Chemistry

Unit 1
Matter
&
Measurement

Name_____

Literal Equations

Date_____ Period_____

Solve each equation for the indicated variable.

1) $g = 6x$, for x

2) $u = 2x - 2$, for x

3) $z = m - x$, for x

4) $g = ca$, for a

5) $u = x - k$, for x

6) $g = c + x$, for x

7) $u = \dfrac{k}{a}$, for a

8) $g = xc$, for x

9) $12am = 4$, for a

10) $-3x + 2c = -3$, for x

11) $am = n + p$, for a

12) $u = \dfrac{ak}{b}$, for a

13) $a - c = d - r$, for a

14) $xm = np$, for x

/

15) $z = b + \dfrac{m}{a}$, for a

16) $g = x - c + y$, for x

17) $g = b - ca$, for a

18) $g = ca - b$, for a

19) $2x + 4 = xg$, for x

20) $g = \dfrac{1 + 2a}{a}$, for a

21) $g = \dfrac{x - c}{x}$, for x

22) $xm = x + z$, for x

23) $u + ka = ba$, for a

24) $u = kx + yx$, for x

25) $u = 3b - 2a + 2$, for a

26) $z = 9a - 9 - 3b$, for a

27) $g = 4ca - 3ba$, for a

28) $-3a - 3 = -2n + 3p$, for a

29) $4x = -4r + 2d$, for x

30) $u = \dfrac{-2a - 3}{ka}$, for a

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LITERAL EQUATIONS WORKSHEET

Solve for the indicated variable in the parenthesis.

1) $P = IRT$ *(T)*

2) $A = 2(L + W)$ *(W)*

3) $y = 5x - 6$ *(x)*

4) $2x - 3y = 8$ *(y)*

5) $\dfrac{x + y}{3} = 5$ *(x)*

6) $y = mx + b$ *(b)*

7) $ax + by = c$ *(y)*

8) $A = 1/2h(b + c)$ *(b)*

9) $V = LWH$ *(L)*

10) $A = 4\pi r^2$ *(r²)*

11) $V = \pi r^2 h$ *(h)*

12) $7x - y = 14$ *(x)*

13) $A = \dfrac{x + y}{2}$ *(y)*

14) $R = \dfrac{E}{1}$ *(I)*

15) $x = \dfrac{yz}{6}$ *(z)*

16) $A = \dfrac{r}{2L}$ *(L)*

17) $A = \dfrac{a + b + c}{3}$ *(b)*

18) $12x - 4y = 20$ *(y)*

19) $x = \dfrac{2y - z}{4}$ *(z)*

20) $P = \dfrac{R - C}{N}$ *(R)*

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Formula Manipulation Worksheet

Solve for the indicated unknown:

1. $C_1 V_1 = C_2 V_2$ *solve for* V_2

2. $A = \pi r^2$ *Solve for* r

3. $C^0 = \dfrac{5}{9}(F^0 - 32)$ *Solve for* F^0

4. $A = \dfrac{h(a+b)}{2}$ *Solve for* b

5. $PV = nRT$ *Solve for* n

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Name_____

Two-Step Equations

Date_____ Period____

Solve each equation.

1) $6 = \dfrac{a}{4} + 2$

2) $-6 + \dfrac{x}{4} = -5$

3) $9x - 7 = -7$

4) $0 = 4 + \dfrac{n}{5}$

5) $-4 = \dfrac{r}{20} - 5$

6) $-1 = \dfrac{5 + x}{6}$

7) $\dfrac{v + 9}{3} = 8$

8) $2(n + 5) = -2$

9) $-9x + 1 = -80$

10) $-6 = \dfrac{n}{2} - 10$

11) $-2 = 2 + \dfrac{v}{4}$

12) $144 = -12(x + 5)$

5

13) $-15 = -4m + 5$

14) $10 - 6v = -104$

15) $8n + 7 = 31$

16) $-9x - 13 = -103$

17) $\dfrac{n + 5}{-16} = -1$

18) $-10 = -10 + 7m$

19) $-10 = 10(k - 9)$

20) $\dfrac{m}{9} - 1 = -2$

21) $9 + 9n = 9$

22) $7(9 + k) = 84$

23) $8 + \dfrac{b}{-4} = 5$

24) $-243 = -9(10 + x)$

6

Name:

1. Density = volume/mass, also written as D=m/v
   Solve the density formula for both volume and mass.

2. Using the density formula above solve the following problem. What is the volume of a rock that has a mass of 6.4 grams and a density of 2 g/ml?

3. Molarity is a measure of concentration, and has the units moles/ liters. Given that there are 6.7 moles found in 1.67 liters, what is the molarity of this solution?

4. Heat is represented by the letter q. In chemistry we use the formula $q=mc\Delta T$ to calculate heat. Given that m= 43g, c= 4.01 J/g °C, ΔT=37°C, What is q?

5. When diluting solutions we often add water to weaken the substance. Using the formula $M_1V_1=M_2V_2$ we can distinguish how diluted our solution has become. Molarity (M) is a measure of concentration, whereas V is a measure of volume. Given that the initial molarity is 3.67M, and the initial volume is 357 ml, what would be the finial volume (V_2), if the final molarity is 1.57M?

6. In chemistry we use the formula PV=nRT to explain gasses at ideal conditions. Solve the formula for each of the variables.

7. Given that pressure typically has units of Atmospheres (ATM), Volume has units of liters (L), Temperature has units of kelvin (K), and n stands for moles (mol). Prove what the units for R in the above formula would be?

The Scientific Method
Exploring Experimental Design

Scientific Method Practice 2

DIRECTIONS: *Answer these questions on a separate sheet of paper using complete sentences to answer all questions. Be sure to restate the question in your answer!*

Stephanie and Amy were vacationing in Canada. Bundled up in warm clothing, they walked along the beach. Glistening strips of ice hung from the roofs of the beach houses. Only yesterday, Stephanie commented, these beautiful icicles had been a mass of melting snow. Throughout the night, the melted snow had continued to drip, freezing into lovely shapes. Near the ocean's edge, Amy spied a small pool of sea water. Surprisingly, she observed the sea water was not frozen like the icicles on the roofs. What could be the reason, they wondered?

A scientist might begin to solve the problem by gathering information. The scientist would first find out how the sea water in the pool differs from the fresh water on the roof. This information might include the following facts: The pool of sea water rests on sand, while the fresh water drips along a tar roof. The sea water is exposed to the cold air for less time than the fresh water. The sea water is saltier than the fresh water.

Using all of the information that has been gathered, the scientist might be prepared to suggest a possible solution to the problem. A proposed explanation or solution to a scientific problem is called a hypothesis. A hypothesis almost always follows the gathering of information about a problem. Sometimes, however, a hypothesis is a sudden idea that springs from a new and original way of looking at a problem.

A scientist (or a science student) does not stop once a hypothesis has been suggested. In science, evidence that either supports a hypothesis or does not support it must be found. This means that a hypothesis must be tested to show whether it is supported. Such testing is usually done by performing experiments.

Experiments are performed according to specific rules. By following these rules, scientists can be confident that the evidence they uncover will clearly support or not support their hypothesis. For the problem of the sea water and freshwater, a scientist would have to design an experiment that ruled out every factor but salt as the cause of the different freezing temperatures. Stephanie and Amy, being excellent science students, set up their experiment in the following manner.

First, they put equal amounts of fresh water into two identical containers. Then Stephanie added salt to only one of the containers. [The salt is the independent variable. In any experiment, only one independent variable should be tested at a time. In this way, scientists can be fairly certain that the results of the experiment are caused by one and only one factor — in this case the variable of salt.] To eliminate the possibility of hidden or unknown variables, Stephanie and Amy conducted a controlled experiment. A control group is set up exactly like the one that contains the variable. The only difference is that the control setup does not contain the independent variable. Scientists compare the results of the experimental setup to the control setup.

