Honors Chemistry Summer Assignment for Incoming Freshmen

The honors chemistry summer assignment is comprised of four parts and is designed to prepare students for the first unit of study as well as review essential information from the junior high physical science standards and the ELA science literacy standards. **All work is to be done by the individual student.** The summer assignment is due on the first day of class (August 15 – A day and August 16 - B day). The grade for this assignment will be equal to one summative assessment grade (75 points). If you have questions regarding summer homework, please contact Mrs. Engel via email. Mrs. Engel's email is dengel@mchs.net

PART 1: **Atomic Structure Venn Diagram** (10 points)

What do you know about the structure of the nuclear atom? Brainstorm everything you know about the atom, its parts, and its structure. Draw a diagram to help you visualize the atom and label all parts of your drawing. Don't worry if you are right or wrong just list everything you remember. Once you have brainstormed, read the "Expert" articles on the Bohr model and the Rutherford Model. Create a Venn diagram with two overlapping circles – "Bohr" and "Rutherford" In the intersection of the circles, record how these models compare. In the outer circles, list the differences or how these models contrast. Turn in both your labeled drawing and your Venn diagram.

PART 2: **Scientific Measurement** 1-2 page typed essay (25 points)

One of the most important skills we will use this year is scientific measurement. Read the articles on accuracy, precision, and significant figures. Answer the following essential questions in an expository essay. Make sure your essay answers these questions and references the articles.

- What determines if a measurement is good?
- How does measurement error impact data collection or data calculations?
- Why is measurement important in science?
- How does a scientist utilize significant figures in calculations and why is this important?

PART 3: **Claim, Evidence, and Reasoning (15 points)**

Read the segment CER Writing. Write a paragraph to answer the following question: Which samples of matter are the same substance and which are different substances? Follow the CER format. You will need to include the following academic vocabulary words: intensive properties, extensive properties, and physical properties in your reasoning. Do all questions on a separate sheet of paper.

Claim, Evidence, and Reasoning Summer Homework

Sample	Volume	Mass	Density	Color	Boiling point
1	100.0 mL	100.0 g	1.0 g/mL	Clear	100°C
2	100.0 mL	78.57 g	0.7857 g/mL	Clear	56°C
3	50.0 mL	50.0 g	1.0 g/mL	Clear	100°C
4	50.0 mL	39.3 g	0.786 g/mL	Clear	82.6°C

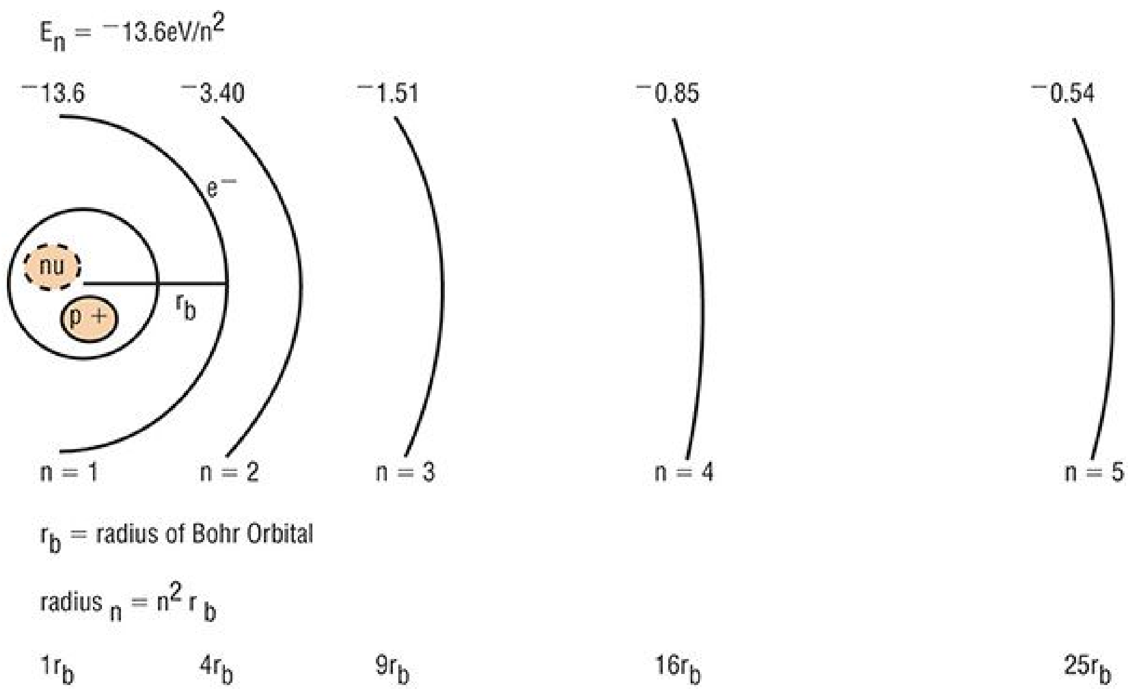
1) In a complete sentence, make a *claim* based on the above data set and based on your knowledge of physical properties.
2) In complete sentences, use *evidence* from the data table above to support your claim.
3) In complete sentences, give *reasons* to explain why your evidence supports your claim.
4) Write a full paragraph where you state your ***claim***, cite your ***evidence*** from the data table, and provide ***reasoning*** to explain why the evidence supports your claim.

