Chemistry & STEAM Fundamentals II

Precision & Accuracy

Dr. Ron Rusay

William Tell: his Son & the Arrow
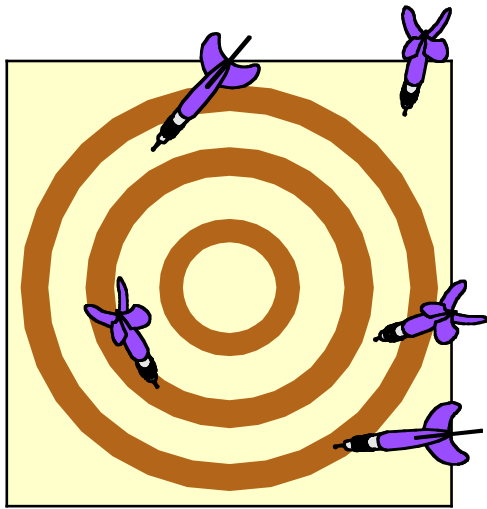## *14th Century Swiss Legend & Subject of Rossini's 1829 Opera*

http://chemconnections.org/general/movies/William%20Tell%20Overture%202.mp3
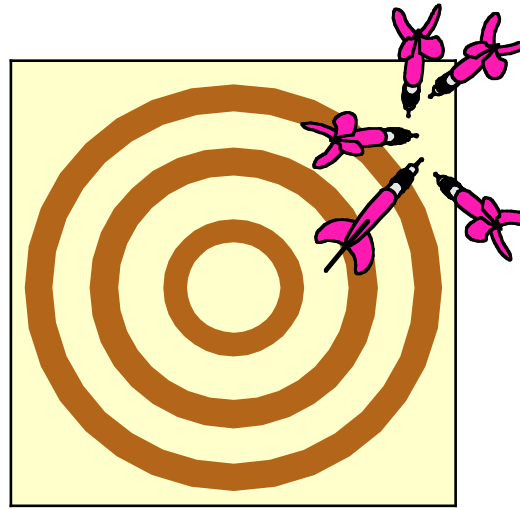

https://www.youtube.com/watch?v=hRAFPdDppzs

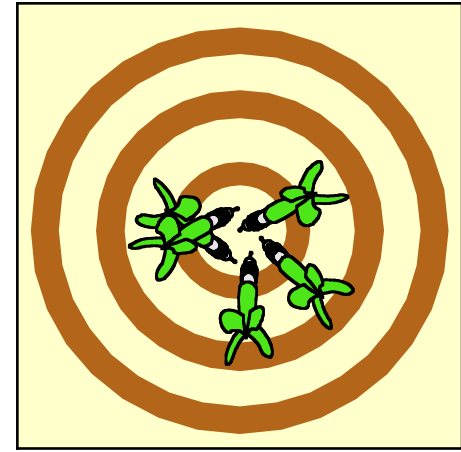# Precision

(a)   (b)   (c)

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

Precision

(a)

(b)

(c)
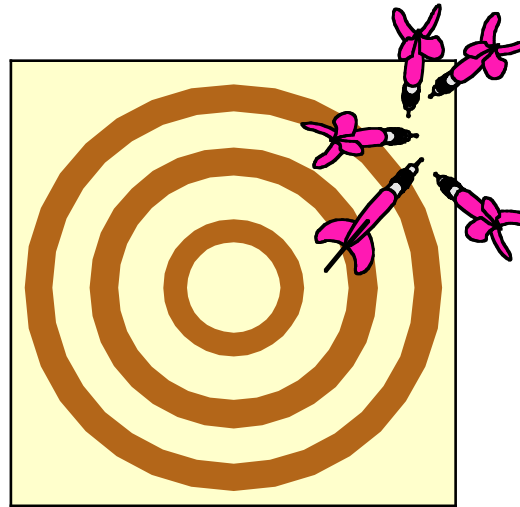
Answer:

Rank the images from best to worst precision.