In the experiment, Stephanie and Amy used two containers of the same size with equal amounts of water. The water in both containers was at the same starting temperature. The containers were placed side by side in the freezing compartment of a refrigerator and checked every five minutes. But only one container had salt in it. In this way, they could be fairly sure that any differences that occurred in the two containers were due to the single variable of salt. In such experiments, the part of the experiment with the salt is called the experimental setup. The part of the experiment without salt is called the control setup.

Stephanie and Amy collected the following data: the time intervals at which the containers were observed, the temperature of the water at each interval, and whether the water in either container was frozen or not. They recorded the data in the tables below and then graphed their results.

Water (Control Setup)							
Time (min)	0	5	10	15	20	25	30
Temperature (°C)	25	20	15	10	5	0*	−10

*Asterisk means liquid has frozen

Water with Salt (Experimental Setup)							
Time (min)	0	5	10	15	20	25	30
Temperature (°C)	25	20	15	10	5	0	−10*

*Asterisk means liquid has frozen

Stephanie and Amy might be satisfied with their conclusion after just one trial. For a scientist, however, the results from a single trial are not enough to reach a conclusion. A scientist would want to repeat the experiment many times to be sure the data was reproducible. In other words, a scientific experiment must be able to be repeated. Also, before the conclusion of a scientist can be accepted by the scientific community, other scientists must repeat the experiment and check the results. Consequently, when a scientist writes a report on his or her experiment, that report must be detailed enough so that scientists throughout the world can repeat the experiment for themselves. In most cases, it is only when an experiment has been repeated by scientists worldwide that it is considered to be accurate and worthy of being accepted.

By now it might seem as if science is a fairly predictable way of studying the world. After all, you state a problem, gather information, form a hypothesis, run an experiment, and determine a conclusion. However, sometimes it is not so neat and tidy.

In practice, scientists do not always follow all the steps in the scientific method. For example, while doing an experiment a scientist might observe something unusual or unexpected. That unexpected event might cause the scientist to discard the original hypothesis and suggest a new one. The scientist may never do the analysis and conclusion steps, but use the revised hypothesis to design and complete a new experiment. The scientific method is more like a cycle, as results are often the basis of writing a new, revised hypothesis.

As you already learned, a good rule to follow is that all experiments should have only one variable. Sometimes, however, scientists conduct experiments with several variables. Naturally, the data in such experiments are much more difficult to analyze. For example, suppose scientists want to study lions in their natural environment in Africa. It is not likely they will be able to eliminate all

the variables in the environment and concentrate on just a single lion. So, although a single variable is a good rule and you will follow this rule in almost all of the experiments you design or perform, it is not always practical in the real world.

CONCLUSION QUESTIONS

1. State Stephanie and Amy's problem in the form of a question.

2. Form a hypothesis to answer the problem question above based on the fact that fresh water does not contain salt.

3. According to the data table from Stephanie and Amy's experiment, at what temperature did the experiment begin?

4. At what time intervals were the temperature measurements taken?

5. What conclusions can you draw from these data tables about the effect of salt on the freezing point of water?

6. What can you say about the rate at which the temperature in the fresh water container dropped compared to the rate at which the temperature in the salt water container dropped?

7. What was the independent variable in Stephanie and Amy's experiment?

8. What was the dependent variable?

9. Explain why detailed, step-by-step written procedures are an essential part of any scientific experiment.

10. The following hypothesis is suggested to you: Water will heat up faster when placed under the direct rays of the sun than when placed under indirect, or angled, rays of the sun. Design an experiment to test this hypothesis. Be sure to number each step of your procedure. Identify your independent variable, dependent variable and control. Identify those things which will remain constant during your experiment.

Graphing is an important procedure used by scientists to display the data that is collected during a controlled experiment. When a graph is put together incorrectly, it detracts the reader from understanding what you are trying to present. Most graphs have 5 major parts:

1. Title
2. Independent Variable (X-axis)
3. Dependent Variable (Y-axis)
4. Scale for each variable
5. Legend (or Key)

A. **Title:** Depicts what the graph is about. The Title gives the reader an understanding about the graph. A good title is closer to a sentence than a phrase and is usually found at the top of the graph.
B. **Independent Variable:** Variable controlled by the experimenter. The variable that "I" am testing. (I for Independent). Common independent variables include: time, generations, measurements (length, distance), and temperature. This variable goes on the X-axis.
C. **Dependent Variable:** Variable that is affected by the independent variable; what the experimenter measures. Example: How many oxygen bubbles will depend on the depth of the water. This variable goes on the Y-axis.
D. **Scale:** Before you can plot your data points, you must figure out how much each box on your graph paper is worth. Scale doesn't' always have to start at zero, but I must be consistent. If you start off making each box worth 5 cm, each subsequent box must also be 5 cm. Always make sure your scale is labeled with what it is and what the units are.
E. **Legend:** A short description about the graph's data. Most often used to show what different patterns or colors stand for on your graph.

Rules and Tips for Graphing:

1. Always use a pencil to draw your graph. It's easier to fix mistakes (Or use Excel!).
2. Always draw lines with a ruler. Do not freehand. Use at least half of your paper for the graph.
3. Make sure Independent Variable is on the X-axis and Dependent Variable is on the Y-axis.
4. Include all parts:
    a. Title
    b. Axis Labels WITH Units
    c. Legend
5. If you are graphing multiple subjects, use different colored or patterned lines and explain what they are in the legend.
6. Choose an appropriate graph to explain your data. Examples:
    a. LINE: Measuring a change in something over time
    b. BAR: Comparing individuals to each other with only one data point.
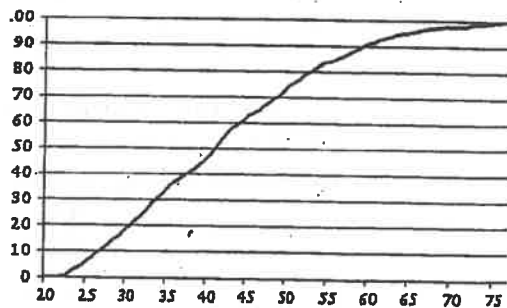   c. PIE: Show percentages that add up to 100%.

1. The following graph is a fair to good example. Fill in the table with what is good about the graph and what could use improvement.

