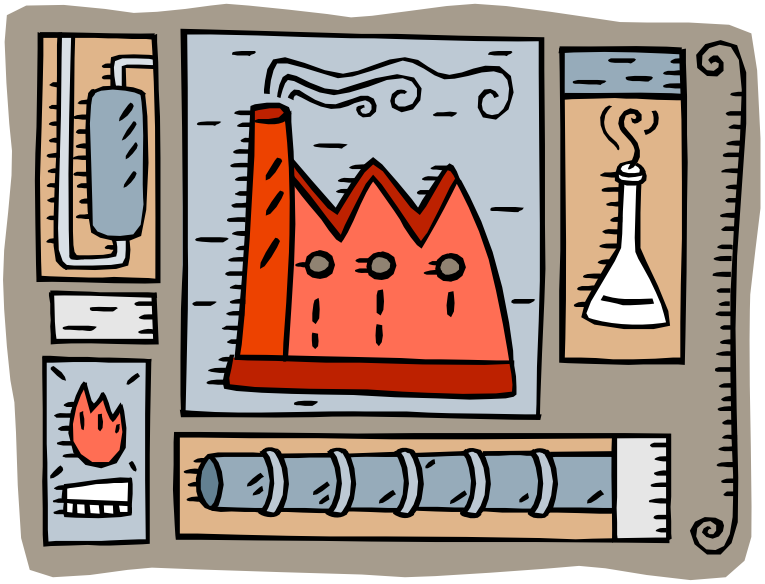
Scientific Investigation, Reasoning and Logic



Concept Sheet
Scientific Investigation, Reasoning, and Logic

LS.1 and PS.1: The student will plan and conduct investigations.

1. **Investigations** are classified as **observational studies** or **experimental studies**.
   An *observational study* may generate a **hypothesis** (a testable prediction).
   - An **observation** is the gathering of information by using the senses.

   An *experimental study* (experiment) tests a hypothesis.
   - An **experiment** is an organized process used to gather observations and test a hypothesis. The first step in designing an experiment is to the state the **problem**.

   Example: *Does the amount of water available affect how tall a corn plant grows?*

2. A **hypothesis** (a testable prediction) is a possible answer to the stated problem. It is stated so that the independent (manipulated) and dependent (responding) variables are identified.

   Hypothesis example: *If a corn plant receives more water, then it will grow taller.*

   It is often helpful to conduct research on a topic before an experiment is conducted. Resources in print (i.e., scientific articles, journals, and books) and electronic resources (i.e., online encyclopedias and websites) are readily available. The researcher must determine whether the resource is credible.

3. An experiment should have only two things that change.
   1) The **independent variable** is the condition that you change on purpose (the *manipulated variable*). The *levels of the independent variable* are the various ways you change the independent variable.
   2) The **dependent variable** is the condition that changes in response to the variable that you intentionally change (the *responding variable*). It is the variable you measure to see if there is a change.

   Corn plant example:
   - The *amount of water given* to corn plants is the independent variable.
   - *How tall the corn plants grow* is the dependent variable.
   - The levels of the independent variable are the *various amounts of water given to the plant*.

4. All experiments should have only one independent variable that you manipulate (change) during many repeated trials. *In our corn plant example, the independent variable was the amount of water.*

   Repeated trials reduce the effects of chance or random errors that may occur in a single trial. Repeated trials also verify results.
   The **reliability** of an experiment increases as the number of trials increases.

   If you test only one corn plant, that particular plant could be diseased, and you may not obtain a valid result from your experiment. Using more plants (repeated trials) helps verify the results and reduces the chance of random errors.

5. Other than the independent and dependent variables, nothing in an experiment should change. **Constants** are the unchanged conditions in an experiment. Constants are important because they show that the dependent variable is responding only to the independent variable.

   Examples of constants:
   The type of plant, the age of the plant, the brand of fertilizer, the amount of sunlight

6. Many experiments also have **controls**. A control is a group or sample that gets no experimental treatment and is used as a standard for comparison.

   Example of a control:
   Watering some corn plants with the usual amount of water (the control) would allow the researcher to compare the effects of watering with more and less water (the independent variable).

7. A **data table** is used in an experiment to organize and record results. A data table makes it easier to analyze the results of the experiment, and it reports data to other people. The data table should have a column for the levels or variations of the independent variable. There should be a column for the results of each repeated trial. There may be a final column that shows the average results of the repeated trials. The independent variable is usually found in the left hand column.

