Chemistry 11

Unit 2: Introduction to Chemistry

Book 1: Measuring and Recording Scientific Data

Name: Key

Block:

Measuring and Recording Significant Data

SI Units

The **SI system** (International System of Units) is the modern metric system of measurement and the dominant system of international commerce and trade. The abbreviation SI comes from the French, Système international d'unités. The SI system was developed in 1960 and is maintained by the International Bureau of Weights and Measures (BIPM) in France.

Molarity

5.0 m (length) 5.0 M (concentration)

Table 1.3.1 *The Fundamental SI Units*

Name	Unit Symbol	Quantity
metre	m	length
kilogram (g)	kg	mass
second	s	time
ampere	A	electric current
kelvin	K	temperature
candela	cd	luminous intensity
mole	mol	amount of substance
Litre	L	volume

gram

4.6g 4.6 g 4.6 g

SI units are given in Table 1.3.1.

- Unit symbols are always lower case letters unless the unit is named after a person. The one exception to this rule is L for litres. The full names of units are always written in lower case with the exception of *degrees Celsius*.
- Unit symbols should never be pluralized. cm ~~cm's~~
- Symbols should only be followed by a period at the end of a sentence.
- In general, the term mass replaces the term *weight*. Force ''''''''''g (N)
- The symbol cc should not be used in place of mL or cm^3.
- For values less than 1, use a 0 in front of the decimal point (e.g., 0.54 g not .54 g).
- Use decimal fractions rather than common fractions (0.25 rather than ¼)
- Abbreviations such as sec, cc, or mps are avoided and only standard unit symbols such as s for second, cm^3 for cubic centimeter, and m/s for metre per second should be used.
- There is a space between the numerical value and unit symbol (4.6 g).
- unit symbol in preference to words for units attached to numbers (e.g., 5.0 g/mol rather than 5.0 grams/mole). Note that 5.0 grams per mole is incorrect but five grams per mole is correct.
- A specific temperature and a temperature change both have units of degrees Celsius (°C).

Quick Check

Locate the SI error(s) in each of the following statements and correct them.

1. Ralph bought 6 ~~kilos~~ of potato salad. 6 kg.
2. The thickness of the oxide coating on the metal was 1/2 c.m. 0.5 cm.
3. The ~~weight~~ mass of 1 Ml mL of water is exactly 1 ~~gms~~ g at 4 °c. 4 °C.
4. My teacher bought 9.0 litres L of gasoline for her 883 ~~c.c.~~ cm^3 motorcycle.
5. Rama's temperature increased by .9 C°.

Accuracy and Precision —

The Quality of Measurements

Measured values like those listed in the Warm Up at the beginning of this section are determined using a variety of different measuring devices.

There are devices designed to measure all sorts of different quantities. The collection pictured in Figure 1.3.1 measures volume, Temperature and Length. In addition, there are a variety of precisions (**exactnesses**) associated with different devices.

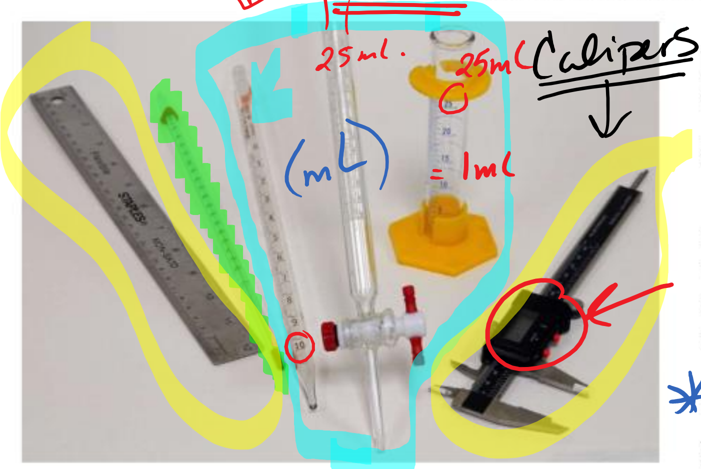


Figure 1.3.1 *A selection of measuring devices with differing levels of precision*

The micrometer (also called a caliper) is more precise than the ruler while the burette and pipette are more precise than the graduated cylinder.

Despite the fact that some measuring devices are more precise than others, it is impossible to design a measuring device that gives perfectly exact measurements.

*All measuring devices have some degree of uncertainty associated with them.

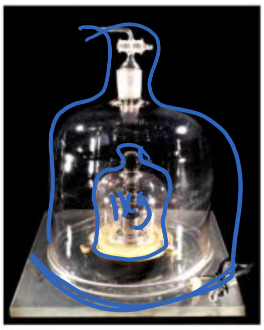


Figure 1.3.2 *This kilogram mass was made in the 1880s and accepted as the international prototype of the kilogram in 1889. (© BIPM — Reproduced with permission)*

The 1-kg mass kept in a helium-filled bell jar at the BIPM in Sèvres, France, is the only exact mass on the planet. (Figure 1.3.2). All other masses are measured relative to this and therefore have some degree of associated uncertainty.

Accuracy refers to the agreement of a particular value with the true value.

Accurate measurements depend on careful design and calibration to ensure a measuring device is in proper working order.

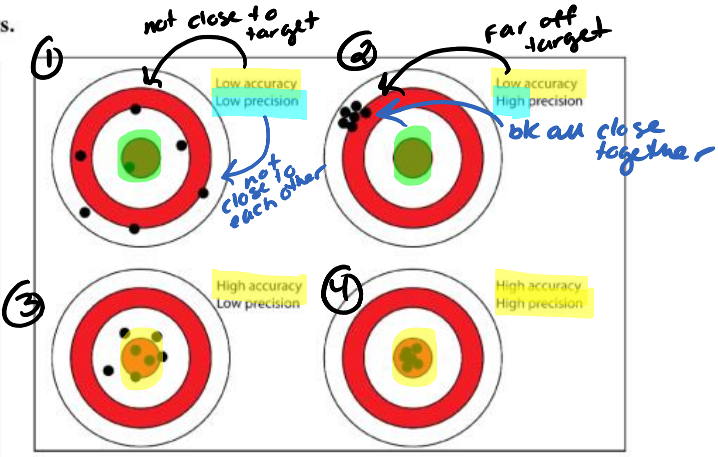
The term precision can actually have two different meanings.

Precision refers to the reproducibility of a measurement *(or the* agreement *among several measurements of the same quantity).*

\- *or* -

Precision refers to the exactness of a measurement.

This relates to uncertainty: the lower the uncertainty of a measurement, the higher the precision.



