Chemistry & STEM Measurement II

Precision & Accuracy

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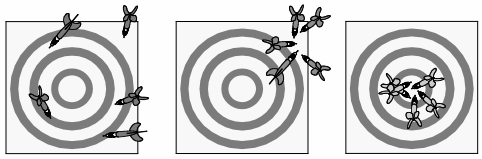
William Tell: his Son & the Arrow

14th Century Swiss Legend & Subject of Rossini's 1829 Opera

https://www.youtube.com/watch?v=hRAFPdDppzs

Precision

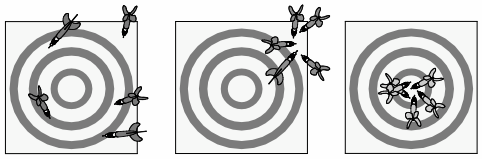


QUESTION:

Rank the images from best to worst precision.

A) a > b > c B) b > c > a C) c > a > b D) c > b > a

Accuracy



QUESTION:

Rank the images from best to worst accuracy.

A) a > b > c B) b > c > a C) c > a > b D) c > b > a

QUESTION

Two Chem 120 students are each drinking a can of cranberry juice after class. The printed label indicates that the respective volume of both containers is 375 milliliters. Euna remarks that the Federal Trade Commision (FTC) requires bottlers to be very precise. Mike correctly responded:

A. If precision were the only requirement, bottlers could claim any volume as long as it was always very nearly the same volume.
B. Since precision is a requirement, bottlers have to get exactly 375 mL in every can.
C. Bottlers must have a precise average of all of the containers in a case of soft drinks equal to 375 mL.
D. If there were a difference of no more than +/- 1 mL between containers, the bottlers can sell their beverage.

Precision & Accuracy

(The Following Measured Data is for Volume in mL)

	a)	b)	c)
	9.52	8.40	7.95
	8.36	8.35	8.00
	7.29	8.42	8.05
	8.34	8.36	7.95
Average	8.378	8.383	7.988
Round Off	8.38	8.38	7.99

	a)	deviation	b)	deviation	c)	deviation
	9.52	-1.14	8.40	-0.02	7.95	0.04
	8.36	0.02	8.35	0.03	8.00	-0.01
	7.29	1.09	8.42	-0.04	8.05	-0.06
	8.34	0.04	8.36	0.02	7.95	0.04
Average	8.378	**0.573**	8.383	**0.028**	7.988	**0.038**
Round Off	8.38	+/- 0.57	8.38	+/- 0.03	7.99	+/- 0.04

Absolute value (all of the - become +)

QUESTION

The melting point of pure benzoic acid is 122°C. Data obtained by four students in a laboratory experiment are shown below. Which student's data are precise but not the most accurate?

Student A	Student B	Student C	Student D
115°C	119°C	122°C	118°C
112°C	118°C	121°C	120°C
118°C	119°C	122°C	124°C
116°C	120°C	123°C	126°C

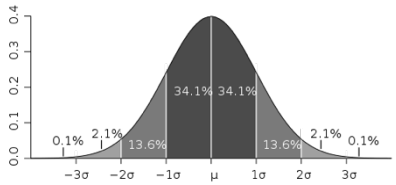
A) Student A ***B) Student B***

C) Student C ***D) Student D***

Precision

(Average Deviation vs. Standard Deviation)

http://en.wikipedia.org/wiki/Standard_deviation



The distribution of data (individual data points) in a set is not considered by the Average Deviation. Standard Deviation, which is the square root of the data set's variance relative to its average (mean), is commonly used to do this.

Precision

(Standard Deviation)

http://en.wikipedia.org/wiki/Standard_deviation

Standard Deviation is the square root of the data set's variance relative to its average (mean). Mathematically:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}.$$

Where σ is the Standard Deviation, μ is the data's average (mean), N is the total number of data points, and x_i is the individual data point.

Precision & Accuracy

Comparing Average & Standard Deviation

(The Following Measured Data is for Volume in mL)

	a)		b)		c)
	9.52		8.40		7.95
	8.36		8.35		8.00
	7.29		8.42		8.05
	8.34		8.36		7.95
Average	8.378		8.383		7.988
Round Off	8.38		8.38		7.99

Standard		Standard		Standard
deviation		deviation		deviation
+/- 0.91		+/- 0.03		+/- 0.05
+/- 0.57	*(Avg. Dev)*	+/- 0.03	*(Avg. Dev)*	+/- 0.04

QUESTION

Rank the relative precision of the three sets of data: a), b) and c). The accepted value is 8.08 mL.