Independent Variable: Amount of Water (L)	**Dependent Variable:** Height of Plants (m)			Average Plant Height (m)
	Trial A	Trial B	Trial C	
0.5	1.3	1	0.9	1.1
1.5	2	2.1	2.3	2.1
2.5	3	3.7	4	3.6

Levels of the independent variable

Average over all repeated trials

Columns for Repeated trials

8. After all data are collected for an experiment, the data are usually illustrated as a graph. **Graphs** help people see trends in the data.

   Commonly used graphs:
   - **Bar graphs** are used when the independent variable is in levels that are unconnected and not continuous. In a bar graph, each separate bar represents each level of the independent variable.
   - **Line graphs** are used if the independent variable is **continuous**, such as time. When constructing a line or bar graph, the independent variable is on the X-axis and the dependent variable is on the Y-axis. The plotted points are connected or a line of best fit is drawn. Continuous line graphs can be used to make predictions.
   - **Circle graphs** are generally used to present data that represent percentages of a whole.
   - **Scattergrams**, or scatterplots, display data which are represented as dots related to a two-dimensional axis. Values of the dependent variable are plotted along the vertical (y) axis; values of the independent variable along the horizontal (x) axis.

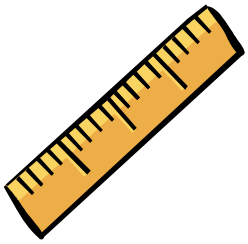
9. After writing down and analyzing the data from an experiment, a **conclusion** is written. A **conclusion** is a summary of the results of your experiment. The conclusion may include possible sources of experimental error and ideas to improve the experiment.

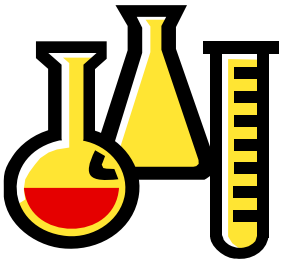
10. When a problem deals with something complicated or difficult to see, you could develop a **model**. A model is an idea or system that represents what you are explaining. It is never exactly like the thing being explained, but it is similar enough to allow comparisons. Models can be used to estimate distances, volumes, and/or quantities.

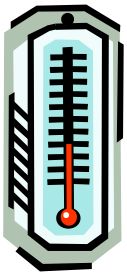
    A **scale model** is a proportional copy of an object or structure. For example, you may use a smaller model rather than the real thing to see how the shape of an airplane wing affects flight performance, or you may create a larger model of a cell out of clay.

11. The **"International System of Units"** (SI Units) is the official name for the metric system. The **metric system** of measurement is always used in scientific investigations.

Measurement	Basic SI Unit	Measuring Instrument
Length	Meter (m)	Metric Ruler
Mass	Gram (g)	Triple Beam Balance
Volume	Liter (L) or cm^3	Graduated Cylinder
Weight	Newton (N)	Spring Scale
Temperature	Degrees Celsius (^oC) or Kelvin (K)	Thermometer
Density	Grams per Cubic Centimeter (g/cm^3)	Calculate from mass and volume
Time	Second	Clock or Stopwatch







Length	**Volume**	**Temperature**	**Time**
Meter (m)	Liter (L) or cm^3	Degrees Celsius (^oC) or Kelvin (K)	Second

12. **Prefixes** can be applied to the basic metric units to indicate a smaller or larger measurement. Conversions can be made easily among metric units as they are based on powers of ten. Scientific Notation is used to express numbers with lots of zeros, but can be used on any number.

Prefix	Symbol	Multiplier	Scientific Notation
Larger than 1 of the unit			
mega-	M	1,000,000	1×10^6
kilo-	k	1,000	1×10^3
hecto-	h	100	1×10^2
deka-	da	10	1×10^1
Smaller than 1 of the unit			
deci-	d	0.1	1×10^{-1}
centi	c	0.01	1×10^{-2}
milli	m	0.001	1×10^{-3}
micro-	μ	0.000001	1×10^{-6}

13. **Scientific Notation** is used to write very large and very small numbers.

For example, the mass of the earth is 5,980,000,000,000,000,000,000,000 kilograms. To make it easier to write this very large number, scientists use scientific notation. The mass of the earth written in scientific notation is 5.98×10^{24} kilograms (the decimal is moved 24 digits to the left).