Uncertainty

Every measurement has some degree of uncertainty associated with it.
The uncertainty of a measuring device depends on its precision.
The most precise measuring devices have the smallest. uncertainties.
The most common way to report the uncertainty of a measuring device is as a **range uncertainty.**

The **range uncertainty** is an "acceptable" range of values within which the true value of a measurement falls. This is commonly presented using the ______ notation (shown as +/–).

eg. mass of $CaCO_3$ is 4.6g ±0.3 acceptable answers: 4.3g – 4.9g

meniscus
bottom of the curve

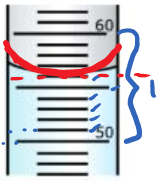


Figure 1.3.2 *A meniscus in a graduated cylinder*

56.3 ← uncertain digit.
certain digits

An acceptable range uncertainty is **usually considered** plus or minus 1/10 (0.10) to (0.5) 1/2 the smallest division marked on a measuring scale.
For the graduated cylinder in Figure 1.3.2, the smallest division marked on its scale is 1mL
One-half of this division is 0.5 mL.
Therefore, reading the volume from the bottom of the meniscus would give a value of 56.3 mL +/– 0.5 mL. Because it is possible to go down to one-tenth of the smallest division on the scale as a range, the volume could also be reported as 56.3 mL +/– 0.1 mL. ← range of uncertainty
Notice that the unit is given twice, before and after the +/– symbol. This is the correct SI convention.

When *two uncertain values* with range uncertainties are *added or subtracted*, their uncertainties must be added

Quick Check

1. Sum the following values:

27.6 mL +/– 0.2 mL
+ 14.8 mL +/– 0.2 mL
42.4mL ± 0.4mL

add uncertainty.

−0.2
27.4mL
+ 14.6mL
42.0mL

27.8mL
+ 15.0mL
42.8mL

2. Subtract the following values:

19.8 mL +/– 0.2 mL
– 7.2 mL +/– 0.2 mL
12.6mL +/– 0.4mL

add uncertainty

increased the range of possible values.

Absolute **uncertainty** refers to **exactly** how much higher or lower a measured value is than an accepted value.

In such a case, an accepted value is the value considered to be the best measurement available.

Constants such as the speed of light or the boiling point of water at sea level are **accepted values.**
For absolute uncertainties, a sign should be applied to indicate whether the measured value is above or below the accepted value.

Another common way to indicate an error of measurement is as a percentage of what the value should be.

$$\textbf{percentage error} = \frac{(\text{measured value} - \text{accepted value})}{\text{accepted value}} \times 100\%$$

not for measuring (for mixing liquids)

Quick Check

Volumetric devices measure liquids with a wide variety of precisions.

1. Which of these is likely the *most precise*?
   Syringe – because it has the most incraments to measure i.e: most decimal places.
2. Which is likely the *least precise*?
   (vol flask) Graduated Cylinder – least number of decimal places.
3. Is the *most precise* device necessarily the *most accurate*?
   No.... you can still measure precisely but be far off the 'true value' (accurate)
4. Discuss your answers.

Types of Errors

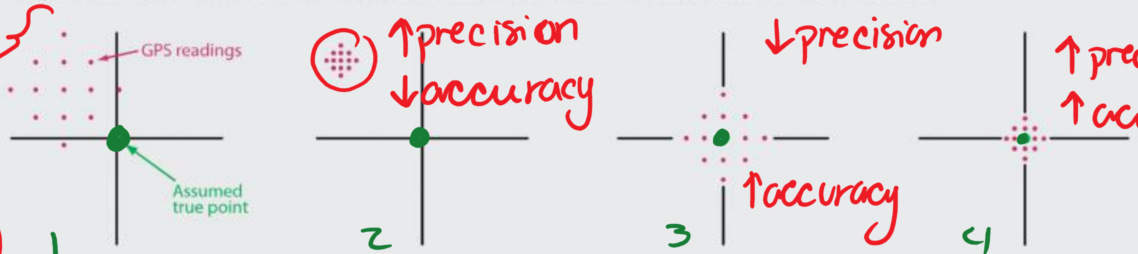
No measurement can be completely precise. In fact, all measurements must have some degree of uncertainty associated with them, so it must be true that every measurement involves some degree of error.

A group of measurements may tend to consistently show error in the same direction. Such a situation is called systematic **error**.

When a group of errors occurs equally in high and low directions, it is called random **error**.

Quick Check

Four groups of Earth Science students use their global positioning systems (GPS) to do some geocaching. The diagrams below show the students' results relative to where the actual caches were located.



student

↓precision (spread out)
↓accuracy (away from true point)

↑precision ↓accuracy

↓precision ↑accuracy

↑precision ↑accuracy

1. Comment on the **precision** of the students in each of the groups. (In this case, we are using the "reproducibility" definition of precision.)
2. What about the **accuracy** of each group?
3. Which groups were making **systematic** errors? error in same way/direction
   1 + 2 - error NW of the geocache
4. Which groups made errors that were more **random**? – error in all directions
   (maybe 1)... groups 3 + 4

PRACTICE

Quick Check

A student ~~weighs~~ gets the mass of a Canadian penny and finds the mass is 2.57 g. Data from the Canadian Mint indicates a penny from that year should weigh 2.46 g.

1. What is the absolute uncertainty of the penny's mass? $2.57g - 2.46g = {}^{+}0.11g$
2. What is the percentage error of the penny's mass? $\frac{0.11g}{2.46g} \times 100\% = 4.5\%$
3. Suggest a reasonable source of the error.
   uncertainty of scale; damaged penny; forgery

chemistry homework

Assignment #1- Review Questions + Hebden pg 29 #43-45

all assignments are to be completed on a separate page with the assignment number & heading

$\% = \frac{\text{measured} - \text{accepted}}{\text{accepted}}$

Review Questions

1. Determine the errors and correct them according to the SI system:
   (a) Th
   (b) Th
   (c) Th
   mi
   (d) Jo
   pi
2. A zin
   with
   slug
   4.891
   value
   mean
3. A stu
   dens
   dens
   abso
   perc
4. Two
   mass
   0.72 g, while the other gets a mass of 0.64 g. How do their percent errors compare? How do their absolute errors compare?

Page 43, 1.3 Review Questions ANSWERS

1. a. 750Gm → 750g
   b. km/hour → km/h, 10sec → 10s
   c. ML → mL, cc → mL
   d. gms → g, inch → in.
2. Not accurate, but precise (consider both meanings).
3. Absolute error = $-0.0054 g/cm^3$
   $$\% \text{ error} = \frac{0.0054 g/cm^3}{0.1733 g/cm^3} \times 100\% = 3.1\%$$
4. (Same/Opposite direction)
   |error| of 0.72g=0.04g
   |error| of 0.73g=-0.04g
   Total error = 6%
5. $\frac{5.00}{100} \times 1.44 = 0.0720 g/cm^3$
   Maximum: $1.512 \rightarrow 1.51 g/cm^3$
   Minimum: $1.368 \rightarrow 1.37 g/cm^3$
6. 84.08g ± 0.05g
7. 35-24=11m
8. Maximum: $20.0 \times 2.5 = 50.0 cm^2$
   Minimum: $19.8 \times 2.3 = 45.54 cm^2$
   Average: 47.77 ± 2.23
   $\therefore 48 \pm 3 cm^2$
9. a. 14.3 mL ± 0.5mL   b. 112 °F ± 2 °F or 44°C ± 1 °C

5. In an experiment to determine the density of a liquid, a maximum error of 5.00% is permitted. If the
   is 1.44 g/cm³, what are the maximum
   n values within which a student's
   fall into the acceptable range?