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Accuracy

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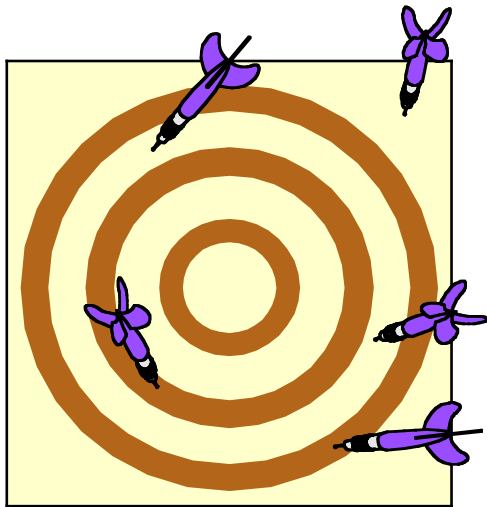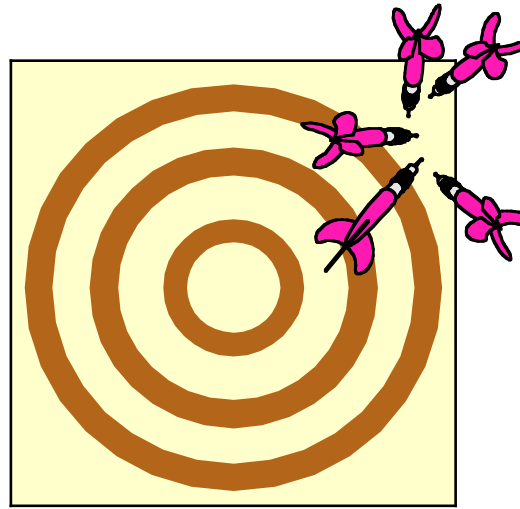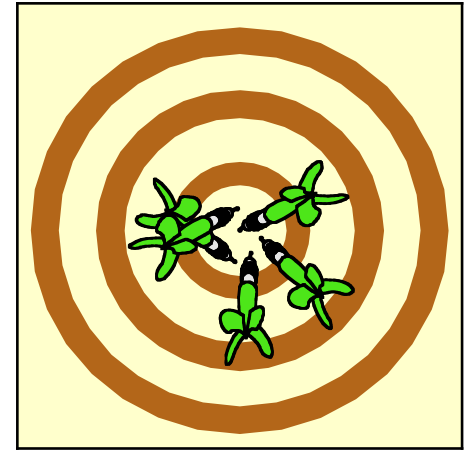
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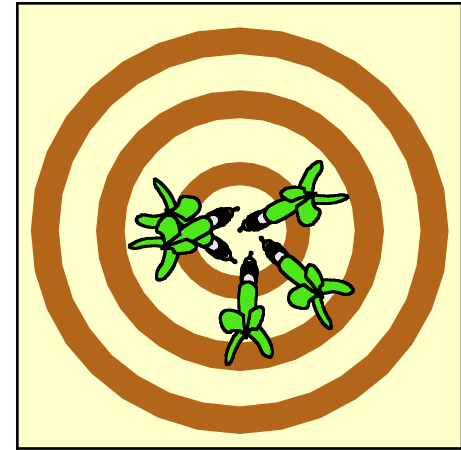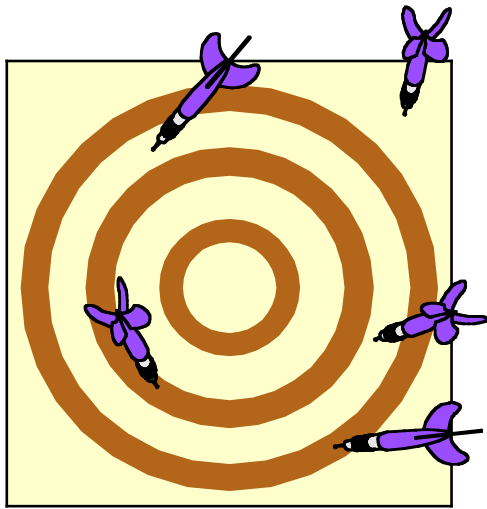A) a > b > c   B) b > c > a   C) c > a > b   D) c > b > a

Accuracy

(a)