Crimes Of Robbery
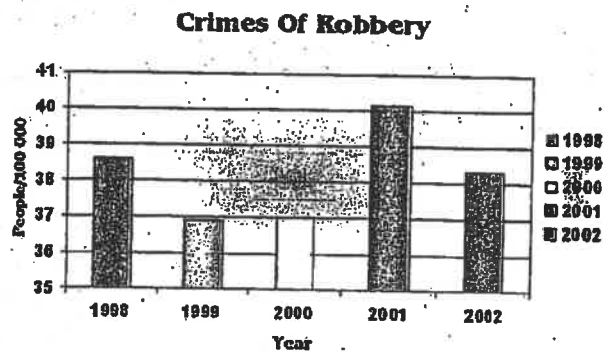
| GOOD	IMPROVE

2. The graph below is not a good graph. What parts are missing?

Experiment #1: Use the following data to create an appropriate graph and answer the questions. (graph paper on next page).
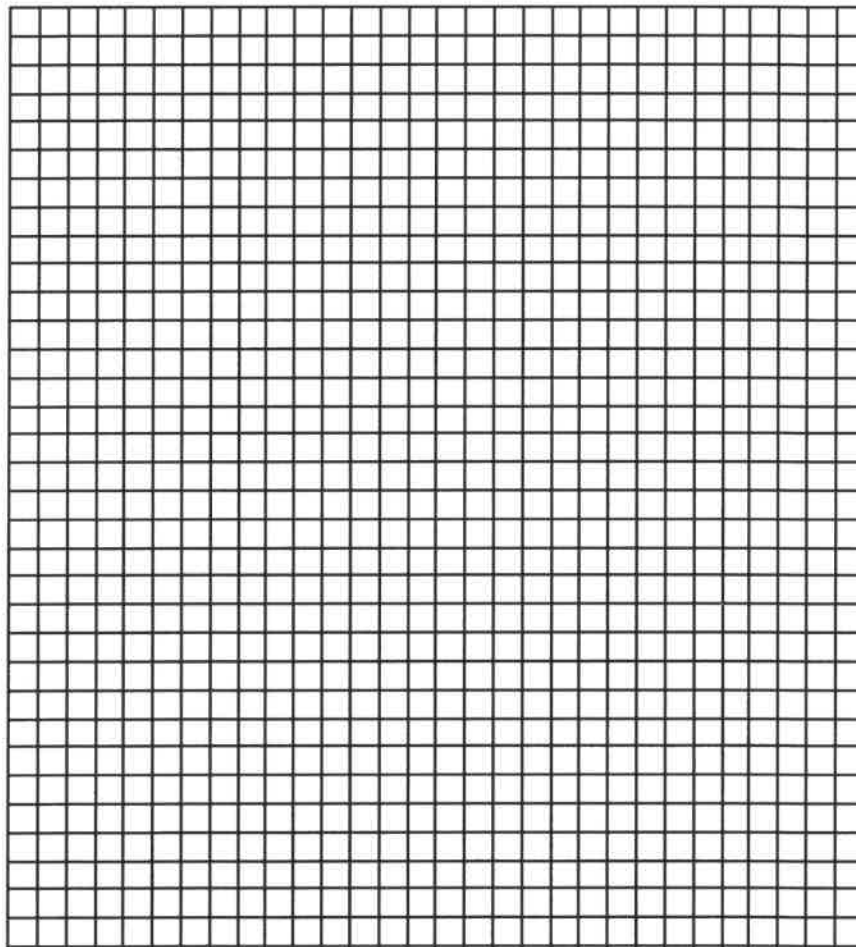
Depth (meters)	Bubbles per minute Plant A	Bubbles per minute Plant B
2	29	21
5	36	27
10	45	40
16	32	50
25	20	34
30	10	20

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3. What is the dependent variable? Why did you pick that answer?

4. What is the independent variable? Why did you pick that answer?

5. What type of graph would be best for this data? Why did you pick that answer?

6. What title would you give this graph?

7. What information would you include in the legend of the graph?

8. What will you label the X-axis with?

9. What will you label the Y-axis with?
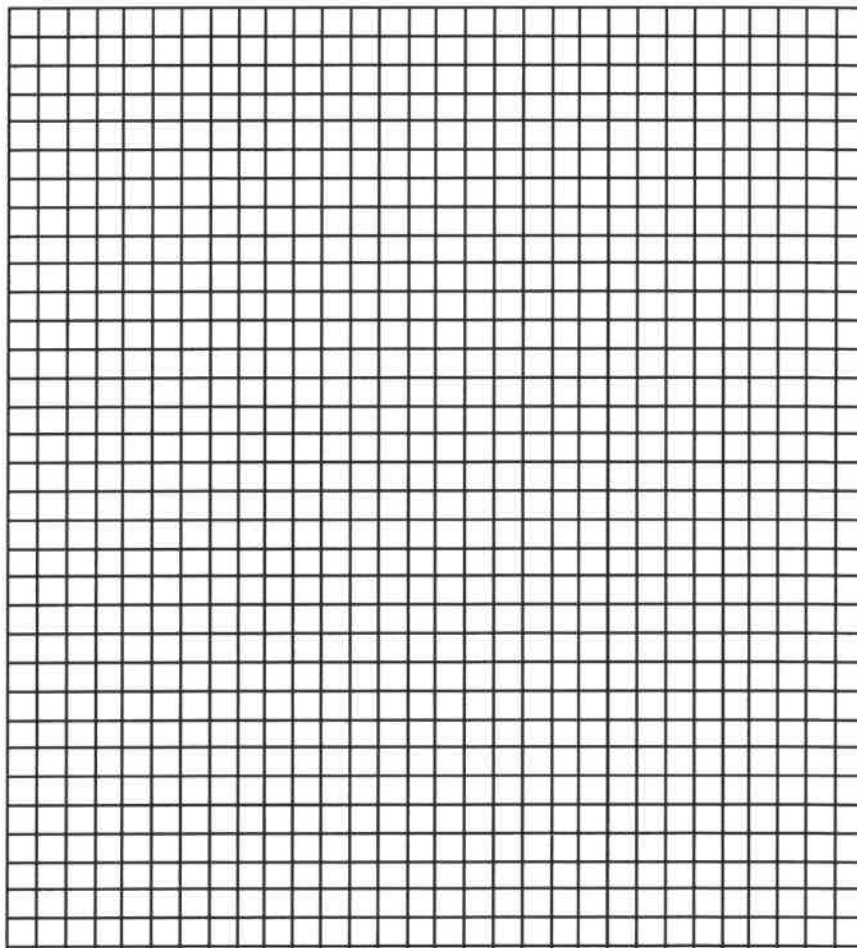
Experiment 2: Use the following data to create an appropriate graph and answer the questions.

Time after eating (Hours)	Glucose in mg/dL Person A	Glucose in mg/dL Person B
0.5	170	180
1	155	195
1.5	140	230
2	135	245
2.5	140	235
3	135	225
4	130	200

10. Which individual would you potentially diagnose as diabetic?

11. What evidence do you have that supports your answer to #10?

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12. IF the time period was extended to 6 hours, what would be the expected blood glucose level for Person A? _____ Person B? _____ (assume they don't eat again).

13. What conclusion can you make about the data and graph for experiment 1?

14. What evidence did you use to support your conclusion?

15. What conclusion can you make about the data and graph for experiment 2?

16. What evidence did you use to support your conclusion?

17. What other type of graph could you have created for experiment 1? For experiment 2?

Interpreting Graphs

In addition to being able to draw a graph based on data collected, you will also need to interpret data given to you in graph form. Answer the following questions based on the graphs presented. NOTE: Most of these are NOT examples of great graphs, they are for interpretation practice only.
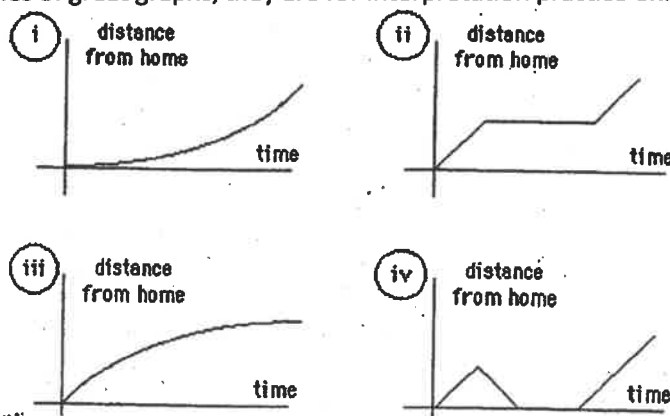
Identify the graph that matches each of the following stories:

18. _____ I had just left home when I realized I had forgotten my books so I went back to pick them up.

19. _____ Things went fine until I had a flat tire.

20. _____ I started out calmly, but sped up when I realized I was going to be late.

The graph to the right represents the typical day of a teenager. Answer the questions:

21. _____What percent of the day is spent watching TV?
22. _____How many hours are spend sleeping?
23. What activity takes up the least amount of time?