$0.05 = \frac{x}{1.44 g/cm^3}$

$x = (0.05)(1.44)$

$x = 0.0720 g/cm^3$

diff. between measured value & accepted value.

1.44 ± 0.0720

range

$1.368 g/cm^3 - 1.512 g/cm^3$

nass, including uncertainty, arrived at
of summing 45.04 g +/– 0.03 g, and
.02 g?

mallest number that could result from
2 m +/– 2 m from 38 m +/– 3 m?

19.9 × 2.4 = 47.76

ons of a rectangle are measured to
/– 0.1 cm and 2.4 +/– 0.1 cm. What
the rectangle, including the range

min 19.8 – max 20.0

min 2.3 – max 2.5

smallest area

19.8 × 2.3 = 45.54 cm²

Largest area

20.0 × 2.5 = 50.00 cm²

of the following devices, including a
range uncertainty:

niscus

(a)

(b)

47.77 ± 2.23

range

45.54 – 50.00 cm

diff. 50 - 45.54 = $\frac{4.46}{2}$ = 2.23

min 45.54 – Actual 47.77 – max 50.00

-2.23   +2.23

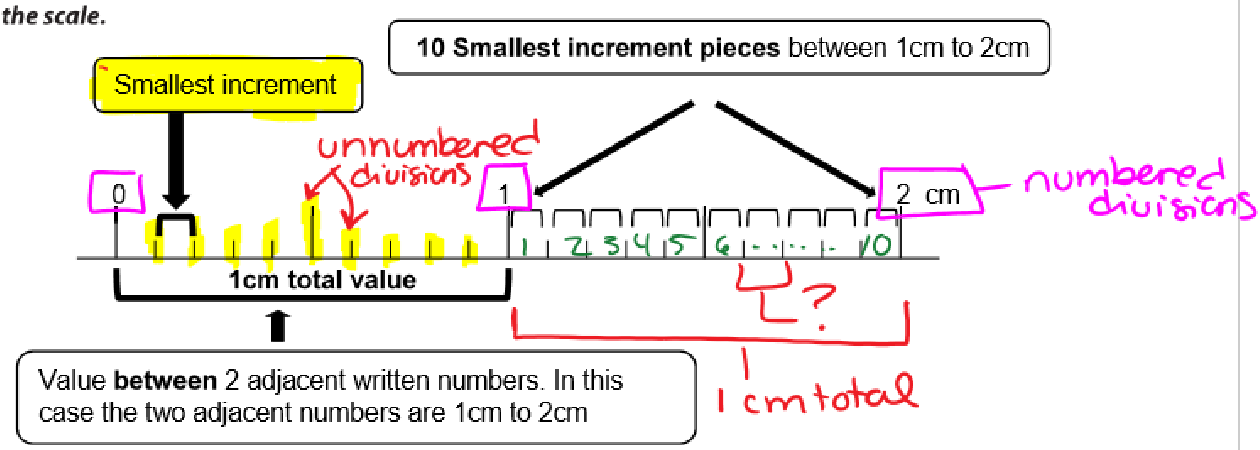
uncertainty ± 2.23

Reading & Recording Measurements

On all scales the numbered and unnumbered subdivisions are calibrated divisions.

The overall scale has been *marked off* or ***calibrated*** at regular intervals

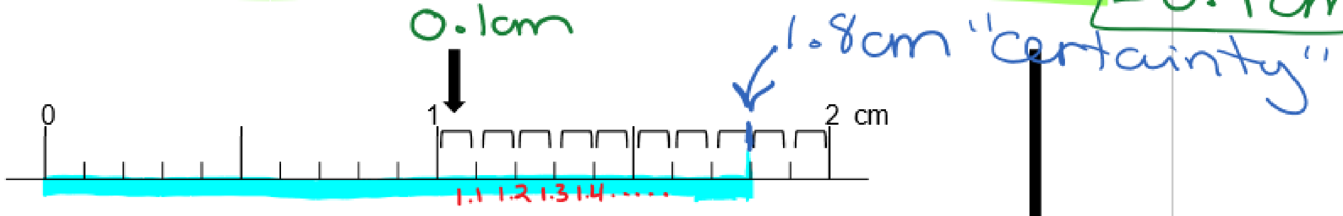
A common error student make when reading & recording measurements, is ***interpreting the values of the scale.***



Formula:

$$\text{value of 1 smallest increment piece} = \frac{\textbf{total value between 2 adjacent numbers}}{\textbf{\# of smallest increment pieces between 2 adjacent numbers}} = \frac{1\text{cm}}{10\text{s}}$$

$$\boxed{= 0.1\text{cm}}$$



$$* \text{value of 1 smallest increment piece} = \frac{1\text{cm (total value 1–2cm)}}{10\text{ (\# of small increments)}}$$

So, this results in the following value per piece

$$\text{value of 1 smallest increment piece} = \frac{\mathbf{0.1\ cm}}{\textbf{per smallest increment piece}}$$

Determining number of allowed decimal places in measurement reading:

The unnumbered divisions on a scale allow 2 MORE decimal places to read.

RULE: You are allowed to ESTIMATE any measurement to 1 more decimal place than the smallest increment.

Smallest increment has 1 decimal place, so you can ESTIMATE measurement to 2 decimal places.

uncertain digit
⇓
"uncertainty"
± ?
⇓
significant figures

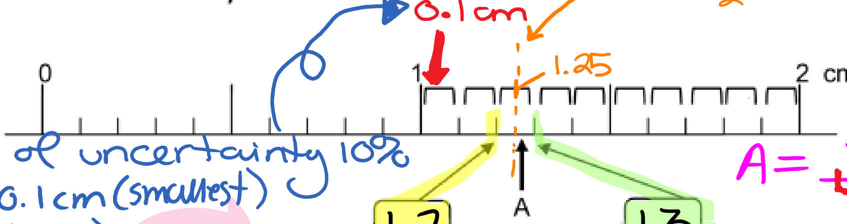
$$\text{value of 1 smallest increment piece} = \frac{0.1\ cm}{\text{per smallest increment piece}}$$

Example 1:

Determine the value at *position A*.

½ of 0.1 = 0.05

$\frac{0.1}{2}$



uncertain digit

A = 1.27cm ±0.01cm

range of uncertainty 10%

10% of 0.1cm (smallest)

(0.10)×(0.1cm) = 0.01

±0.01

1.2

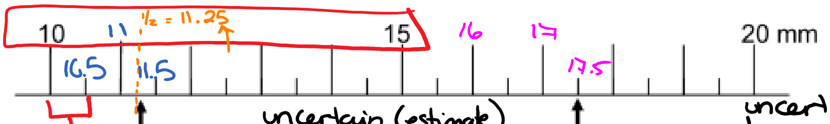
1.3

1.2cm < A < 1.3cm

"certain digits"

Example 2:

Determine the value at *position B and C.*



value of smallest increment = $\frac{15-10}{10}$ = 0.5

0.5

B = 11.30mm ±0.05

uncertain (estimate)

certain

10% of 0.5

C = 17.50 ±0.05

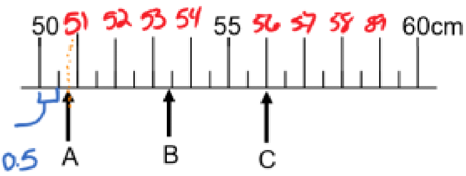
uncertain

certain

2 d.p.

