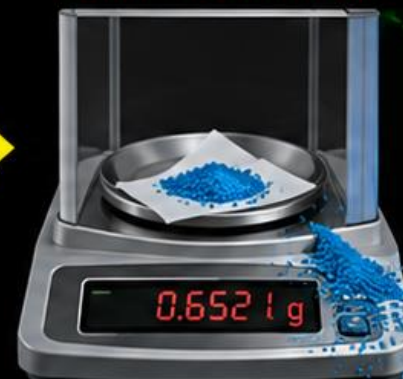
PRODUCES OUTLIERS

Value lies far from the cluster of other results.

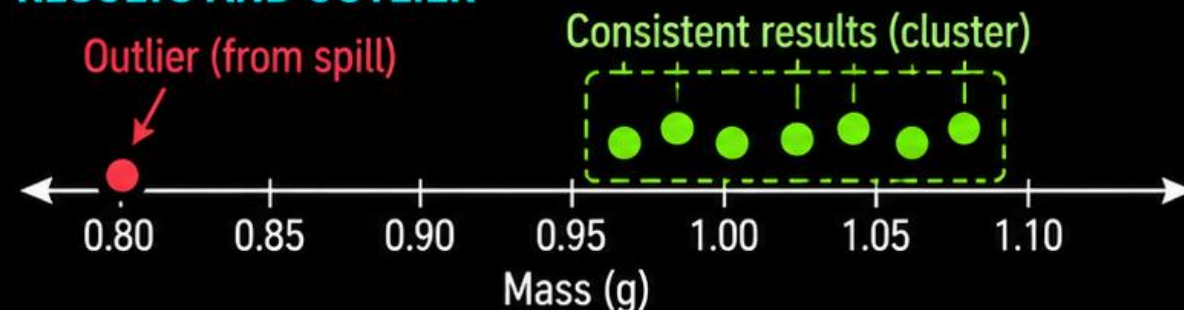
CORRECT WEIGHING



SPILLED SAMPLE



RESULTS AND OUTLIER



TAKEAWAY: GROSS ERRORS ARE ACCIDENTAL AND OFTEN CREATE OUTLIERS.



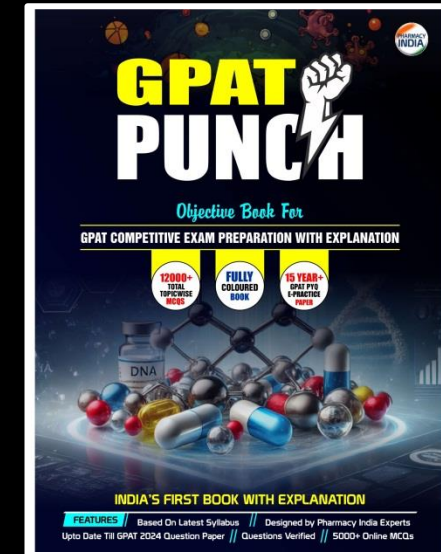
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48.

Repeatability means precision under:

- (a) Different laboratories
- (b) Same conditions over short interval
- (c) Different instruments only
- (d) Different analysts only



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48.

Repeatability means precision under:

- (a) Different laboratories
- (b) Same conditions over short interval**
- (c) Different instruments only
- (d) Different analysts only



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REPEATABILITY

SHORT-TERM PRECISION UNDER THE SAME CONDITIONS



Repeatability is the **closeness of agreement** between independent test results obtained under the **same conditions** over a **short interval**.



Same **Analyst**, Same **Equipment**,
Same **Laboratory**



Represents **short-term precision**:
measurements taken over a short
time interval under **identical conditions**.

REPEATED MEASUREMENTS

UNDER IDENTICAL CONDITIONS



**SAME
ANALYST**



**SAME
EQUIPMENT**



**SAME
LABORATORY**



**SHORT
INTERVAL**



MEASUREMENT 1
99.82



MEASUREMENT 2
99.80



MEASUREMENT 3
99.81



MEASUREMENT 4
99.83



MEASUREMENT 5
99.81



MEASUREMENT 6
99.82

CLOSE AGREEMENT = HIGH PRECISION



TAKEAWAY: REPEATABILITY IS PRECISION UNDER THE SAME CONDITIONS.

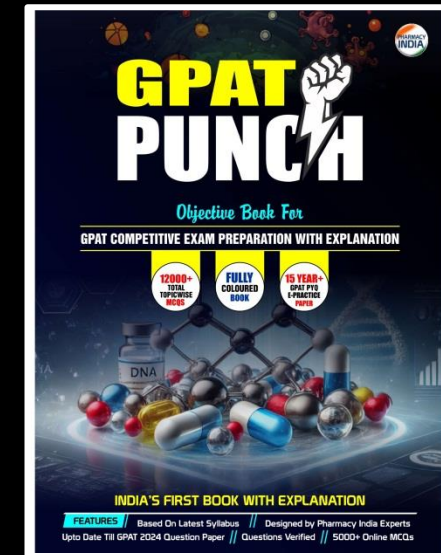


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49.