24. What activity takes up a quarter of the day?

25. What two activities take up 50% of the day?

26. What two activities take up 25% of the day?

Answer the questions about the graph to the right:

27. How many total miles did the car travel?

28. Describe the motion of the car between hours 5 & 12.

29. What direction is represented by line CD?

30. How many miles were traveled in the first two hours of the trip?

17
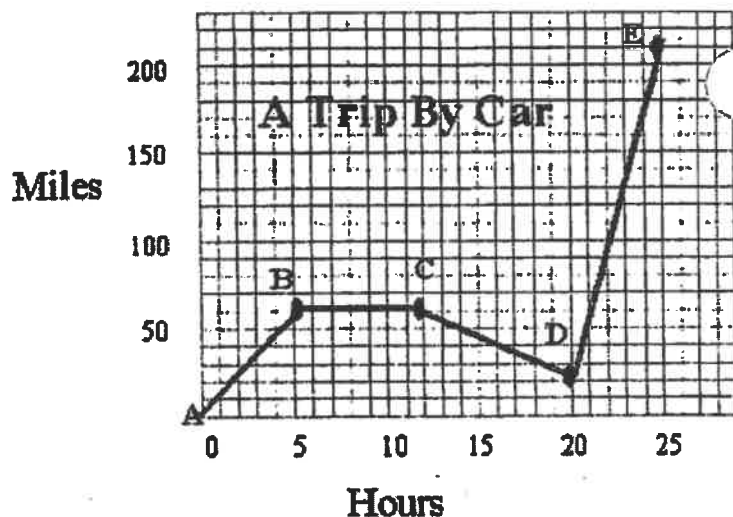
The bar graph to the right represents the declared majors of freshman enrolling at a university. Answer the following questions:

31. What is the total freshman enrollment of the college?

32. What percent of the students are majoring in physics?

33. How many students are majoring in economics?

34. How many more students major in poly sci than in psych?
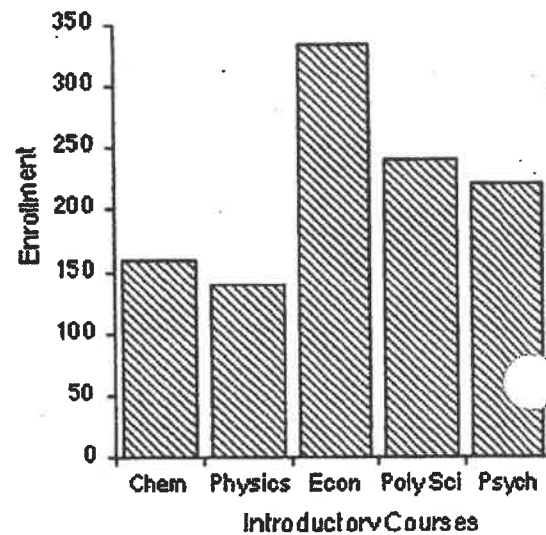
Answer the following questions about the graph below.
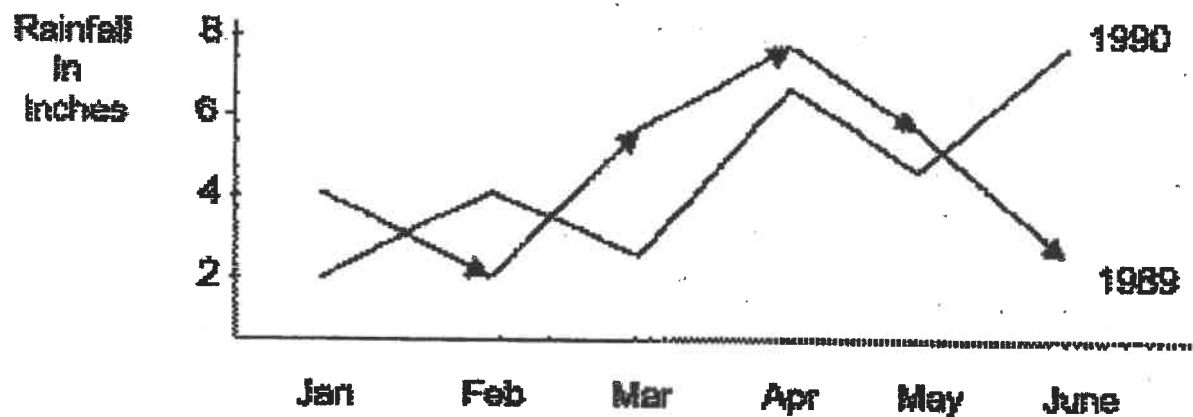
35. How much rain fell in March of 1989?

36. How much more rain fell in Feb of 1990 than in Feb of 1989?

37. Which year had the most rainfall?

38. What is the wettest month on the graph?

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More Graphing Information:

LINE GRAPHS:
Line graphs are most often used to show continuous change. Most scientific graphs are lines graphs. Examine the following data:

Population of the United States 1880-1990

Year	Population (Millions)	Year	Population (Millions)
1881	50.2	1940	131.7
1890	62.9	1950	151.3
1900	76	1960	179.2
1910	92	1970	203.2
1920	105.7	1980	226.5
1930	122.8	1990	251.4

In the example given above, both the year and the populations are variables. The factor which is *changed or manipulated*, in this case the year, is called the **independent variable (IV)**. The *measured effect* of the IV is called the **dependent variable (DV)**. The population is determined by the year; therefore, the population is the dependent variable. Another way to think about the IV and DV is to think about the amount of sleep you get. You know how alert or tired you feel often depends on the number of hours of sleep you got the night before. The amount of sleep is the IV an; your alertness is the DV. Throughout your year of AP Biology, you will be asked to identify variables in many different investigations.

Review "rules and tips for graphing" from front page for how to set up graphs.

Using line graphs to make predictions:
To predict what the population of the US was in the year 2000, you will need to go beyond the data points on the graph. This is called **extrapolation**. We can also use graph to find data point between two sets of plotted data pairs. For example, we can read the graph to determine that the population of the United States in 1905 was approximately 84 million people. Determining data points between two sets of data pairs is called **interpolating**.

Population of the United States, 1889-1990
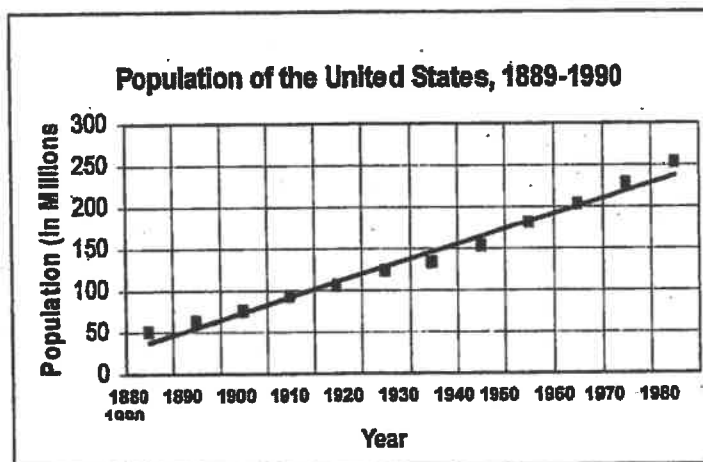
Bar Graphs:
Bar graphs should be used for data that are not continuous. It is a good indicator fo trends if the data are taken of a sufficiently long period of time.

Examples of when to use bar graphs: When comparing different groups. When trying to measure **large** changes over time.

Look at the line graph on the previous page called, "Population of the United States 1889-1990."