PRACTICE Determine the measurement to the proper number of decimal places. You should show some work in the space provided above the scales.

a)



0.5

10% of 0.5 = 0.05cm

A= 50.75cm ±0.05cm

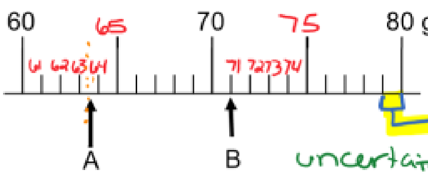
B= 53.49cm ±0.05cm

C= 56.00cm ±0.05cm

(55.95 - 56.05cm)

10% range of uncertainty

b)



1g

10% 1g = 0.1g

uncertain

A= 63.6g ±0.1g

B= 70.9 ±0.1g

certain

range of uncertainty

(63.5g - 63.7g)

When the reading seems to be EXACTLY on a numbered division:

When a pointer, or reading appears to fall *exactly* on a numbered division, we must be careful that we include the correct certain and uncertain digits (*significant figures*).

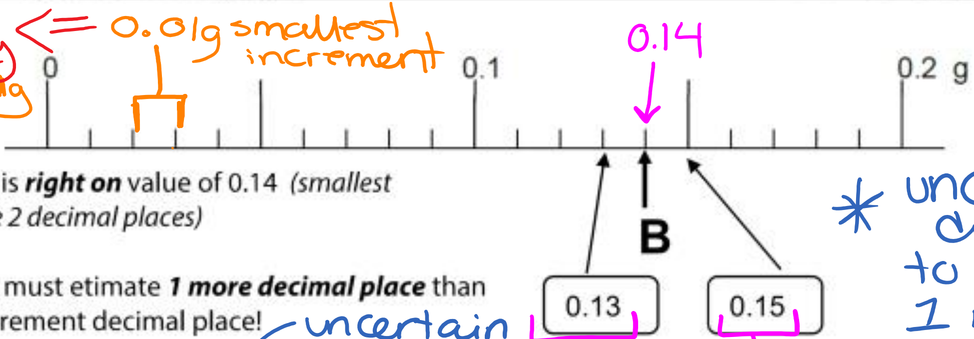
THE PROCEDURE FOR CORRECTLY READING MEASURING SCALES WHEN A POINTER IS EXACTLY ON A NUMBERED DIVISION

- Determine the value that the measurement seems to have.
- Pretend you have a value in between two of the unnumbered subdivisions on your measuring device.
- Determine how many decimal places you could read off the measuring device at the "in–between value".
- Add a sufficient number of zeroes to the actual reading to give you the correct number of decimal places for your reading.

range of uncertainty <= 0.01g smallest increment

10% of 0.01g

±0.001



"B" looks like it is ***right on*** value of 0.14 *(smallest increments have 2 decimal places)*

* uncertain digit is to estimate 1 more d.p.

Remember you must etimate ***1 more decimal place*** than the smallest increment decimal place!

uncertain

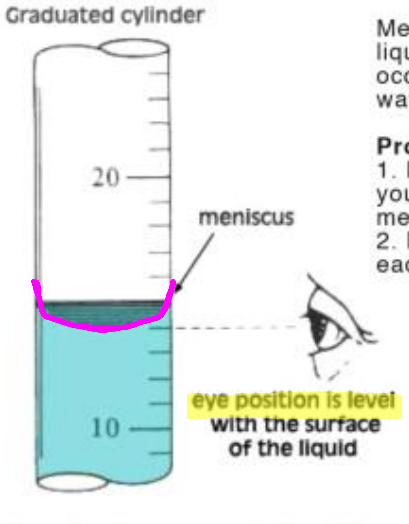
B = 0 . 1 4 0g ±0.001g

certain

certain digits (2 d.p.)

Assignment #2- Hebden pg 32 #48-49 *all assignments are to be completed on a separate page with the assignment number & heading*

Reading liquid measures:



(The unit of measurement is milliliter)

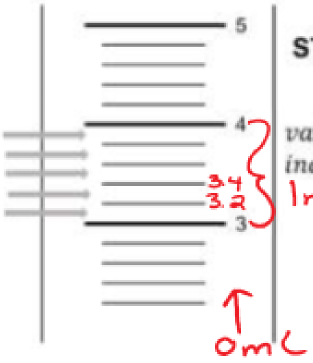
Measuring liquids in graduated cylinders is often tricky because the liquid surface is curved. This curved surface is called the meniscus and occurs because of the strong attractive force between the glass and water.

Procedure:
1. Measure the amount of liquid in the graduated cylinders below. When you measure make sure to measure the amount using the bottom of the meniscus for any liquid volume measuring tool.
2. Record the measurement and label your units in mL on the line below each graduated cylinder.

Meniscus: the curve in the upper surface of a liquid close to the sides of a container. Caused by the surface tension of the fluid.

Can be either convex ↑ or concave ↓ depending on the liquid.

There are 5 smallest increment pieces between 2 adjacent numbers



STEP A

value of 1 smallest increment piece = $\frac{1\ mL}{5\ smallest\ increment\ pieces}$

value of 1 smallest increment piece = $\frac{0.2\ mL}{per\ smallest\ increment\ piece}$

Etc..

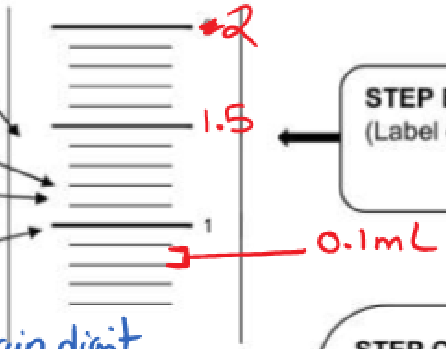
certain digits

1.20

1.10

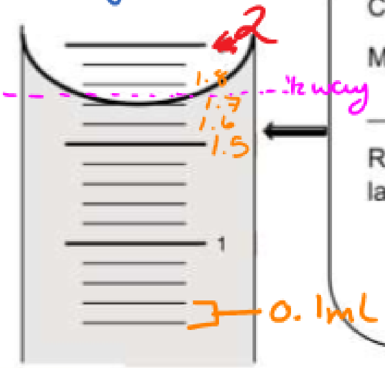
1.00

uncertain digit



STEP B: Smallest increment is 1 decimal place.
(Label each increment to 2 decimal place)
⇧ 2nd place is the estimate

read up.