Average		Average		Average
a)		b)		c)
8.38		8.38		7.99

Standard		Standard		Standard
deviation		deviation		deviation
a)		b)		c)
+/- 0.91		+/- 0.03		+/- 0.05

A) Precision: a > c > b *B) Precision: b > c > a*

C) Precision: a = b > c *D) Precision: a > b > c*

QUESTION

Rank the relative accuracy of the three sets of data: a), b) and c). The accepted value is 8.08 mL.

Average		Average		Average
a)		b)		c)
8.38		8.38		7.99

Standard		Standard		Standard
deviation		deviation		deviation
a)		b)		c)
+/- 0.91		+/- 0.03		+/- 0.05

A) Accuracy: a > c > b *B) Accuracy: b > c > a*

C) Accuracy: c > a = b *D) Accuracy: a = b > c*

Experiment #2 – Measuring Density

Accuracy / Error

- *Data Analysis:*

  Accuracy: #1 = #2 > #3 > #4

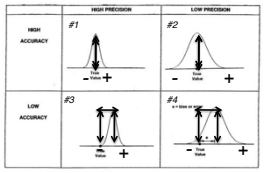
  Error: #4 > #3 > #1 = #2

$$Percent\ Error = \frac{Experimental\ value - True\ value}{True\ value} \times 100$$

4 experimental sets of data

True =1.0 g/mL
Exp. = 1.0 g/mL

True =1.0 g/mL
Exp. = 1.1 g/mL



Value = Average

True =1.0 g/mL
Exp. = 1.0 g/mL

True =1.0 g/mL
Exp. = 1.2 g/mL

Experiment #2 – Measuring Density

Precision & Deviation

- *Data Analysis:*

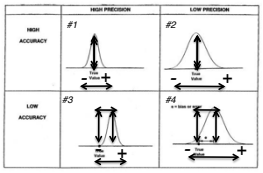
  Precision: #1 = #3 > #2 = #4

  Deviation: #2 = #4 > #1 = #3

4 experimental sets of data

True =1.0 g/mL
Exp. = 1.0 +/- 0.1 g/mL

True =1.0 g/mL
Exp. = 1.1 +/- 0.1 g/mL



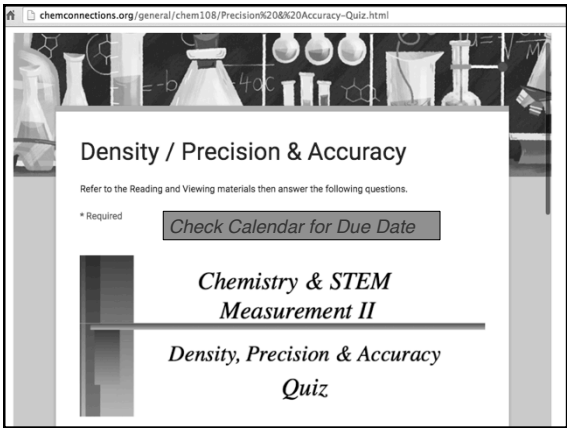
Value = Average

True =1.0 g/mL
Exp. = 1.0 +/- 0.2 g/mL

True =1.0 g/mL
Exp. = 1.2 +/- 0.2 g/mL

Clinical Drug Testing
Studies Follow Rules & Statistics

However, adaptation makes anything possible.



Reporting Results

V	A	T

VISUAL
AUDITORY
TACTILE

What numbers best represent the Chem 108 class's VAT results?

Average of each.

How much does the class vary in each?

Standard Deviation of each, Maximum & Minimum of each.

Reporting Results
Statistics

Chem 108 VAT Survey Results

	V	A	T
AVG	29	26	26
STD +/-	8	7	6
MAX	75	55	38
MIN	12	12	14

	V	A	T
AVG	28	25	26
STD	6	6	5
MAX	38	41	38
MIN	12	12	14

Should V=75 and A=55 be eliminated from the data set and the average recalculated? (Max possible = 44)