1. Predict what the population of the United States will be in 2010. _____
2. Determine the approximate population of the United States in:
    1935: _____ 1945: _____ 1985: _____
3. What was the approximate population of the Untied States in 1970? _____
4. What will be the approximate population in 2020? _____

5. Why would you use a bar graph instead of a line graph?

Precipitation in Hartford Connecticut, April 1-15, 2006
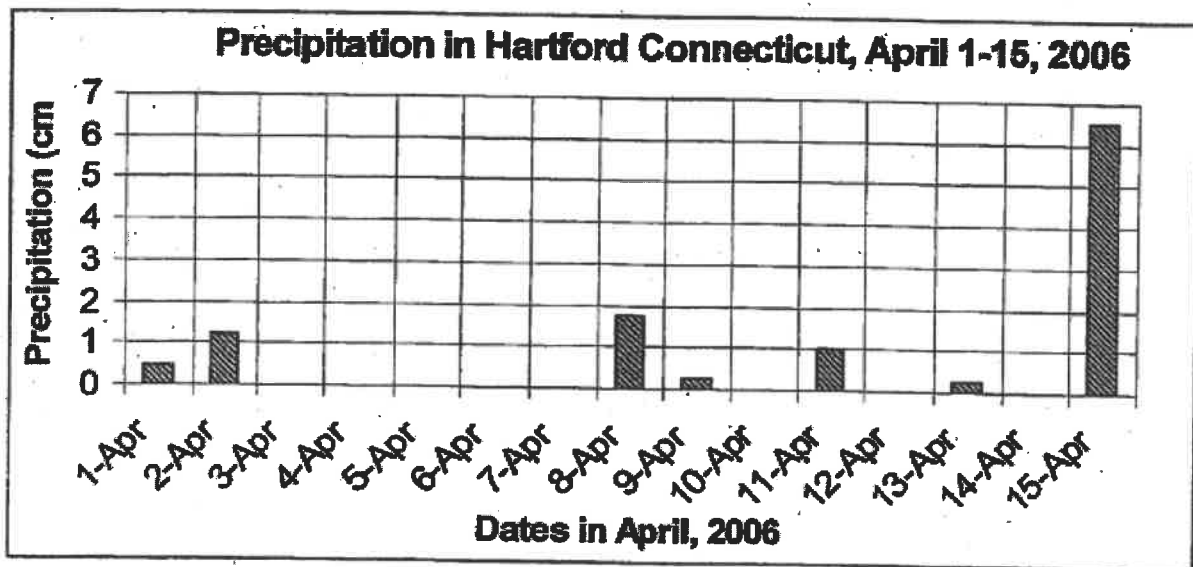
6. According to the bar graph above of precipitation in Harford, CT, how many centimeters of rain fell in Hartford on April 11?

7. Are you able to see any trends in this data set? If so, what is the trend? If not, why not?

8. Can a bar graph show a trend, even if the data are not continuous? Explain.

9. Can the bar graph be used to predict precipitation in Harford on April 20? Why or why not?

10. In 1989, the US Department of the Interior reported that were 360 endangered species of plants and animals in the United States. These endangered organisms included 32 species of mammals, 61 species of birds, 8 species of reptiles, 5 species of amphibians, 45 species of fishes, 3 species of snails, 32 species of clams, 8 species of crustaceans, 10 species of insects, 3 species of spiders, and 153 species of plants. Construct a bar graph of the total number of endangered plants and animals in 1989.
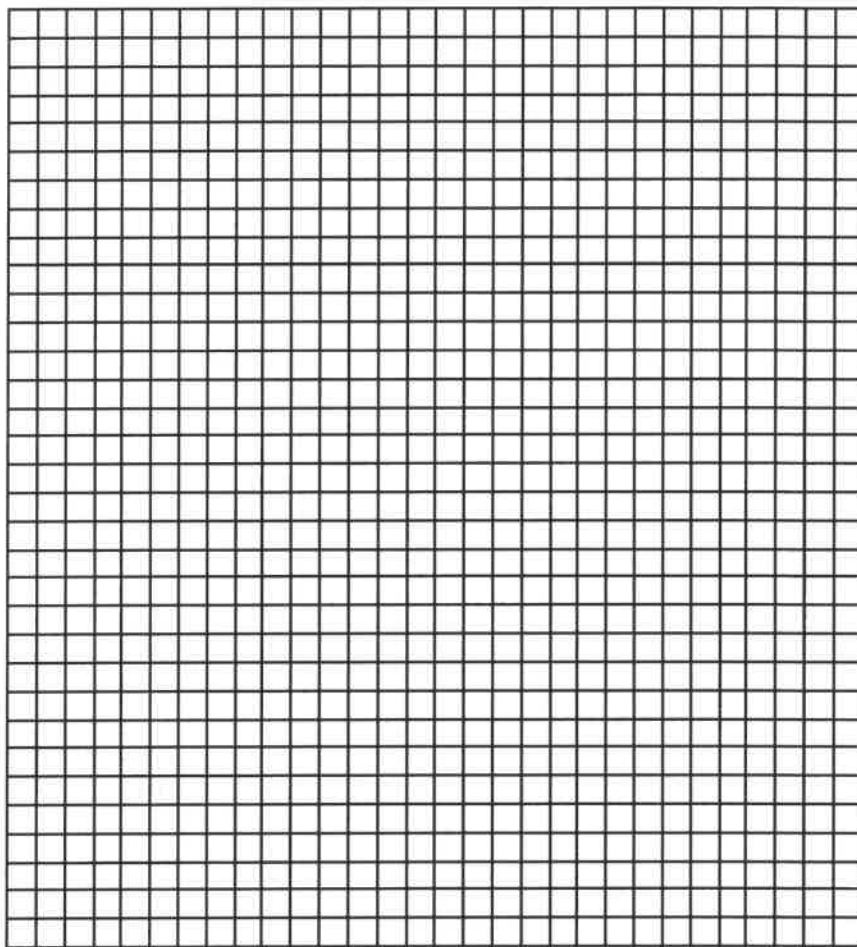
11. After an outbreak of influenza, a student gathered data on the number of students who became ill, until she became sick on the 14th day of her study. The information she gathered is shown below. Create a line graph of the data below.

Date (Feb., 1996)	Number of ill Students
1	12
2	18
3	30
4	49
5	115
6	127
7	125
8	107
9	108
10	115
11	117
12	95
13	60
14	52

Questions:

12. On what day were most students ill?

13. During which period of time did the most students become ill?

14. What was the greatest number of students who were ill on any one day?

15. Estimate the total number of students who were ill on the 15th day.
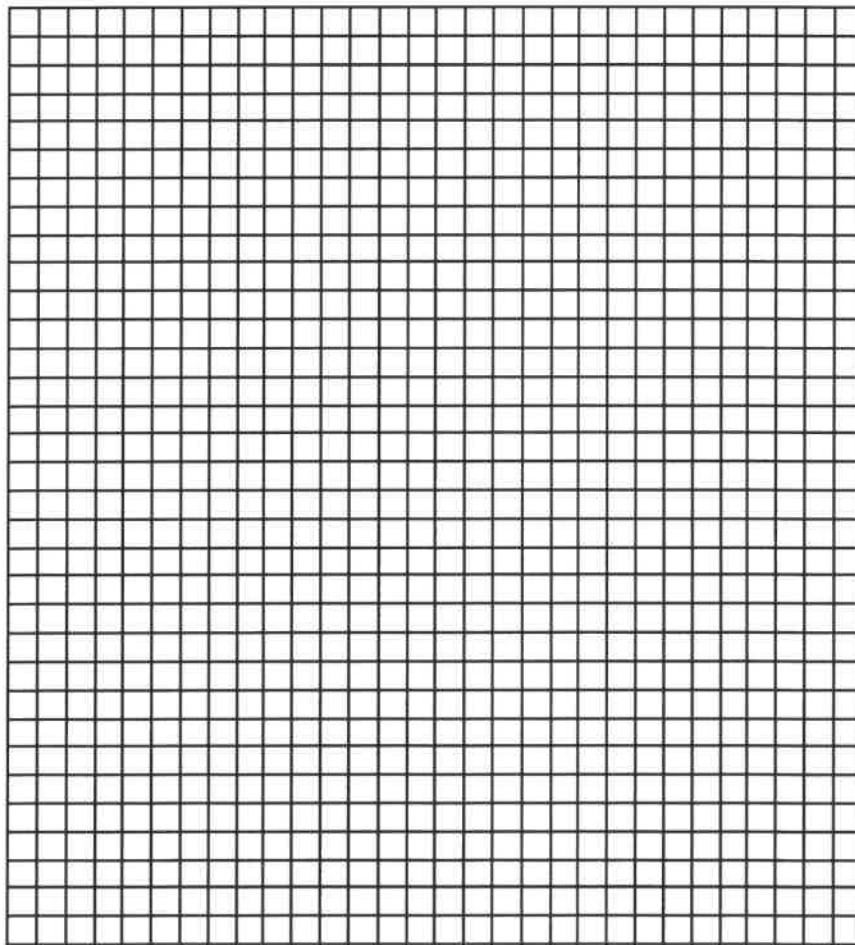
Graphing Skills
Reading, Constructing and Analyzing Graphs

Line Graphs

There are all kinds of charts and graphs used in the science classroom. Graphs are useful tools in science because trends in data are easy to visualize when represented graphically. A line graph is beneficial in the classroom for many different types of data, and is probably the most widely used scientific graph. Line graphs can be used to show how something changes over time or the relationship between two quantities. They can also be readily used to *interpolate* (predict between measured points on the graph) and *extrapolate* (predict beyond the measured points along the same slope) data points that were not actually measured. Analysis of these graphs provides very valuable information.