STEP C: Smallest increment is 1 decimal place.
Can read scale to 2 decimal places

Meniscus is less than ½ way between
1.70 and 1.80 mL

Read from smaller number (1.70) towards the larger number (1.80)

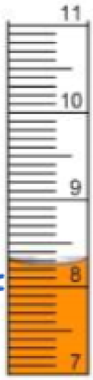
Acceptable range
1.69 mL to 1.71 mL
(actual = 1.70mL)

uncertainty
10% of 0.1mL
±0.01mL

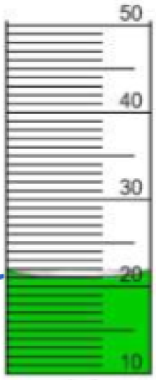
PRACTICE What is the reading in milliliters for each graduated cylinder? what is the uncertainty?

smallest increment
0.1
(10% of 0.1
= ±0.01)

smallest increment
0.1mL



smallest increment
1mL
10% of 1mL
= ±0.1mL



5.25mL ±0.01mL

1.50mL ±0.01mL

8.25mL ± 0.01mL

[redacted]

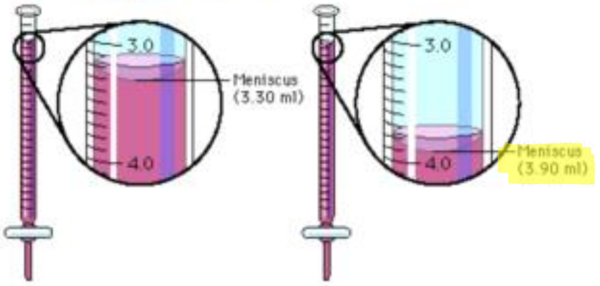
21.1mL ±0.1mL

± ?

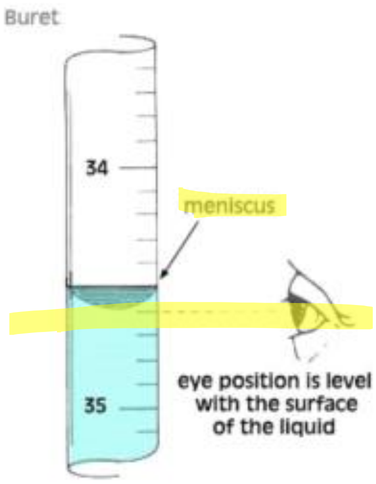
certain uncertain

Reading a Burette

read top down



Assume that the burette is filled to the point indicated in the figure at the left. You would record the initial point as 3.30 ml; the ending point would be 3.90 ml. Therefore, the titration would have required 0.60 ml. Remember that you should read the number that is at the bottom of the meniscus.

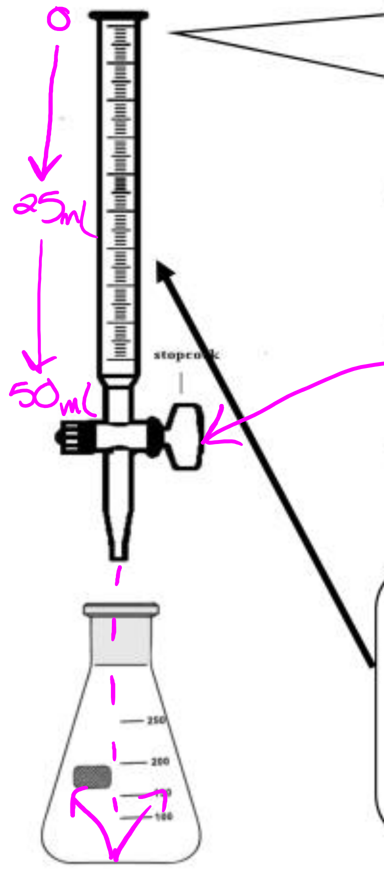


(The unit of measurement is milliliter)

A burette (also buret) is a laboratory equipment used in analytical chemistry for the dispensing of variable amount of a chemical solution and measuring that amount at the same time.

Most often used for titration in acid base chemistry.

This doesn't measure the real volume. Rather it is used to determine the TOTAL AMOUNT of volume added ***from the burette*** to a reaction beaker!



Burette: The number at the TOP is 0.00mL even though you would have a lot of liquid volume present at that point!!

Most burettes start at 0mL and go to 50 mL

Open the valve, and some liquid from the burette would drop into the reaction beaker *(Erlenmeyer flask)* below.

As a result, the liquid level in the burette would drop, and the final reading on the burette scale would actually be a LARGER VOLUME than the initial volume reading. This allows for a positive number for the total volume added. See below.

Volume dispensed = final volume (larger #) - initial volume (smaller #)

HEAT VS. TEMPERATURE

There is often confusion over the terms heat and temperature. Although related, they are not the same.

Temperature is a measure of the intensity of heat. It is the average kinetic energy of the particles is sample of matter.

Temperature is measured in degrees Kelvin (K) where: K = °C + 273.15

Heat is the energy transferred between two objects in contact with one another at *different* temperatures.

· transfer of thermal energy

· a measure of the total kinetic energy of a sample.

Measurement of Temperature

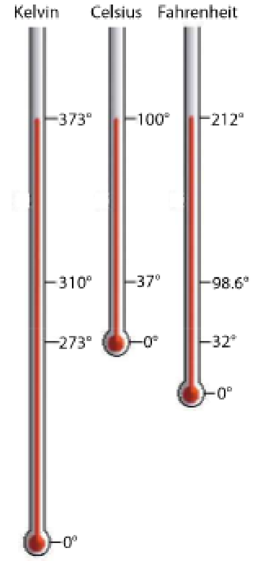


Figure 1.4.3 *The three commonly used temperature scales*

There are several different scales for measuring temperature. Three of these scales are commonly used, two in physical sciences and one in engineering.

1) ***Degrees Celsius:***

In degrees Celsius, water freezes at 0 °C , and boils at 100 °C

The Celsius scale is based on the freezing and boiling points of water ,

with 100 degrees separating them.

2) ***Degrees Fahrenheit:***

In degrees Fahreheit, water freezes at 32 °F and boils at 212 °F The Fahrenheit scale used the coldest temperature German scientist, Daniel Gabriel Fahrenheit, could produce with rock salt and water as his zero point. His original scale was later adjusted so that the freezing point of water was 32 °F and the boiling point of water was 212 °F, with 180°F separating the two.

3) ***Kelvin***

Kelvin is an absolute temperature scale, based on the Kinetic Molecular Theory and the kinetic energy of particles in a substance.

At 0K, particles will have no movement, and therefore ***zero kinetic energy***.

This temperature was called Absolute Zero and is 273.15°C ***colder*** than the freezing point of water.

* **NOTE:** We do not say "degrees" in Kelvin, like we do with Celsius and Fahrenheit.

For example, 300 K is " 300 Kelvin "

no "degrees" symbol either

$K = {}^oC + 273.15$

${}^oC = K - 273.15$

Freezing Point of H_2O

$K = 0 + 273.15$

$K = 273.15$

PRACTICE

symbol

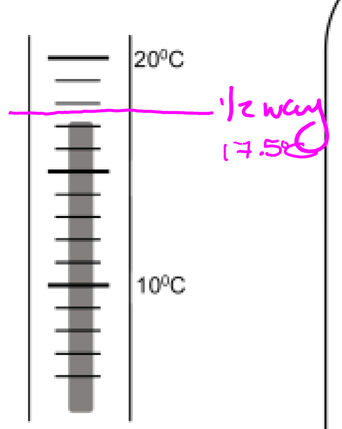
1. **Convert the following temperatures into Kelvin:**

2. **Convert the following temperatures into °C:**

Reading Theremometers

With thermometers not only must you read calibrated divisions accurately, you have to be careful with negative scales.