(b)

(c)
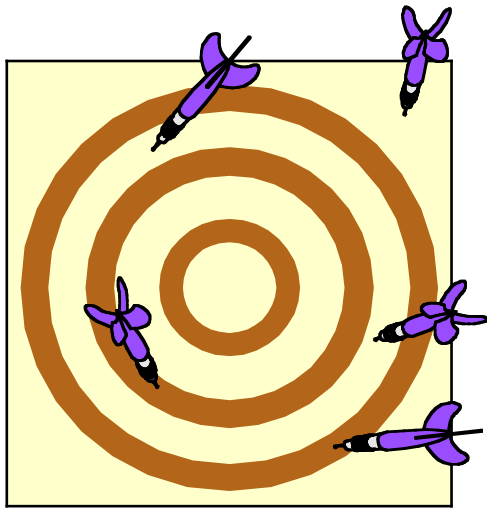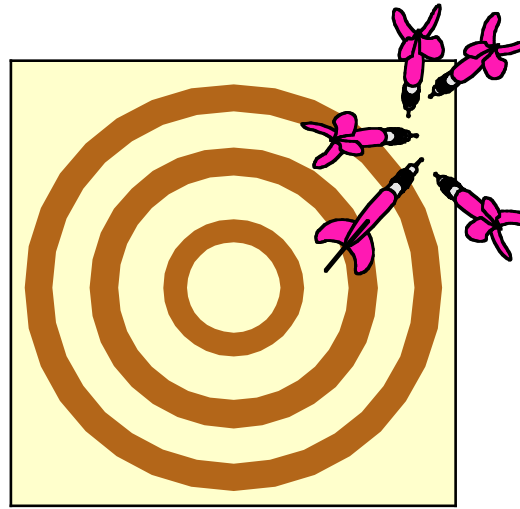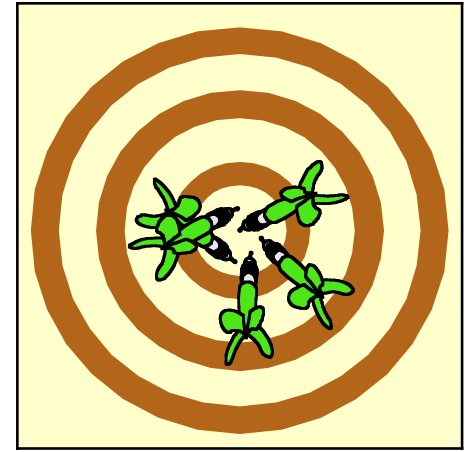
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QUESTION

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.

Answer

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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 +)

Rank the data from best to worst precision.

Precision & Accuracy
(The Following Measured Data is for Volume in mL)

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	8.36	8.35	8.00
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	----------		----------		----------	
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 +)				

Rank the data from best to worst precision.

