Test Course

Laboratory Techniques and Measurements

Final Report - Answer Guide

Institution	SI Curriculum Development University
Session	Test Course
Course	Test Course
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Test Your Knowledge

Rank the measurements in order from smallest to largest.

≡ 1.0×10^{-5} m

1 **Correct answer:** 3.0×10^{-7} m

≡ 2.0×10^{-6} m

2 **Correct answer:** 2.0×10^{-6} m

≡ 3.0×10^{-7} m

3 **Correct answer:** 1.0×10^{-5} m

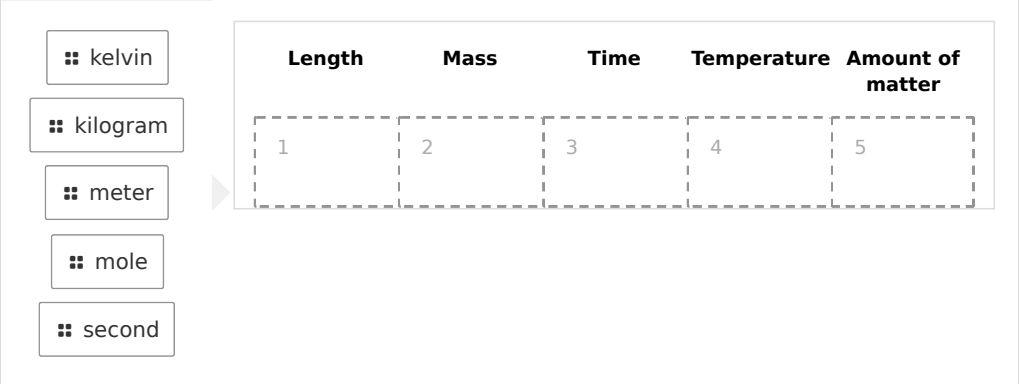
≡ 4.0×10^{3} mm

4 **Correct answer:** 1.0 m

≡ 1.0 m

5 **Correct answer:** 4.0×10^{3} mm

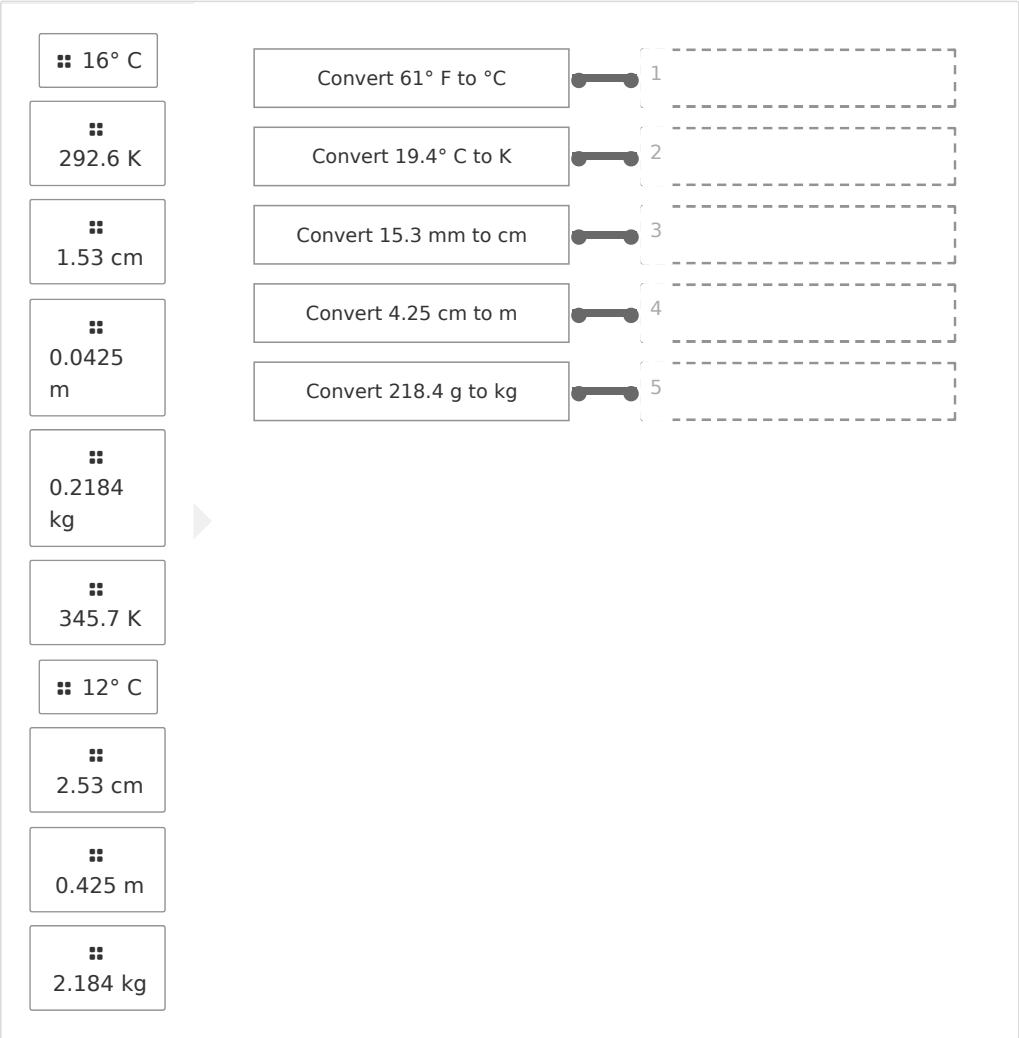
Match each SI base unit to the appropriate measurement.