EXAMPLE:



Step A: smallest increment:

$\dfrac{1\ ^{o}C}{smallest\ increment\ piece}$ uncertainty 10% 0.1°C

Step B: smallest increment has 0 dp. (certain digits)

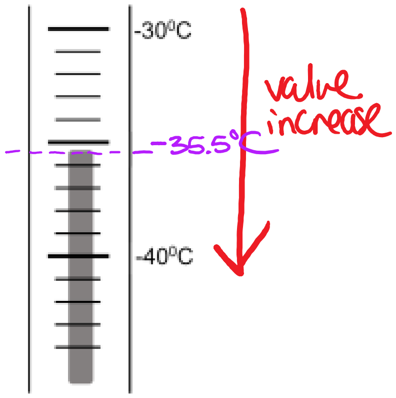
So can read the scale to 1 dp. (uncertain digits)

Step C:

10% of smallest increment

Measurement Answer: 17.2°C ± 0.1°C

(acceptable range: 17.1 **to** 17.3 **°C)**



****careful we are in the negative scale ****

Step A: smallest increment:

$\dfrac{1\ ^{o}C}{smallest\ increment\ piece}$

Step B: smallest increment has 0 dp.

So can read the scale to 1 dp. uncertainty ± 0.1 °C

Step C:

Measurement Answer: -35.4°C

(acceptable range: -35.5 **to** -35.3 **°C)**

chemistry homework

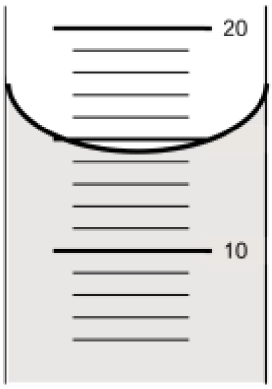
Assignment #3- Hebden pg 34 #50 + Extra Practice Worksheet below

All assignments are to be completed on a separate page with the assignment number & heading

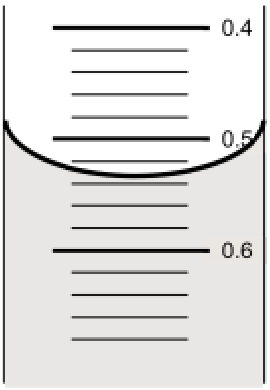
Extra Practice Worksheet

1)For the following volume(mL) scales, determine the measurement to the proper number of decimal places. Remember where to read on the meniscus

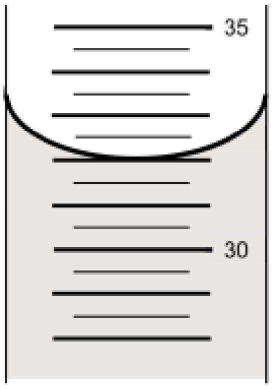
a)



b)

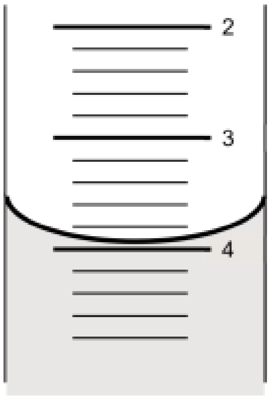


c)

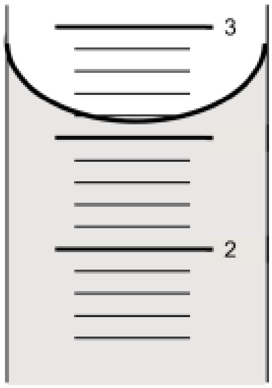


Answers ______________ ______________ ______________

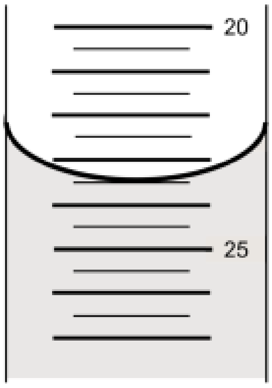
d)



e)



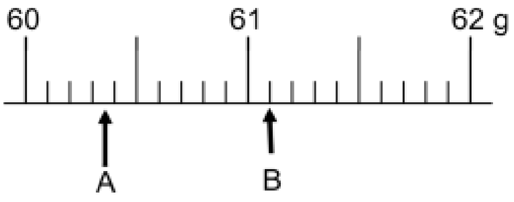
f)



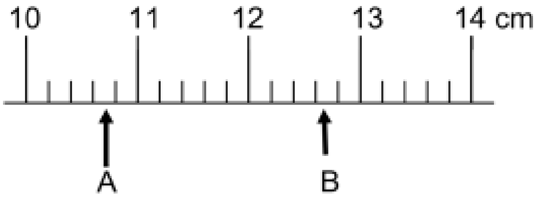
Answers ______________ ______________ ______________

2) For the following ruler and centigram balance scales, determine the measurement to the proper number of decimal places

a)



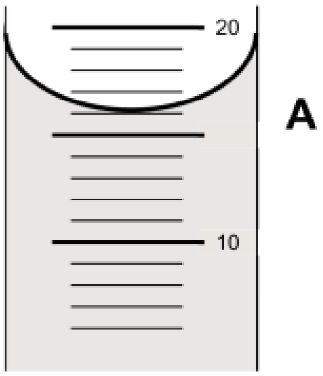
b)

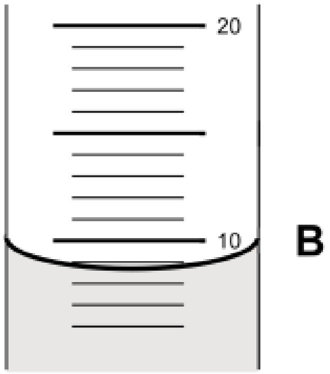


A= ________________ B=______________ A= ________________ B=______________

Extra Practice Worksheet: Graduated Cylinders/Burettes

1. Fill in the blanks for the scale given. Then determine the measurement for the following to the proper decimal places. Remember to put the unit (mL) at the end of the measurement.





a) How do you know if this is a graduated cylinder or burette?____________________

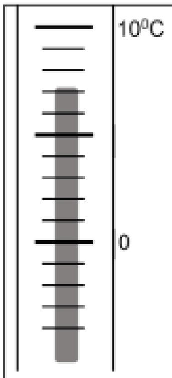
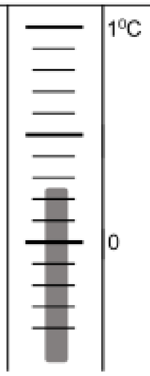
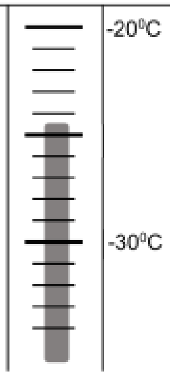
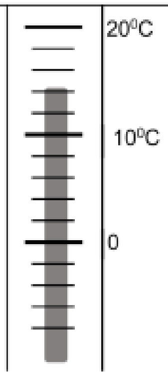
b) Value between 2 adjacent numbers on the scale _______________

c) Number of smallest increment pieces between 2 adjacent numbers __________

d) Smallest increment calculation : formula given below

Thermometer practice

1. Thermometer practice. Determine the measurement to the proper number of decimal places. With a thermometer you have to be careful with a negative scale.