In numbers less than one, the decimal is moved to the right and the notation contains a negative number, as in "micro" above: $0.000001 = 1 \times 10^{-6}$

Scientific Investigation, Reasoning, and Logic

Name _____ Class _____ Date _____

Read each question and choose the best answer or complete the required task.

___1. The process of gathering information through the senses is called ___

A. analyzing.
B. concluding.
C. hypothesizing.
D. inferring.
E. observing.

___2. An idea, structure, or system that can be used to represent something you are trying to explain is a ___

A. constant.
B. hypothesis.
C. law.
D. model.
E. variable.

___3. In an experiment, the condition that changes as a result of manipulating the independent variable is the ___

A. constant.
B. control.
C. dependent variable.
D. hypothesis.
E. stated problem.

4. We want to see how changing the amount of sunlight a plant receives affects its growth. If one plant gets the normal amount of sunlight, we would call this plant the

_____

___5. An organized process used to gather observations and then test a hypothesis is ___

A. an exercise.
B. an experiment.
C. a constant.
D. a problem.
E. a graph.

___6. When designing an experiment, the first step is to ___

A. analyze the data.
B. list a procedure.
C. state a hypothesis.
D. state the problem.
E. create a graph.

___7. In an experiment, the condition that is manipulated to cause a change in the dependent variable is called the ___

A. constant.
B. control.
C. dependent variable.
D. hypothesis.
E. independent variable.

8. What do we call a testable prediction about a possible solution to a problem?

_____

___9. A beaker contains 0.32 liters of water. What is the volume in milliliters?

A. 320 mL
B. 32 mL
C. 3.2 mL
D. 0.32 mL
E. 0.032 mL

___10. The prefix milli- added to ***any*** metric unit means ___

A. 1,000
B. 100
C. 0.01
D. 0.001
E. 0.0001

___11. A condition that does ***not*** change in an experiment is the ___

A. constant.
B. control.
C. dependent variable.
D. hypothesis.
E. independent variable.

___12. Convert the following number to scientific notation: 200,000,000,000.

A. 2.0×10^{12}
B. 200×10^{12}
C. 2.0×10^{10}
D. 20×10^{11}
E. 2.0×10^{11}

___13. The ***best*** type of graph to use to display data in parts that add up to a whole (100 percent) is a ___

A. a bar graph.
B. a line graph.
C. a circle graph.
D. a scatter graph.
E. a histogram.

___14. The correct symbol for temperature in the metric system is ___

A. ^{o}C
B. ^{o}F
C. ^{o}K
D. ^{o}S
E. ^{o}T

___15. How many meters are there in 1,865 centimeters?

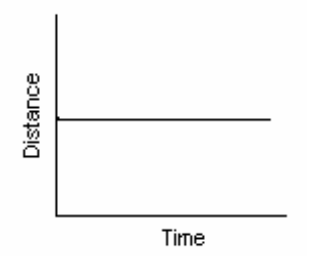
A. 0.1865
B. 1.865
C. 18.65
D. 186.5
E. 18,650

16. In the table below, fill in each blank with the property being measured and the instrument you would use to obtain that measurement.

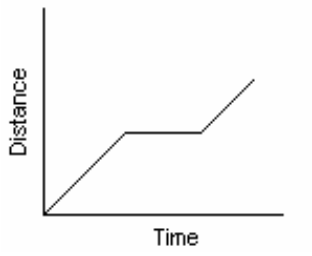
METRIC UNIT	**MEASUREMENT**	**INSTRUMENT USED**
Example: second	*time*	*stopwatch*
A. meter		
B. ^{o}C		
D. gram		
E. liter		

Refer to the following graphs to answer questions 17 & 18.

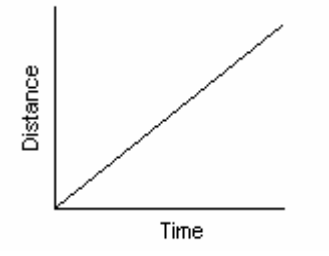
a.



b.



c.



