Scientific & Chemical Fundamentals

Applications:

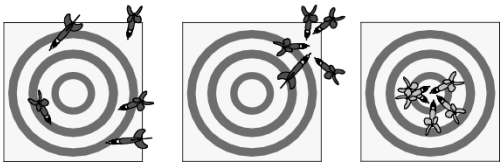
Precision & Accuracy

Density

Refer to Lab Manual & Worksheets

Dr. Ron Rusay

Precision

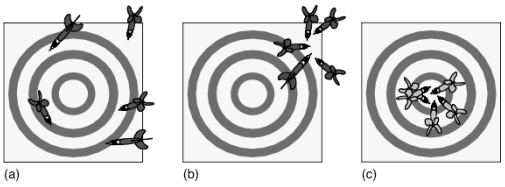


QUESTION:

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			

Average Deviation?

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

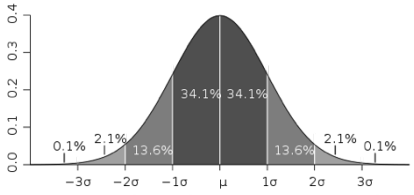
A) Student A ***B) Student B***

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

Provide the 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

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

Density

Density = Mass / Volume [g/mL or g/cm^3; g/L]

Refer to Lab Manual/Worksheets

- *One of the densest substances: a White Dwarf*

http://antwrp.gsfc.nasa.gov/apod/ap961203.html

1.0 teaspoon = 3.0 T (metric tons);

Calculate its density:

D = ? g/cm^3

(1 tsp = 4.93 mL; 1 mL = 1 cm^3; 1 metric ton = 1,000 kg)

Density

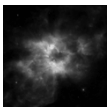
Density = Mass / Volume [g/mL or g/cm³; g/L]

Refer to Lab Manual/Worksheets

White Dwarf

http://antwrp.gsfc.nasa.gov/apod/ap961203.html

A White Dwarf's mass is comparable to our Sun's, but its volume is about a million times smaller; the average density is ~1,000,000 times greater than the Sun's, approximately 1 x 10^6 g/cm³



Our Sun will eventually become a white dwarf "butterfly"….. but not for ~5 billion years.

Density

Density = Mass / Volume [g/mL or g/cm³; g/L]

Refer to Lab Manual/Worksheets

White Dwarf

http://antwrp.gsfc.nasa.gov/apod/ap961203.html

D = 610,000 g/cm³ (6.1 x 10^5 g/cm³)

$Density_{astro}$= ? kg/m³

The density of a Neutron star (pulsar) is 3.7×10^{17} to 5.9×10^{17} kg/m³ (~ 3 ×10^{14} times the density of our Sun)

How many times denser a Neutron Star versus a White Dwarf?

Density

Density = Mass / Volume [g/mL or g/cm³; g/L]

Refer to Lab Manual/Worksheets

- *One of the least dense man-made solid substances: Aerogel*

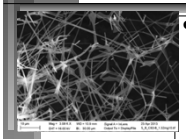
  http://eetd.lbl.gov/ECS/aerogels/aerogels.htm

  http://stardust.jpl.nasa.gov/spacecraft/aerogel.html
- *PS 275 has a volume of ~220 yd³.*
- *When filled with Aerogel, the total weight of Aerogel is ~ 1100 lbs. What is the density of Aerogel?*
- *D = ? g/cm³*
- *D = ? g/L*

Density

Density = Mass / Volume [g/mL or g/cm³; g/L]

Refer to Lab Manual/Worksheets



- *Aerographite is a synthetic foam consisting of a porous interconnected network of tubular carbon. It was first reported by researchers at the University of Kiel and the Technical University of Hamburg in Germany in a scientific journal in June 2012. It's density is:*
- *D = 0.00112 lbs/ft³*
- *Which is less dense Aerogel or Aerographite?*
- *D = ? g/m³*

QUESTION

A metal sample is hammered into a rectangular sheet with an area of 31.2 ft^2 and an average thickness of 2.30 × 10^{-6} cm. If the mass of this sample is 0.4767 g, predict the identity of the metal.

The density of the metal is shown in parenthesis.
Useful information: 1 in = 2.54 cm

A) Aluminum (2.70 g/cm^3) ***B) Copper (8.95 g/cm^3)***

C) Gold (19.3 g/cm^3) ***D) Zinc (7.15 g/cm^3)***

Densities of Various Common Substances at 20° C*

Densities of Various Common Substances* at 20°C

Substance	Physical State	Density (g/cm^3)
Oxygen	Gas	0.00133
Hydrogen	Gas	0.000084
Ethanol	Liquid	0.789
Benzene	Liquid	0.880
Water	Liquid	0.9982
Magnesium	Solid	1.74
Salt (sodium chloride)	Solid	2.16
Aluminum	Solid	2.70
Iron	Solid	7.87
Copper	Solid	8.96
Silver	Solid	10.5
Lead	Solid	11.34
Mercury	Liquid	13.6
Gold	Solid	19.32

*At 1 atmosphere pressure

Density

Density = Mass / Volume [g/mL or g/cm^3; g/L]
Refer to Lab Manual/Worksheets

- *How many pounds of air are there in PS 277? It has a volume of ~220 yd^3.*
- *D_{air} = 1.22 x 10^{-3} g/cm^3 (1.22 g/L)*

QUESTION

Which would provide more grams of NaCl, sample one with a mass of 2,350 mg, or sample two, a solid with a volume of 2.00 cm^3? (The density of solid salt is 2.16 g/cm^3.) Select the most massive sample and its mass in grams.

A. Sample two; 1.08 grams
B. Sample two; 4.32 grams
C. Sample one; 2.35 grams
D. Sample one; 2.350 grams

QUESTION

The volume of any material can be obtained from its density and mass.

If the mass of a sample of acid from a battery were 5.00 grams and its density was 1.2 g/mL, what would the correct reported volume in mL with the proper number of significant digits?

A. 6.0 mL
B. 6.00 mL
C. 4.2 mL
D. 4.17 mL