			
Answer:	Answer:	Answer:	Answer:

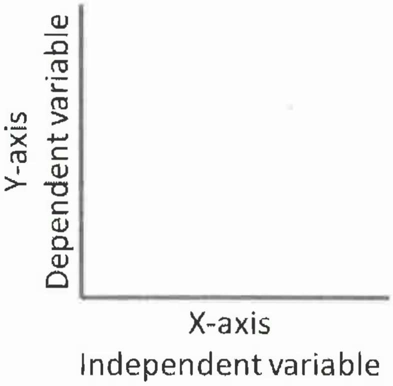
Pictorial Representation of Data — Graphing

Often in scientific investigations, we are interested in measuring how the value of some property changes as we vary something that affects it.

We call the value that responds to the variation the dependant **variable**, while the other value is the independant **variable**.

For example, we might want to measure the extension of a spring as we attach different masses to it. In this case, the extension would be the dependent variable, and the mass would be the independent variable. ("I change")

Notice that the amount of extension ***depends*** on the mass loaded and not the other way around. The variable "time" is nearly always independent.



The series of paired measurements collected during such an investigation is quantitative data. It is usually arranged in a data table. Tables of data should indicate the unit *of measurement* at the top of each column. The information in such a table becomes even more useful if it is presented in the form of a graph.

The independent data is plotted on the x-axis. A graph reveals many data points not listed in a data table.

Once a graph is drawn, it can be used to find a mathematical relationship (equation) that indicates how the variable quantities depend on each other.

The first step to determining the relationship is to calculate the slope "***m***" for the *line of best fit.*

First, the constant is been determined by finding the change in *y* over the change in *x* ($\Delta y/\Delta x$ or the "rise over the run").

Then substitution of the *y* and *x* variable names and the calculated value for *m*, including its units, into the general equation $y=mx+b$ The result will be an equation that describes the relationship represented by our data.

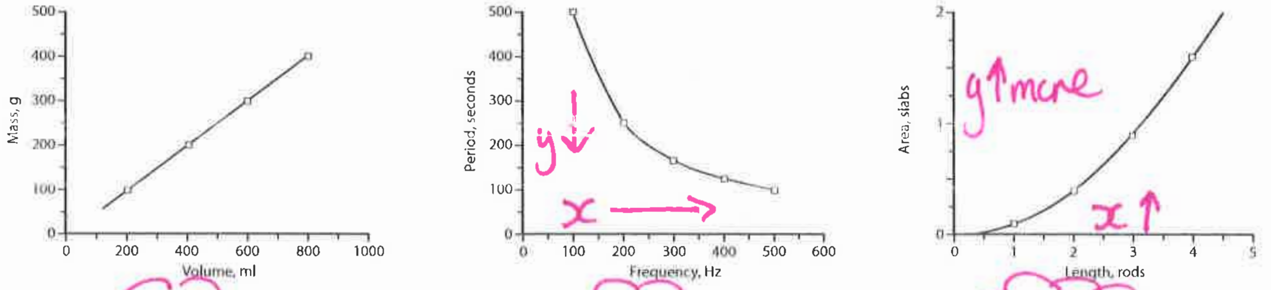
$y=mx+b$ is the general form for the equation of a *straight line relationship* where:

m represents the *slope* $m = \frac{\Delta y}{\Delta x} = \frac{rise}{run} = \frac{y_2-y_1}{x_2-x_1}$

In scientific relationships, the slope includes units and represents the constant that relates two variables.

For this reason, it is sometimes represented by a K.

The three most common types of graphic relationships are shown below in Figure 1.2.2.



Direct: $y = Kx$
(*y* and *x* increase in direct proportion)

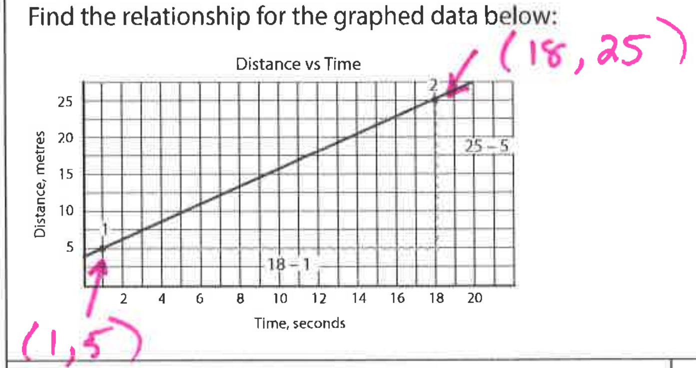
Inverse: $y = K/x$
(as *x* increases, *y* decreases)

Exponential: $y = Kx^n$
(as *x* increases, *y* increases more quickly)

Figure 1.2.2 *Three common types of graphic relationships*

Sample Problem — Determination of a Relationship from Data

Find the relationship for the graphed data below:



What to Think about

1. Determine the constant of proportionality (the slope) for the straight line. To do this, select two points on the line of best fit.
   These should be points whose values are easy to determine on both axes. *Do not use data points* to determine the constant.
   Determine the change in *y* (Δ*y*) and the change in *x* (Δ*x*) including the units.
   The constant is Δ*y*/ Δ*x*.

2. The relationship is determined by subbing in the *variable names* and the constant into the general equation, $y = Kx + b$.

   Often, a straight line graph passes through the origin, in which case, $y = Kx$.

How to Do It

$$m = \frac{(25-5)}{(18-1)} = \frac{20m}{17s} = 1.18\frac{m}{s}$$

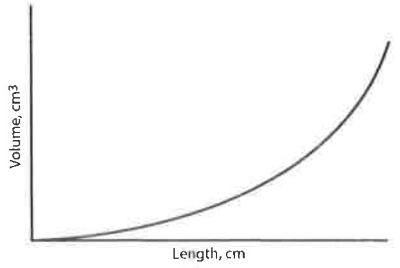
y-intercept

$$y = mx + b$$

$$\text{Distance} = \left(1.18\frac{m}{s}\right) \cdot \text{time} + 4.0\frac{m}{s}$$

Practice Problem — Determination of a Relationship from Data

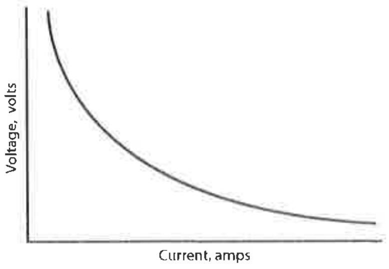
Examine the following graphs. What *type of relationship* does each represent?