PURPOSE
In this activity you will learn the basic procedure for constructing and analyzing line graphs.

MATERIALS

3 sheets of graph paper	data
pencil	ruler

PROCEDURE

1. Follow along with your teacher as a sample line graph is constructed. Label a blank piece of graph paper as your teacher explains the important components of a line graph.

2. When instructed, use the sample sets of data to construct line graphs. Place only one graph on each sheet of graph paper and use as much of the graph as possible to display your points. *Do not connect the dots!* Draw the best smooth curve or line of best-fit as your teacher demonstrated.

3. Following the steps below will help ensure that all components of the graph are correctly displayed.
   a. **Identify the variables.** Independent on the *x*-axis and dependent on the *y*-axis
   b. **Determine the range.** For each axis subtract the lowest value data point from the highest value data point.
   c. **Select the scale units.** Divide each axis uniformly into appropriate units using the maximum amount of space available. (Remember that the axes may be divided differently but each square along the same axis must represent the same interval.)
   d. **Number and label each axis.** Be sure to include units where appropriate as part of the axis label.
   e. **Plot the data points as ordered pairs.** (*x,y*)
   f. **Draw the best straight line or best smooth curve.** For a straight line, use a straight edge to draw your line in such a way that equal numbers of points lie above and below the line.
   g. **Title the graph.** The title should clearly describe the information contained in the graph. It is common to mention the dependent variable (*y*-axis) first followed by the independent variable (*x*-axis).

4. After creating graphs for the 3 data sets below, use the graphs to answer the conclusion
   questions on your student answer page.

Sample Data Set 1: The following set of data was collected while experimenting with position
and time of a miniature motorized car traveling on a straight track.

Time (minutes)	Position (meters)
0	0
5	15
10	30
15	45
20	60
25	75

Sample Data Set 2: The following set of data was collected during an experiment to find the
density for an unknown metal.

Volume (cm^3)	Mass (g)
0.18	2.00
0.44	5.00
0.66	7.50
1.41	16.00
2.11	24.00

Sample Data Set 3: The following set of data was collected during an experiment studying the
effect of light on the process of photosynthesis.

Time (minutes)	Percent Transmittance (%)
0	32.5
5	54.3
10	63.5
15	65.0

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Graphing Skills
Reading, Constructing and Analyzing Graphs

Line Graphs

DATA AND OBSERVATIONS
Staple your completed graphs behind this answer page.

CONCLUSION QUESTIONS
Using the graphs that you constructed, answer the following questions:

Sample Data Set 1:

1. What is the independent variable for this graph? Explain.

2. Determine the position of the car after 2.5 minutes.

3. If the experiment were carried out for 30 minutes, what would be the position of the car?

4. Calculate the slope of the line drawn. What does the slope of this line represent? Explain.

5. Write the equation for the line and substitute the value determined for the slope.

Sample Data Set 2:

6. What values were considered when creating the scale for each axis in this experiment?

7. What does a data point on this graph actually represent?

8. What volume would a 20.00 gram sample of this substance occupy?

9. Calculate the density of the substance. (HINT: calculate the slope of the line.)

10. Write the equation for the line and substitute the value determined for the slope.

11. Use the equation to find the mass when the volume is 5.00 cm3.

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Sample Data Set 3:

12. Does this graph represent a linear relationship? Why or why not?

13. Identify the dependent variable in this graph. Explain.

14. If the experiment were continued for 30 minutes, what trend in percent transmittance could be expected?

15. Calculate the slope of the line at 5 minutes. What does this represent?

Numbers in Science
Exploring Measurements, Significant Digits, and Dimensional Analysis

TAKING MEASUREMENTS

The accuracy of a measurement depends on two factors: the skill of the individual taking the measurement and the capacity of the measuring instrument. When making measurements, you should always read to the smallest mark on the instrument and then estimate another digit beyond that.
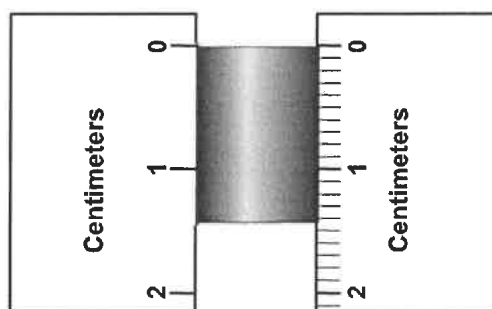
For example, if you are reading the length of the steel pellet pictured above using only the ruler shown to the left of the pellet, you can confidently say that the measurement is between 1 and 2 centimeters. However, you MUST also include one additional digit estimating the distance between the 1 and 2 centimeter marks. The correct measurement for this ruler should be reported as 1.5 centimeters. It would be incorrect to report this measurement as 1 centimeter or even 1.50 centimeters given the scale of this ruler.

What if you are using the ruler shown on the right of the pellet? What is the correct measurement of the steel pellet using this ruler? 1.4 centimeters? 1.5 centimeters? 1.40 centimeters? 1.45 centimeters? The correct answer would be 1.45 centimeters. Since the smallest markings on this ruler are in the tenths place we must carry our measurement out to the hundredths place.

If the measured value falls exactly on a scale marking, the estimated digit should be zero.

The temperature on this thermometer should read 30.0°C. A value of 30°C would imply this measurement had been taken on a thermometer with markings that were 10° apart, not 1° apart.

When using instruments with digital readouts you should record all the digits shown. The instrument has done the estimating for you.

When measuring liquids in narrow glass graduated cylinders, most liquids form a slight dip in the middle. This dip is called a *meniscus*. Your measurement should be read from the bottom of the meniscus. Plastic graduated cylinders do not usually have a meniscus. In this case you should read the cylinder from the top of the liquid surface. Practice reading the volume contained in the 3 cylinders below. Record your values in the space provided.

Left:_____

Middle:_____

Right:_____
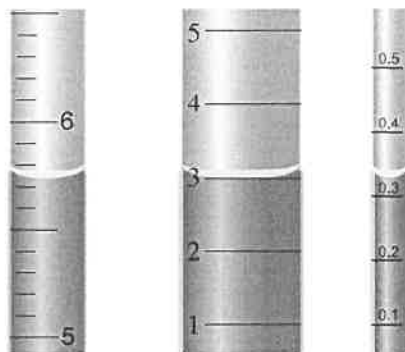
SIGNIFICANT DIGITS

There are two kinds of numbers you will encounter in science, exact numbers and measured numbers. *Exact numbers* are known to be absolutely correct and are obtained by counting or by definition. Counting a stack of 12 pennies is an exact number. Defining 1 day as 24 hours are exact numbers. Exact numbers have an infinite number of significant digits.

Measured numbers, as we've seen above, involve some estimation. Significant digits are digits believed to be correct by the person making and recording a measurement. We assume that the person is competent in his or her use of the measuring device. To count the number of significant digits represented in a measurement we follow 2 basic rules:

1. If the digit is NOT a zero, it is significant.

2. If the digit IS a zero, it is significant if

    a. It is a sandwiched zero.