Which statistical test is commonly used to decide whether a doubtful result should be rejected?

- (a) Q-test
- (b) Limit test
- (c) Biuret test
- (d) Molisch test



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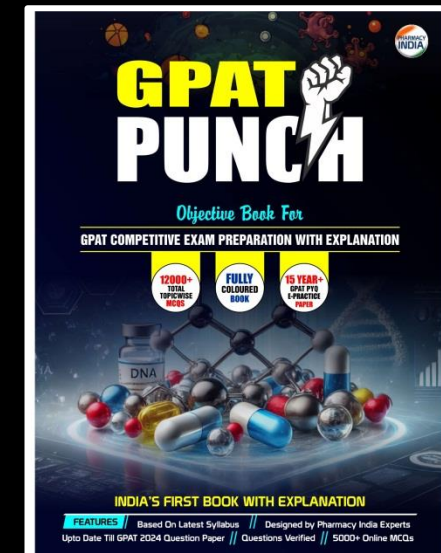
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49.

Which statistical test is commonly used to decide whether a doubtful result should be rejected?

- (a) Q-test**
- (b) Limit test**
- (c) Biuret test**
- (d) Molisch test**



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Q-TEST

Q-test is a statistical test used to decide whether a **doubtful result** should be **rejected**.

WHAT IS Q-TEST?



Q-test is used for **rejection** of **doubtful** observations (possible **outliers**).

PURPOSE

- ✓ Helps identify possible **outliers**.
- ✓ Ensures **reliability** of analytical data.
- ✓ Useful in **analytical data treatment**.

HOW Q-TEST WORKS

- 1 Arrange the results in **ascending order**.
- 2 Calculate the **Q value** for the suspected outlier.

$$Q_{\text{calc}} = \frac{\text{Gap}}{\text{Range}}$$

Gap = Difference between the suspected value and its nearest value

Range = Highest value – Lowest value

- 3 Compare Q_{calc} with the tabulated Q_{critical} value (for given n and **confidence level**).

DECISION RULE



If $Q_{\text{calc}} > Q_{\text{critical}} \rightarrow$ **Reject** the doubtful result (outlier).



If $Q_{\text{calc}} \leq Q_{\text{critical}} \rightarrow$ **Accept** the result.



EXAMPLE OF Q_{CRITICAL} (90% CONFIDENCE LEVEL)

Number of results (n)	3	4	5	6	7	8	10
Q_{critical}	0.941	0.765	0.642	0.560	0.507	0.468	0.412



KEY TAKEAWAY

Q-test helps maintain the **accuracy** and **reliability** of analytical results by identifying and rejecting **outliers**.

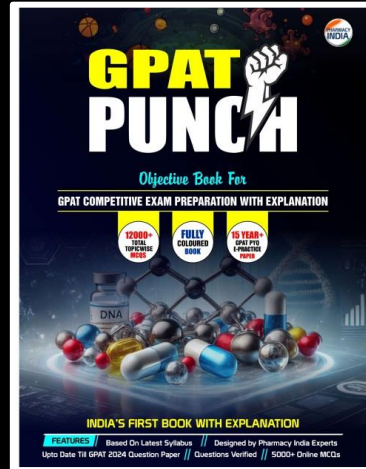


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Which of the following is the best way to improve reliability of analytical results?

- (a) Use uncalibrated instruments
- (b) Perform replicate analysis and use validated method
- (c) Ignore blank correction
- (d) Use approximate weighing only



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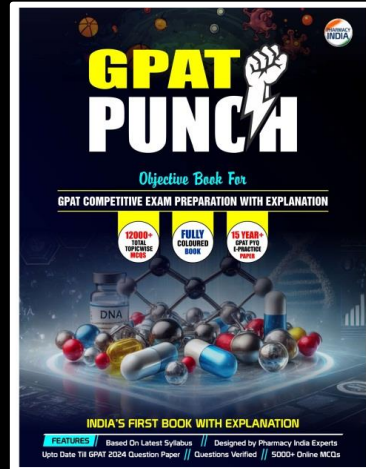


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Explanation:

Perform replicate analysis and use validated method is the best way to improve **reliability** of analytical results.



Replicate analysis improves confidence in results.



Validated methods reduce systematic and method errors.



Proper analytical practice improves reliability.

How it improves reliability?