Correct answers:

1	meter	2	kilogram	3	second	4	kelvin
5	mole						

Perform the following conversions.



Correct answers:

1 16° C 2 292.6 K 3 1.53 cm 4 0.0425 m 5 0.2184 kg

Exploration

A micrometer is equal to 0.000001 m.

- True ✔
- False

The SI system is derived from the _____.

- United States system
- metric system ✔
- English unit system
- math system

Every measuring device measures length to the same degree of accuracy and precision.

- True
- False ✔

The SI system unit for temperature is _____.

- degrees Celsius
- degrees Fahrenheit
- kelvin ✔
- body temperature

One liter is equal to _____.

- 1 cm^3
- 10 cm^3
- 100 cm^3
- 1,000 cm^3 ✔

A meniscus is the curve that forms at the surface of a liquid.

- True ✔
- False

Archimedes' method is used to measure the volume of a(n) _____.

- square
- rectangle
- sphere
- irregularly shaped object ✔

Density is derived from SI units of _____ and _____.

- volume; length
- mass; amount of substance
- length; mass
- mass; volume ✔

In the equation C_1 x V_1 = C_2 x V_2, C_1 represents the _____ of the solution.

- initial concentration ✔
- initial volume
- final concentration
- final volume

The final digit in any measurement is the estimated, uncertain digit.

- True ✔
- False

Exercise 1

Water boils at 100°C at sea level. If the water in this experiment did not boil at 100°C, what could be the reason?

If the water did not boil at 100°C it is the result of a higher elevation. The higher the elevation (from sea-level) the lower the atmospheric pressure and the lower the boiling point. HOL is located at approximately 5280 feet above sea-level and the boiling point was determined to be 93.8°C.

While heating two different samples of water at sea level, one boils at 102°C and one boils at 99.2°C. Calculate the percent error for each sample from the theoretical 100.0°C.

$$\frac{|102^{\circ}C - 100^{\circ}C|}{100^{\circ}C} \times 100 = 2\%$$

$$\frac{|99.2^{\circ}C - 100^{\circ}C|}{100^{\circ}C} \times 100 = 0.8\%$$

Data Table 1: Length Measurements
(SAMPLE ANSWER BELOW)

Object	Length (cm)	Length (mm)	Length (m)
CD or DVD	12.00	120.0	0.1200
Key	6.30	63.0	0.0630
Spoon	19.50	195.0	0.1950
Fork	19.60	196.0	0.1960

Data Table 2: Temperature Measurements
(SAMPLE ANSWER BELOW)

Water	Temperature (°C)	Temperature (°F)	Temperature (K)
Hot from tap	35.0	95.0	308.2
Boiling	94.0	201.2	367.2
Boiling for 5 minutes	95.5	203.9	368.7
Cold from tap	13.6	56.5	286.8
Ice water – 1 minute	8.6	47.5	281.8
Ice water – 5 minutes	5.6	42.1	278.8

Data Table 3: Mass Measurements
(SAMPLE ANSWER BELOW)

Object	Estimated Mass (g)	Actual Mass (g)	Actual mass (kg)
Pen or pencil	3.0	4.5	0.0045
3 Pennies	12.3	7.6	0.0076

1 Quarter	5.1	5.8	0.0058
2 Quarters, 3 Dimes	15.0	18.2	0.0182
4 Dimes, 5 Pennies	22.5	21.6	0.0216
3 Quarters, 1 Dime, 5 Pennies	35.3	32.0	0.0320
Key	15.0	12.6	0.0126
Key, 1 Quarter, 4 Pennies	22.2	28.2	0.0282

Exercise 2

An unknown, rectangular substance measures 3.60 cm high, 4.21 cm long, and 1.17 cm wide. If the mass is 21.3 g, what is this substance's density (in grams per milliliter)?

$$\text{Volume} = 3.6\ \text{cm} \times 4.21\ \text{cm} \times 1.17\ \text{cm} = 17.7\ \text{cm}^3$$

$$\text{Mass} = 21.3\ \text{g}$$

$$\text{Density} = \frac{21.3\ \text{g}}{17.7\ \text{cm}^3} \times \frac{1\ \text{cm}^3}{1\ \text{mL}} = 1.20\ \text{g/mL}$$

A sample of gold (Au) has a mass of 26.15 g. Given that the theoretical density is 19.30 g/mL, what is the volume of the gold sample?