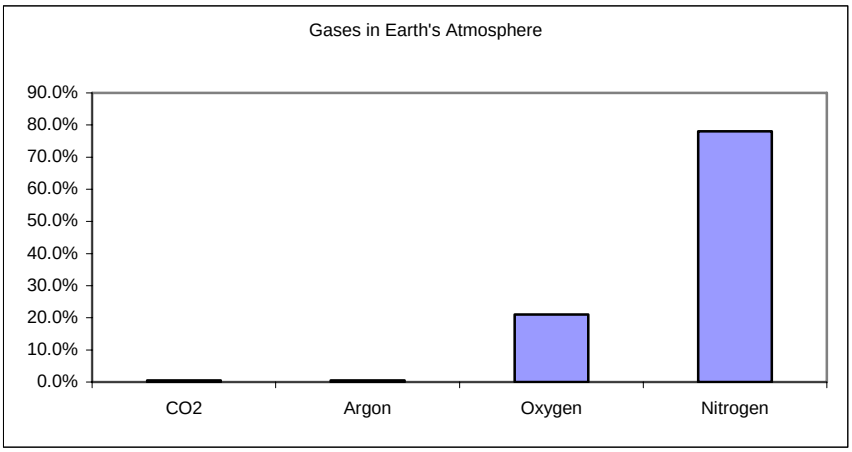
____17. Which graph shows, that as time increases, an object is moving at a constant speed?

A. a
B. b
C. c
D. None of the above
E. All of the above

____18. What is the dependent variable that is measured on graph (b)?

A. Time
B. Distance
C. Speed
D. None of the above
E. All of the above

Refer to the following graph to answer questions 19 & 20.



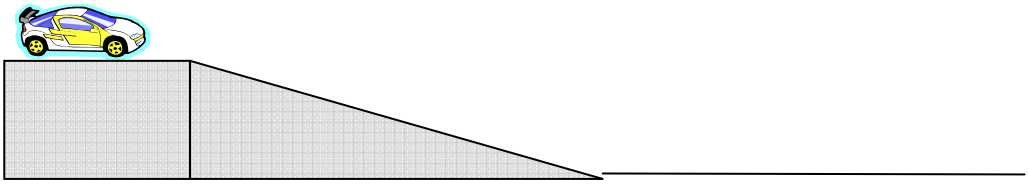
19. What type of graph is shown above?

_____

____20. According to the graph, what percentage of air is oxygen?

A. 78%
B. 21%
C. less than 5%
D. 10%
E. 90%

___21. Some students want to find out how the height of a ramp affects how far a toy car can travel on a smooth floor after going down the ramp. How should the students test their problem?



A. Set up 3 ramps with different heights on 3 different floor surfaces for each trial and use the same car for each trial.
B. Set up one ramp on the same floor surface for each trial and use 3 different cars.
C. Set up 3 ramps with different heights on the same floor surface for each trial and use the same car.
D. Set up one ramp on 3 different floor surfaces for each trial and use the same car.
E. Set up 3 ramps with different heights on the same floor surface for each trial and use three different cars.

___22. What instrument would provide the ***best*** data for the toy car experiment?

A. Triple beam balance
B. Stopwatch
C. Thermometer
D. Protractor
E. Meter stick

___23. In the toy car experiment, what is the independent variable?

A. Type of floor surface
B. Type of car
C. Height of ramp
D. Distance the car travels
E. None of the above

24. Write a hypothesis for the toy car experiment.

25. What are the constants for the toy car experiment?

26. Why is it important to conduct repeated trials in an experiment? What effect do they have on the reliability of the experiment?

27. When is a conclusion written? What information does a good conclusion include?

Refer to the following chart to answer question 28.

Mammal	Class	Order	Family	Genus	Species
1	Mammalia	Artiodactyla	Giraffidae	*Okapia*	*johnstoni*
2	Mammalia	Artiodactyla	Giraffidae	*Giraffa*	*camelopardalis*
3	Mammalia	Artiodactyla	Camelidae	*Camelus*	*dromedarius*
4	Mammalia	Artiodactyla	Camelidae	*Lama*	*pacos*
5	Mammalia	Artiodactyla	Camelidae	*Lama*	*glama*

___28. Which of the species shown are ***most*** closely related?

A. 1 and 2
B. 2 and 3
C. 3 and 4
D. 3 and 5
E. 4 and 5

29. Name <u>one print resource</u> and <u>one electronic resource</u> that you have used in Life or Physical Science and state **why** you consider it to be a valid and reliable resource.
(Note: The resources should be different, not a print resource and its online version)