1. Replicate Analysis



Trial 1 Trial 2 Trial 3



Consistent results
increase confidence

2. Validated Method



Minimizes systematic
and method errors

3. Reliable Results



High reliability and
accuracy achieved



Replicate analysis + validated method + good practice
= **reliable** and **trustworthy** analytical results.



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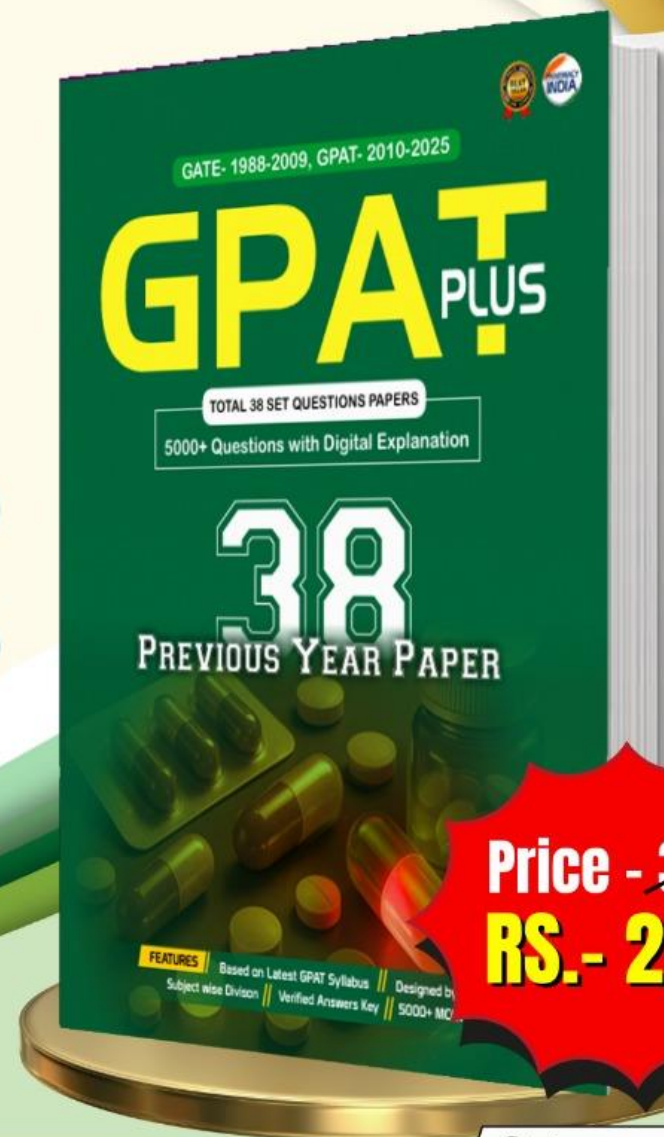
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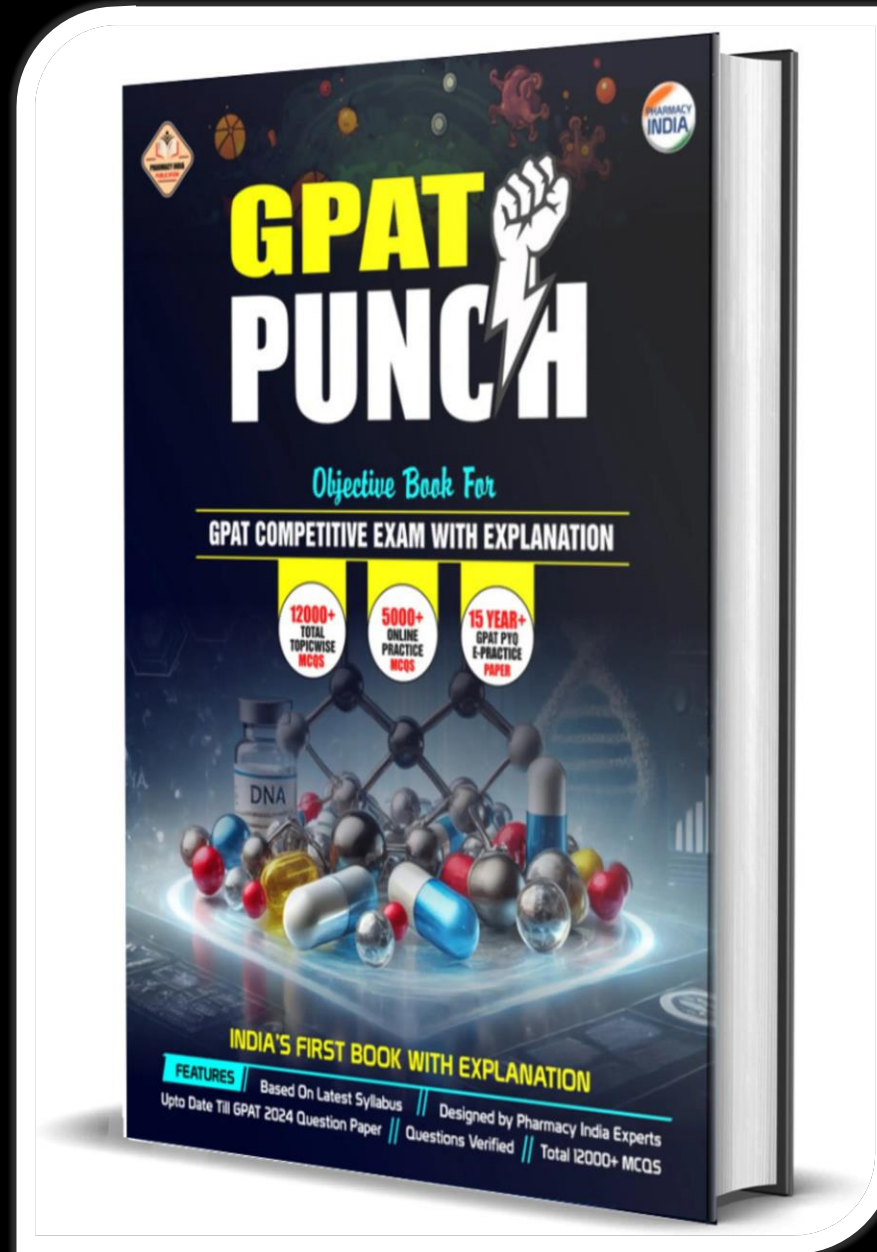