(a)

Exponential:

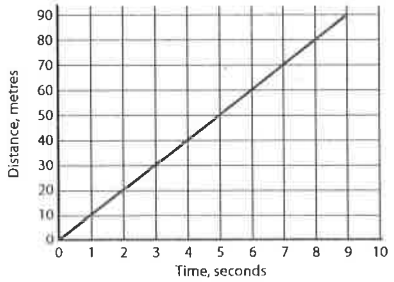
· as x increases, y increases more.



(b)

Inverse:

· as current ↑ voltage ↓



(c)

Direct (linear)

· as time increases, distance increases proportionally.

Activity: Graphing Relationships

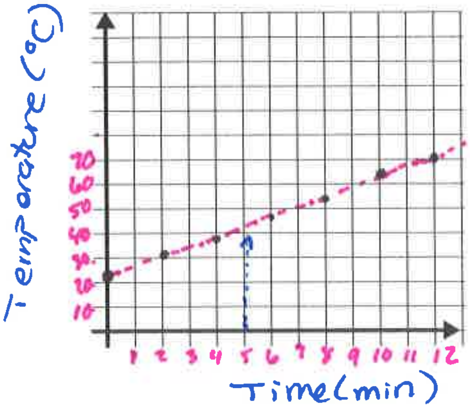
Question

Can you produce a graph given a set of experimental data?

Background

A beaker full of water is placed on a hotplate and heated over a period of time. The temperature is recorded at regular intervals. The following data was collected.

Temperature (°C)	Time (min)
22	0
30	2
38	4
46	6
54	8
62	10
70	12



$y = mx + b$

$y = (4°C/min)x + 22$

Procedure

1. Use the grid above to plot a graph of temperature against time. (Time goes on the *x*-axis.)

Results and Discussion

1. What type of relationship was studied during this investigation?

   direct, linear relationship.

2. What is the constant (be sure to include the units)?

   $slope = m = K = \frac{y_2 - y_1}{x_2 - x_1} = \frac{70-22}{12-0} = \frac{48}{12} = 4.0 °C/min.$

3. What temperature was reached at 5 minutes?

   $y = (4)(5) + 22 = 42°C$

4. Use the graph to determine the relationship between temperature and time.

   Temperature increases with time. (proportional relationship)

5. How long would it take the temperature to reach 80°C?

   $80°C = (4)(x) + 22 \quad \frac{80-22}{4} = x = 14.5 min$

6. What does the *y*-intercept represent?

   the initial temp. of the water

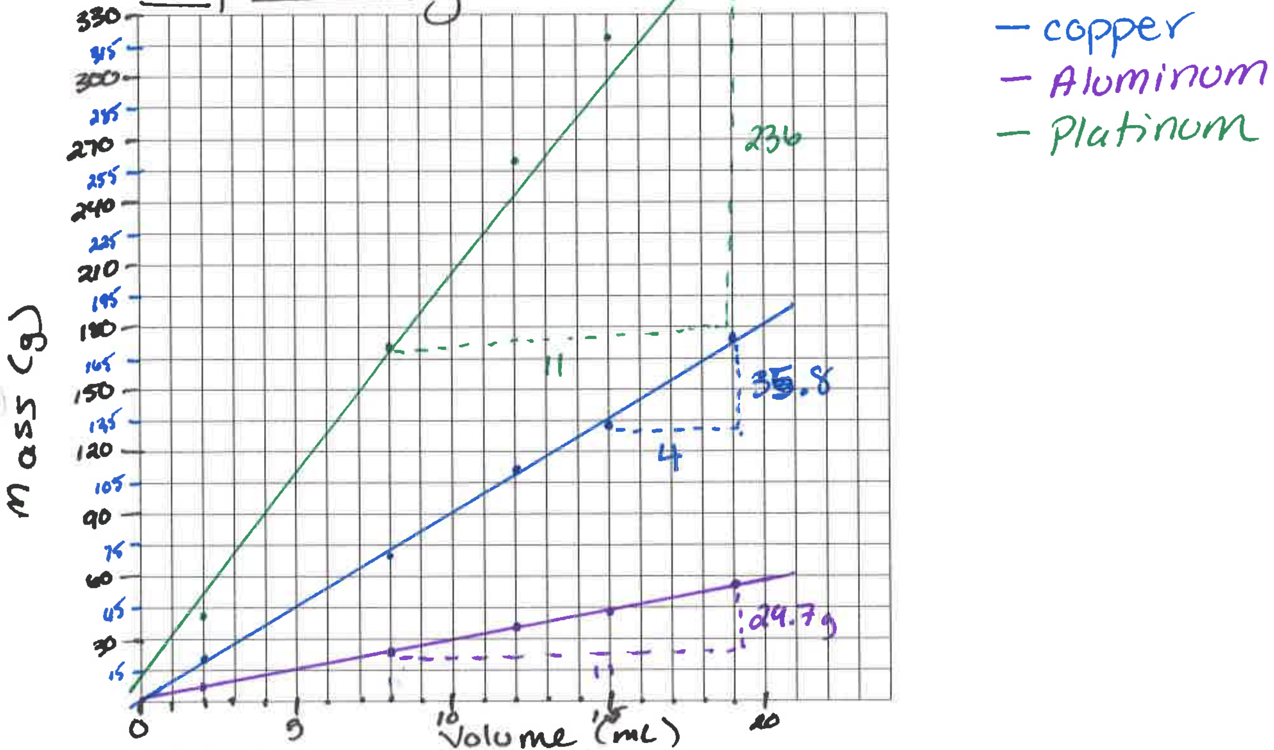
7. Give a source of error that might cause your graph to vary from that expected.

   - hotplate may not heat evenly - alter temperature
   - temperature readings could be erroneous due to lack of precision in reading instruments.

Use the grid provided to plot graphs of **mass against volume** for a series of metal pieces with the given volumes. Plot all three graphs on the same set of axes with the independent variable (volume in this case) on the *x*-axis. Use a different colour for each graph.

Volume (mL)	Copper (g) ●	Aluminum (g) ●	Platinum (g) ●
2.0	17.4	5.4	42.9
8.0	71.7	21.6	171.6
12.0	107.5	32.4	257.4
15.0	134.4	40.5	321.8
19.0	170.2	51.3	407.6

Graph 1: Density of common metals



(a) Determine the constant for each metal.

$K = \frac{mass}{volume} = \frac{g}{mL}$

$Cu = \frac{35.8g}{4mL} = 8.95 \simeq 9.0 g/mL$

$Pt = \frac{236}{11mL} = 21.5 g/mL$

$Al = \frac{29.7g}{11mL} = 2.7 g/mL$

(b) The constant represents each metal's density. Which metal is most dense?

Platinum is the most dense metal.

2. Two different liquids (water & acetic acid) were heated a constant rate. The data is:

Time (min)	Water Temperature (C)	Acetic Acid Temperature (C)
0	20.0	20.0
1	21.6	23.1
2	23.0	26.1
3	24.5	29.0
4	25.8	33.0
5	27.3	35.8
6	29.0	38.8
7	30.6	41.1
8	32.0	44.0
9	33.5	47.2
10	34.9	49.9