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\frac{19.30\ \text{g}}{\text{mL}} = \frac{26.15\ \text{g}}{\text{x}}$$

$$19.30\ \text{g}\ (\text{x}) = 26.15\ \text{g(mL)}$$

$$\text{x} = 1.355\ \text{mL}$$

A student was given an unknown metal. The student determined that the mass of the metal was 30.2 g. The student placed the metal in a graduated cylinder filled with 20.0 mL of water. The metal increased the volume of water to 22.9 mL. Calculate the density of the metal and determine the identity of the metal using the table below.

Metal	Density (g/mL)
Lead	11.3
Silver	10.5
Nickel	9.90
Zinc	7.14

The calculated density of the unknown metal is 10.4 g/mL. The closest density is 10.5 g/mL, which makes the unknown silver.

Data Table 4: Liquid Measurements
(SAMPLE ANSWER BELOW)

Liquid	Volume (mL)	Mass A Graduated Cylinder (g)	Mass B Graduated Cylinder with liquid (g)	Mass B - A Liquid (g)	Density g/mL	% Error
Water	5.0	19.9	24.7	4.8	0.97	3.5
Isopropyl alcohol	5.0	19.9	23.7	3.8	0.76	3.3

Data Table 5: Magnet- Direct Measurement Method
(SAMPLE ANSWER BELOW)

Object:	Mass (g)	Length (cm)	Width (cm)	Height (cm)	Volume (cm^3)	Density (g/cm^3)
Magnet	4.3	2.56	0.59	0.59	0.89	4.8

Data Table 6: Water Displacement Method
(SAMPLE ANSWER BELOW)

Object	Mass (g)	Initial volume of graduated cylinder (mL)	Final volume of graduated cylinder (mL)	Object Volume (mL)	Density (g/mL)

Magnet	4.3	7.1	8.0	0.9	5
Metal bolt	8.0	6.5	7.5	1.0	8.0

Exercise 3

How would you prepare 10 mL of a 0.25% m/V HCl solution if 1% m/V HCl was available? How much 1% m/V HCl is needed? How much distilled water is used?

$C_1 \times V_1 = C_2 \times V_2$
(1%) x (x mL) = (0.25%) x (10 mL)
X = 2.5 mL
Thus, 2.5 mL of 1% HCl is needed and it is combined with 7.5 mL of distilled water to create 10 mL of 0.25% HCl.

From the graph of Concentration vs. Density, created in Graph 1, what was the relationship between the concentration of the sugar solution and the density of the sugar solution?

From the graph of Concentration vs. Density, as the concentration of the sugar solution increases the density does as well. Likewise, as the concentration of the sugar solution decreases, the density of the solution decreases to the point of 0.96 g/mL. The density of the sugar solution will not drop below the density of the water, which is why the chart levels out at approximately 0.96 g/mL.

Data Table 8: Initital Concentration
(SAMPLE ANSWER BELOW)

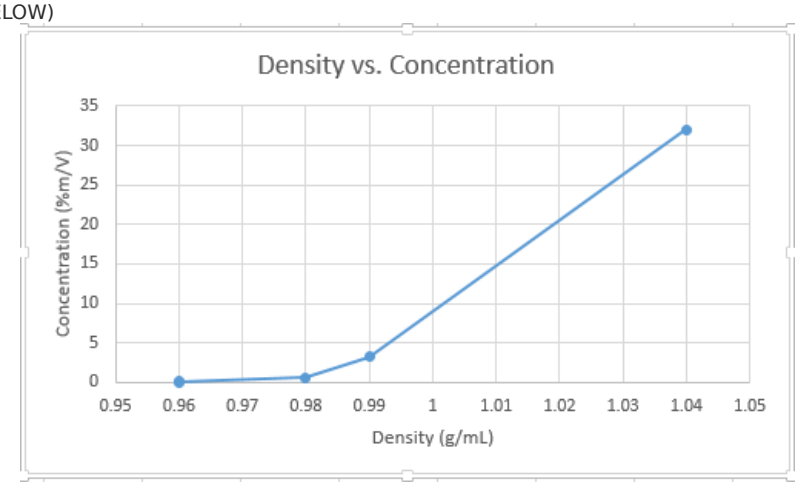
Chemical	Mass of Graduated Cylinder (g)	Mass of Sugar (g)	Total Volume (mL)	Concentration (% m/V)
Sugar ($C_{12}H_{22}O_{11}$)	24.0	8.0	25.0	32