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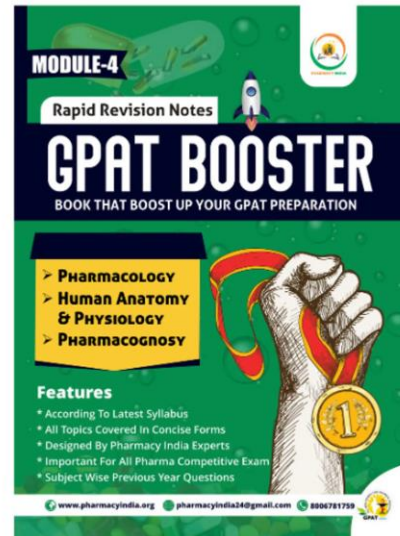
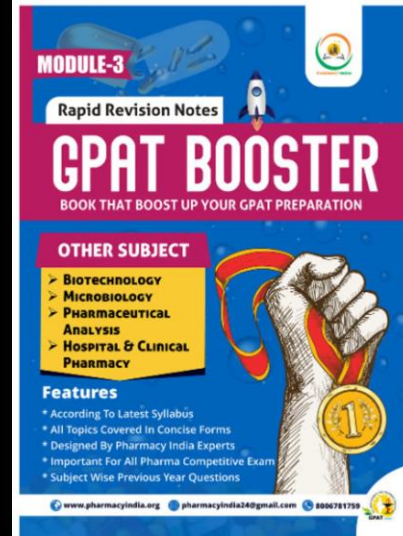
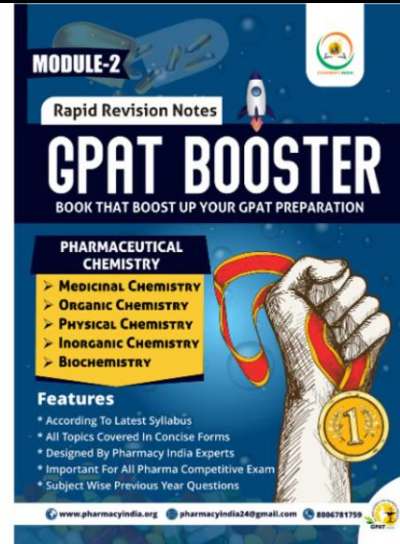
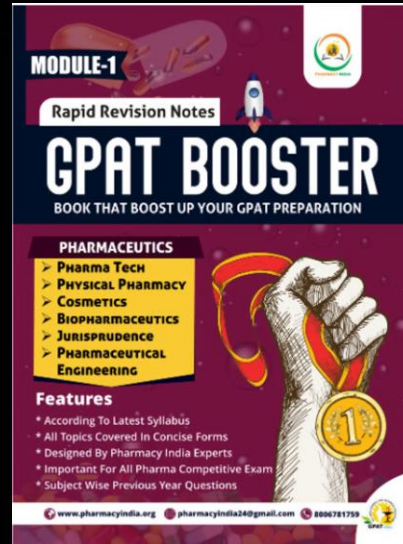
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