       OR

    b. It terminates a number containing a decimal place.

1) Determine the value for the minor grids on the cylinder.
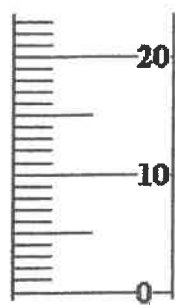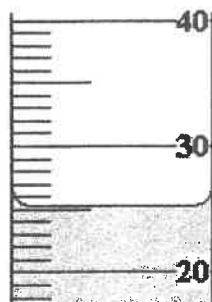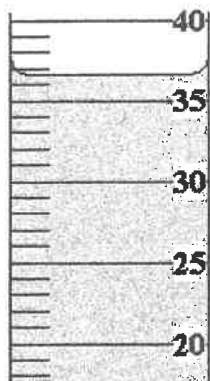
a) _____
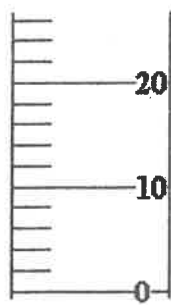
b) _____
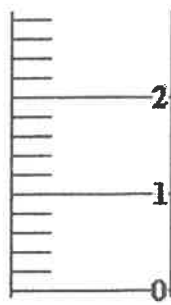
c) _____
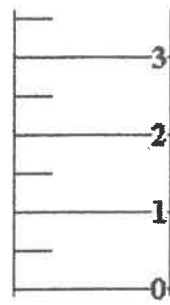
d) _____

When reading a graduated cylinder you need to keep the graduated cylinder on the desk and lower your eyes to the level of the meniscus and you read where the bottom of the meniscus is. Be sure to include one point of estimation in your reading.
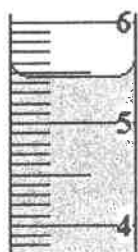
12.4 mL
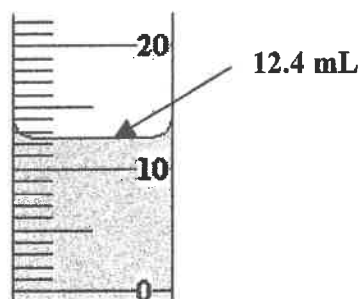
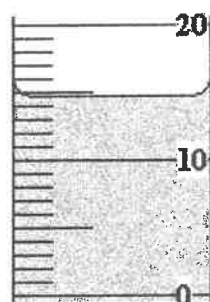2) Determine the volume of the liquids in the following cylinders:
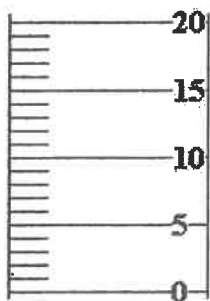
a) _____

b) _____

c) _____

d) _____

3) Draw in the meniscus for the following readings:

a) 49.21 mL

b) 18.2 mL
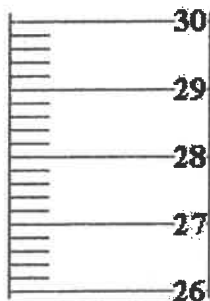
c) 27.65 mL
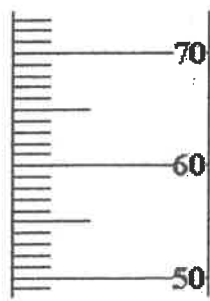
d) 63.8 mL

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Examples:

3.57 mL has 3 significant digits (Rule 1)
288 mL has 3 significant digits (Rule 1)
20.8 mL has 3 significant digits (Rule 1 and 2a)
20.80 mL has 4 significant digits (Rules 1, 2a and 2b)
0.01 mL has only 1 significant digit (Rule 1)
0.010 mL has 2 significant digits (Rule 1 and 2b)
0.0100 mL has 3 significant digits (Rule 1 and 2b)
3.20×10^4 kg has 3 significant digits (Rule 1 and 2b)

SIGNIFICANT DIGITS IN CALCULATIONS

A calculated number can never contain more significant digits than the measurements used to calculate it.

Calculation rules fall into two categories:

1. <u>Addition and Subtraction</u>: answers must be rounded to match the measurement with the *least* number of *decimal places*.

    37.24 mL + 10.3 mL = 47.54 (calculator value), report as 47.5 mL

2. <u>Multiplication and Division</u>: answers must be rounded to match the measurement with the *least* number of *significant digits*.

    1.23 cm × 12.34 cm = 15.1782 (calculator value), report as 15.2 cm^2

Scientific Notation and Unit Prefixes

Make the following conversions:

1)   3.4 liters to milliliters

6)   45 meters to centimeters

2)   876 millimeters to meters

7)   11.7 grams to kilograms

3)   78,999 milligrams to grams

8)   0.0009 kiloliters to liters

4)   0.9 centigrams to grams

9)   44 centimeters to meters

5)   112 meters to millimeters

10)   277 kilograms to grams

Convert the following to scientific notation:

11)   45,700 _____

12)   0.009 _____

13)   23 _____

14)   0.9 _____

15)   24,212,000 _____

16)   0.000665 _____

Convert the following to scientific notation:

17) 21.9 _____

18) 0.00332 _____

19) 321 _____

20) 0.119 _____

21) 1492 _____

22) 0.2713 _____

23) 314159 _____

24) 6022 _____

25) 0.12011 _____

Convert the following numbers in scientific notation to expanded form:

26) 3.825×10^3 _____

27) 6.3×10^4 _____

28) 2.3×10^{-2} _____

29) 4.44×10^{-6} _____

30) 7.121×10^9 _____

31) 1.2×10^{-1} _____

32) 1.8×10^2 _____

33) 8.1×10^{-4} _____

34) 6.7×10^5 _____

35) 3.4×10^7 _____

Significant Figures Practice Worksheet

How many significant figures do the following numbers have?

1) 1234 _____

2) 0.023 _____

3) 890 _____

4) 91010 _____

5) 9010.0 _____

6) 1090.0010 _____

7) 0.00120 _____

8) 3.4×10^4 _____

9) 9.0×10^{-3} _____

10) 9.010×10^{-2} _____

11) 0.00030 _____

12) 1020010 _____

13) 780. _____

14) 1000 _____

15) 918.010 _____

16) 0.0001 _____

17) 0.00390 _____

18) 8120 _____

19) 7.991×10^{-10} _____

20) 72 _____

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Name: _____

_____

1. Round off each of the following numbers to three significant figures:
   a. 15.9994
   b. 0.6654
   c. 87550
   d. 1.0080
   e. 4885
   f. 0.027225

2. Put the following numbers into scientific notation AND write the number of significant digits in each:
   a. 0.225
   b. 4163
   c. 0.000000000000991
   d. 2.5
   e. 20190
   f. 7000

3. How many significant figures are in each of the following numbers?
   a. 225.0
   b. 0.0003210
   c. 1000000.
   d. 1000.0
   e. 0.0067
   f. 2.00001

4. Perform the indicated arithmetic operations, and round the results to the appropriate number of sig figs:
   a. $77.981 \times 2.33 =$ _____.
   b. $4 \times 0.0665 =$ _____.
   c. $17.34 + 4.900 + 23.1 =$ _____.
   d. $9.80 - 4.762 =$ _____.
   e. $3.9 \times 6.05 \times 420 =$ _____.
   f. $14.2 / 5 =$ _____.
   g. $1001 + 16.23 =$ _____.
   h. $424.5 + 2.8461 =$ _____.
   i. $9.9 - 9.54 =$ _____.
   j. $7.3778 - 0.000265 =$ _____.
   k. $8.561 \times 10^{6} - 6.21 \times 10^{10} =$ _____.