$b > c > a$

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**

Answer

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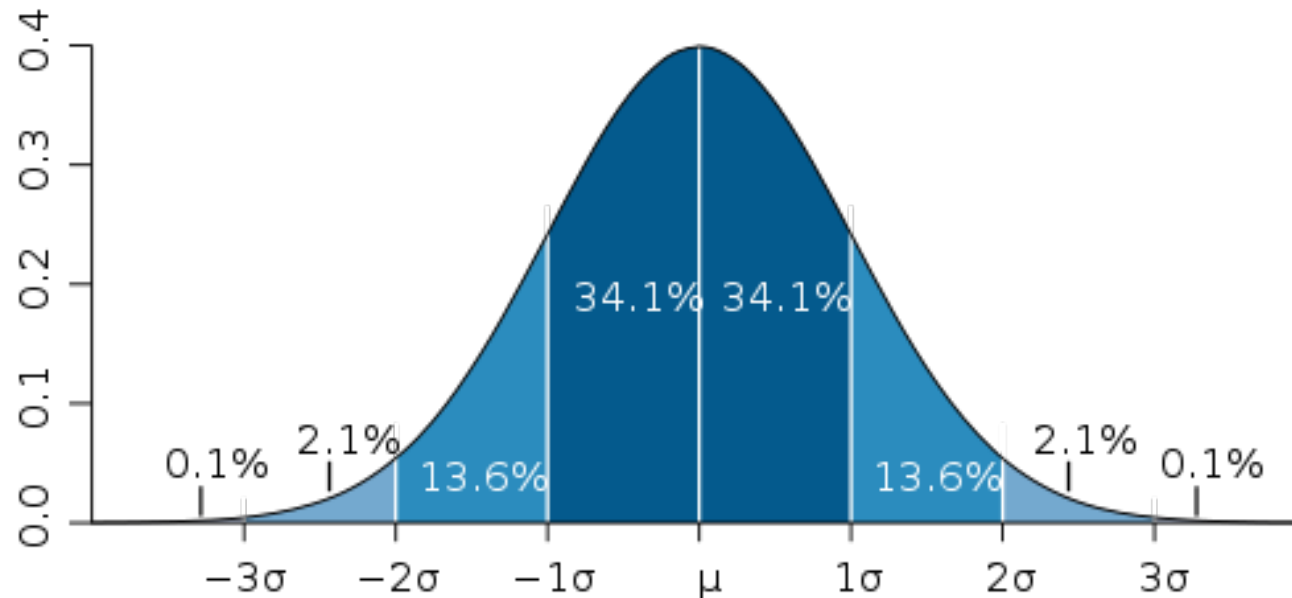
The distribution of data (individual data points) in a set is not considered by the Average Deviation. Standard Deviation, which is the square root of the data set's variance relative to its average (mean), is commonly used to do this.

Precision

(Standard Deviation)

Standard Deviation is the <u>square root</u> of the data set's <u>variance</u> 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 deviation		Standard deviation		Standard 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 a)		Average b)		Average c)
8.38		8.38		7.99

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

Answer:

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 a)		Average b)		Average c)
8.38		8.38		7.99

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

A) Accuracy: a > c > b

B) Accuracy: b > c > a

Answer:
C) Accuracy: c > a = b

D) Accuracy: a = b > c

Reporting Results

What number best represent the respective VAT class result?

Average of each.

V	A	T
34	28	28
34	24	22
28	22	30
30	28	18
32	26	15
36	32	18
26	30	23
30	32	18
36	22	32
28	26	22
22	24	28
32	22	18
35	6	35
36	26	34
30	26	28
34	20	26
30	30	26
32	28	24
28	24	22
30	22	16
28	34	28
25	24	26
32	30	38
34	22	24
34	26	22
34	28	14
28	26	16
32	20	24
34	30	18
40	24	22
34	32	24
32	28	23
30	24	20
24	24	22
32	22	24
36	14	26
34	26	28
28	32	16
22	21	30
38	24	32
26	22	20
38	22	24
32	22	24
28	26	38
32	24	28
34	28	24
30	28	21
32	30	32
32	26	24
26	30	26
28	22	30
26	28	30
30	22	14
32	26	26
30	12	38
28	30	30
22	26	22
30	22	26
28	28	32
32	26	28

How much does the class vary in each?

Standard Deviation of each, Maximum & Minimum of each.

Reporting Results
Statistics & Rules

Chem 106 VAT Survey Results

	V	A	T
AVG	31	25	25
STDev	4	5	6
Max	40	34	38
Min	22	6	14

Should V=40 and A=6 be eliminated from the Data set and the Average recalculated?

Popcorn Science: Analytical Chemistry
How good is the popcorn?

What's Happening

The corn seed has a hard, dry skin that encloses an embryo which contains *carbohydrates* [nominally referred to as compounds with carbon + water]. When the seeds are heated, the water absorbs heat and boils [*vaporizes*: producing steam]. This creates a huge pressure inside the seed. When enough pressure is produced, the outer coat cracks ["pops"], the steam bursts out, and the seed turns inside out. The heat inside the shell cooks the carbohydrate before it actually pops to produce the characteristic white, fluffy pop corn.

Industry's Quality Standards:

Expansion	cm^3 / g
Kernel Size	Kernels / 10 g
Moisture Content	Percent H_2O

How would you experimentally determine these values?