Data Table 9: Dilution Series
(SAMPLE ANSWER BELOW)

Dilution	Volume (mL)	Mass (g)	Density (g/mL)	Initial Concentration (% m/V)	Volume Transferred (mL)	Final Concentration (% m/V)
0	25.0 mL	26.0	1.04		0.0 mL	32

1	25.0 mL	24.8	0.99	32	2.5 mL	3.2
2	25.0 mL	24.5	0.98	3.2	4.5 mL	0.58
3	25.0 mL	24.0	0.96	0.58	3.0 mL	0.070
4	25.0 mL	23.9	0.96	0.070	6.0 mL	0.017

Graph 1: Concentration vs. Density
(SAMPLE ANSWER BELOW)



Competency Review

The SI system unit for the amount of a substance is _____.

- grams per liter
- moles ✔
- Avogadro's number
- kilograms

The International System of Units (SI) is _____.

- a scale of measurement
- the same as U.S. Customary Units
- the same as English units
- a standard system to measure length, temperature, time, amount of substance, and mass ✔

15.00^{o}F converts to _____^{o}C.

- 1.58^{o}C
- 8.33^{o}C
- -9.40^{o}C ✔
- -8.7^{o}C

5.00 miles is equal to _____ kilometers.

- 8.05 ✔
- 3.11
- 2.49
- 1.53

A meniscus is the curve that forms at the surface of a liquid.

- True ✔
- False

_____ is defined as mass per unit of measure.

- Volume
- A kilogram
- Molarity
- Density ✔

The definition of % *m/V* is _____.

- grams solute/mL solution x 100 ✔
- grams solution/mL solute x 100
- mL solute/grams solution x 100
- mL solution/grams solute x 100

Significant figures include only the certain digits of a measurement.

- True
- False ✔

When reading a graduated cylinder made of glass, one must read the volume at eye level from the middle of the meniscus.

- True
- False ✔

A volumetric flask contains 25.0 mL of a 14% *m/V* sugar solution. If 2.5 mL of this solution is added to 22.5 mL of distilled water, the new solution is _____% *m/V*.

- [x] 1.4
- [ ] 14
- [ ] 7.1
- [ ] 71

If the measured value of an experiment is 1.4 cm and the accepted value is 1.2 cm, the experimental error is _____.

- [ ] -14.3%
- [ ] 14.3%
- [ ] -16.7%
- [x] 16.7%

The volume of an irregularly shaped object that has a mass 3.0 grams and a density of 6.0 g/mL is _____.

- [ ] 1.0 mL
- [x] 0.5 mL
- [ ] 2.0 mL
- [ ] 18.0 mL

Extension Questions

In the movie, "*Raiders of the Lost Ark*", Indiana Jones takes a gold idol from a cave. The statue is resting on a table which is rigged with a weight sensor. The weight sensor can detect when the weight is removed and will set off a series of unfortunate accidents. To prevent this from happening, Indiana replaces the gold idol with a bag of sand. The volume of the gold idol is approximately 1.0 L. The density of gold is 19.3 g/mL and the density of sand is 2.3 g/mL.

1. **Assuming the idol is pure gold, what volume would the bag of sand have to be in order to weigh exactly the same as the idol and not set off the booby-traps?**

2. **Let's assume that Indiana is successful in removing the idol and returning with it to his laboratory. He decides to determine if it is really pure gold. He weighs the idol and measures the volume by a water displacement method. The results are: mass = 16.5 kg and volume of water displaced = 954 mL. Is the idol made of pure gold? Explain your answer based on the experimental results.**

(SAMPLE ANSWER BELOW)

1. Mass of idol = 1.0 L x (1000 mL/L) x (19.3 g/mL) = 19,300 g The mass of sand must equal the mass of the idol = 19,300 g The volume of sand can be calculated from: volume = mass/density Volume of sand = 19,300 g/(2.3 g/mL) = 8.390 L, which is an unrealistic volume for Indiana Jones to handle with one hand.

2. The density of the idol from the testing would be calculated as [16.5 kg x (1000 g/kg)]/954 mL = 17.3 g/mL No, the idol is not pure gold. The density is too low.