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Mathematical Manipulations: name: _____

Solve the following problems, Use appropriate significant figures

1. What is the volume of a region of space that measures 752 m x 319 m x 110 m?

2. A 125 mL sample of liquid has a mass of 0.16 kg. What is the density of the liquid?

3. A box measures 900. Mm by 31.5 mm by 6.3 cm. What is the volume of the box? If the box weighs 25g what is its density?

4. A container measures 30.5 mm x 202 mm x 153mm. When it is full of a liquid, it has a mass of 1.33 kg. When it is empty, it has a mass of 0.30 kg. What is the density of the liquid in kg/mm^3?

5. While conducting an experiment a student produced 22.8 g of aspirin. The actual yield should have been 27.8 g. What is the student's percent error?

6. Mary measured the volume of ethanol to be 10.95 mL. The actual volume of alcohol present was 11.97mL. What is Mary's percent error?

7. Patrick measured the specific heat of water to be 3.181 J/g.K. The actual specific heat of water is 4.184 J/g.K. What is Patrick's percent error?

8. In an experiment you determined the temperature of a reactant to be 67.5°C. However, your thermometer was off by 1.5°C, meaning that the actual temperature was 69.0°C. What is your percent error?

9. Cerium sulfate has a density of 3.17 g/cm^3. Calculate the volume of 100g of cesium sulfate.

10. Chromium silicide has a density of 6.60 g/cm^3. Calculate the volume of 35.9g of this substance

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Unit One Matter & Measurement Review

1. What is chemistry?

2. Convert the following & SHOW YOUR WORK!!

   56mm → _____ km

   7.68×10^4 cm → _____ m

   365 K→ _____ °C

   98.6°C → _____ K

3. A sample of bismuth has a mass of 342 g and a volume of 1.64 cm³. What is the density of bismuth?

4. Using a metric ruler with 1-mm divisions, you find the sides of a rectangular piece of plywood are 3.54 cm and 4.85 cm. You calculate that the area is 17.1690 cm2. To the correct number of significant figures, the result should be expressed as _____.

SHOW WORK HERE:

5. Compute each of the following, making sure the units and number of significant figures are correct.
   a. 18 cm³ + 9.0 cm³ = ?   b. 5 moles x 12 grams/mole = ?

   c. 12 sec x 11 meters/sec² = ?   d. 3.00 m x 4.6 m² = ?

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e. $\dfrac{72 \text{ grams}}{1.33 \text{ g/ml}} = ?$

f. $\dfrac{72 \text{ moles}}{9.0 \text{ moles/liter}} = ?$

6. Determine the density of the salt water using the chart below.

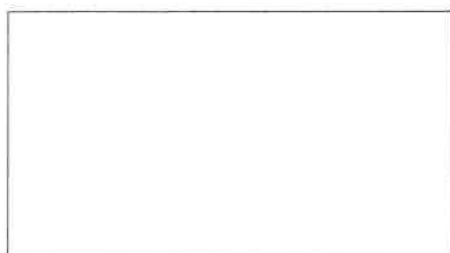| Mass of empty beaker | 56.86 g |
| Mass of beaker and 30.0 mL salt water | 81.36 g |

7. Draw four diagrams to represent each of the following:

High accuracy & high precision
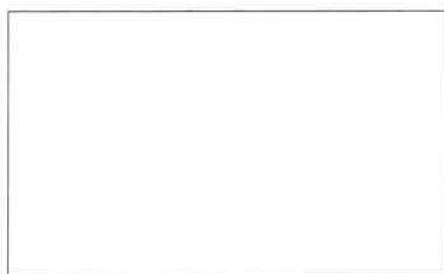
high accuracy and low precision
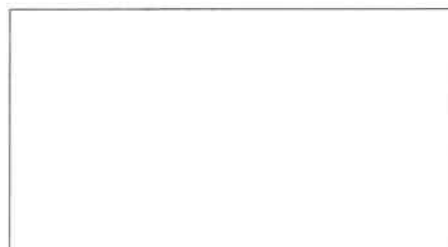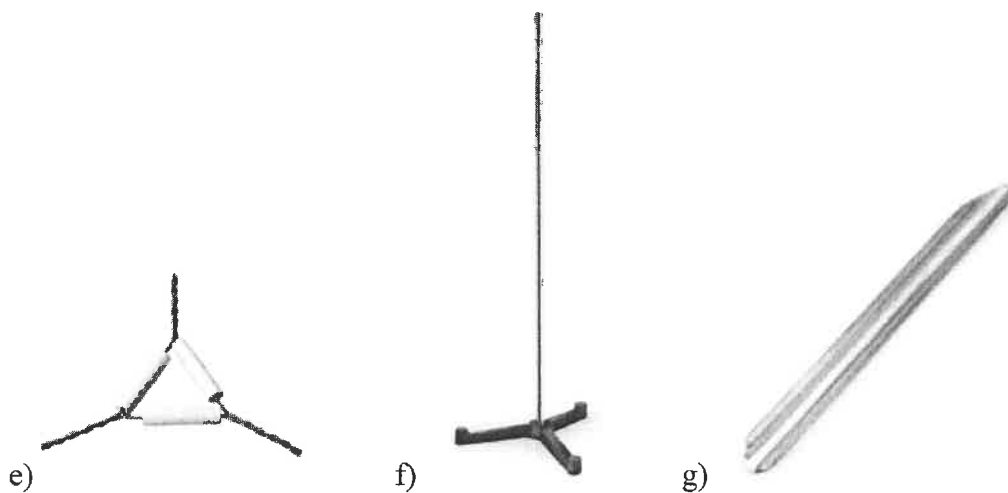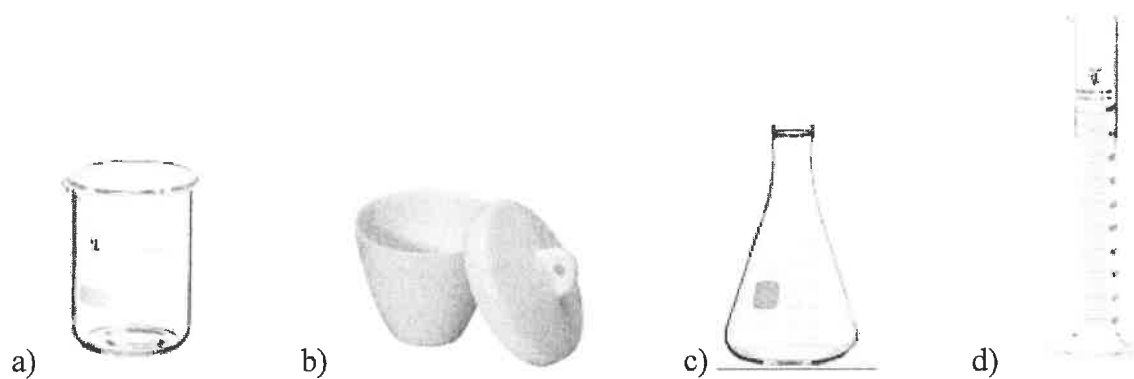
High precision and low accuracy

low precision and low accuracy

8. How are the rules for using significant figures different with addition & subtraction than using multiplication & division?

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9. Identify the following pieces of laboratory equipment.

a) b) c) d)

e) f) g)

10. Determine the density of the salt water using the information below.

Mass of the empty beaker	56.86g
Mass of the beaker and 30.0ml salt water	81.36g

Convert the following to the correct units. SHOW ALL WORK
11) 37.6ml → L   12) 545kg → dg   13) 0.00054hL → cL

14) 0.058mm → km

Identify the correct number of significant figures.
15) 1070   ____
16) 5.0430   ____
17) 511.010   ____
18) 0.0178   ____

Convert the following using scientific notation.
19) 509000   _____
20) 7.84 x 10^{-4} _____

Solve the following problems. Use the proper number of significant figures and units.
21) 12.78g/10.0ml   _____
22) 9.878g – 4.31g   _____
23) 15g + 8.55g   _____
24) 1248g/1010ml   _____
25) 1.23cm x 2.74cm x 2.1cm _____

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