PART 4: **Safety in the laboratory persuasive 1-2 page typed essay (25 points)**

There are inherent dangers in the science laboratory. Please read through the safety contract with your parents and sign it. This needs to be turned in the first day of class. Choose the top 5 safety rules, you believe are the most important to follow in the chemistry laboratory. Write a persuasive essay to convince me these 5 rules are the most important. Be ready to share your essay and defend your choices in a discussion on the first day of class.

Bohr model

The Gale Encyclopedia of Science, 2014



The Bohr model of atomic structure was developed by Danish physicist and Nobel laureate Niels Bohr (1885–1962). Published in 1913, Bohr's model improved the classical atomic models of physicists J. J. Thomson and Ernest Rutherford by incorporating quantum theory. While working on his doctoral dissertation at Copenhagen University, Bohr studied physicist Max Planck's (1858–1947) quantum theory of radiation. After graduation, Bohr worked in England with Thomson and subsequently with Rutherford. During this time Bohr developed his model of atomic structure.

Before Bohr, the classical model of the atom was similar to the Copernican model of the solar system where, just as planets orbit the sun, electrically negative electrons moved in orbits about a relatively massive, positively charged nucleus. The classical model of the atom allowed electrons to orbit at any distance from the nucleus. This predicted that when, for example, a hydrogen atom was heated, it should produce a continuous spectrum of colors as it cooled because its electron, moved away from the nucleus by the heatenergy, would gradually give up that energy as it spiraled back closer to the nucleus. Spectroscopic experiments, however, showed that hydrogen atoms produced only certain colors when heated. In addition, physicist James Clark Maxwell's influential studies on electromagnetic radiation (light) predicted that an electron orbiting around the nucleus according to Newton's laws would continuously lose energy and eventually fall into the nucleus. To account for the observed properties of hydrogen, Bohr proposed that electrons existed only in certain orbits and that, instead of traveling between orbits, electrons made instantaneous quantum leaps or jumps between allowed orbits.

In the Bohr model, the most stable, lowest energy level is found in the innermost orbit. This first orbital forms a shell around the nucleus and is assigned a principal quantum number (n) of n=1. Additional orbital shells are assigned values n=2, n=3, n=4, etc. The orbital shells are not spaced at equal distances from the nucleus, and the radius of each shell increases rapidly as the square of n. Increasing numbers of electrons can fit into these orbital shells according to the formula $2n^2$. The first shell can hold up to two electrons, the second shell (n=2) up to eight electrons, and the third shell (n=3) up to 18 electrons. Subshells or suborbitals (designated *s,p,d,* and *f*) with differing shapes and orientations allow each element a unique electron configuration.

As electrons move farther away from the nucleus, they gain potential energy and become less stable. Atoms with electrons in their lowest energy orbits are in a “ground” state, and those with electrons jumped to higher energy orbits are in an “excited” state. Atoms may acquire energy that excites electrons by random thermal collisions, collisions with subatomic particles, or by absorbing a photon. Of all the photons (quantum packets of light energy) that an atom can absorb, only those having an energy equal to the energy difference between allowed electron orbits will be absorbed. Atoms give up excess internal energy by giving off photons as electrons return to lower energy (inner) orbits.

The electron quantum leaps between orbits proposed by the Bohr model accounted for Planck's observations that atoms emit or absorb electromagnetic radiation only in certain units called quanta. Bohr's model also explained many important properties of the photoelectric effect described by Albert Einstein (1879–1955).

According to the Bohr model, when an electron is excited by energy it jumps from its ground state to an excited state (i.e., a higher energy orbital). The excited atom can then emit energy only in certain (quantized) amounts as its electrons jump back to lower energy orbits located closer to the nucleus. This excess energy is emitted in quanta of electromagnetic radiation (photons of light) that have exactly same energy as the difference in energy between the orbits jumped by the electron. For hydrogen, when an electron returns to the second orbital (n=2) it emits a photon with energy that corresponds to a particular color or spectral line found in the Balmer series of lines located in the visible portion of the electromagnetic (light) spectrum. The particular color in the series depends on the higher orbital from which the electron jumped. When the electron returns all the way to the innermost orbital (n=1), the photon emitted has more energy and forms a line in the Lyman series found in the higher energy, ultraviolet portion of the spectrum. When the electron returns to the third quantum shell (n=3), it retains more energy and, therefore, the photon emitted is correspondingly lower in energy and forms a line in the Paschen series found in the lower energy, infrared portion of the spectrum.

Because electrons are moving charged particles, they also generate a magnetic field. Just as an ampere is a unit of electric current, a magneton is a unit of magnetic dipole moment. The orbital magnetic moment for hydrogen atom is called the Bohr magneton.

Bohr's work earned a Nobel Prize in 1922. Subsequently, more mathematically complex models based on the work of French physicist Louis Victor de Broglie (1892–1987) and Austrian physicist Erwin Schrödinger (1887–1961) that depicted the particle and wave nature of electrons proved more useful to describe atoms with more than one electron. The standard model incorporating quark particles further refines the Bohr model. Regardless, Bohr's model remains fundamental to the study of chemistry, especially the valence shell concept used to predict an element's reactive properties.

The Bohr model remains a landmark in scientific thought that poses profound questions for scientists and philosophers. The concept that electrons make quantum leaps from one orbit to another, as opposed to simply moving between orbits, seems counter-intuitive, that is, outside the human experience with nature. Bohr said, “Anyone who is not shocked by quantum theory has not understood it.” Like much of quantum theory, the proofs of how nature works at the atomic level are mathematical.

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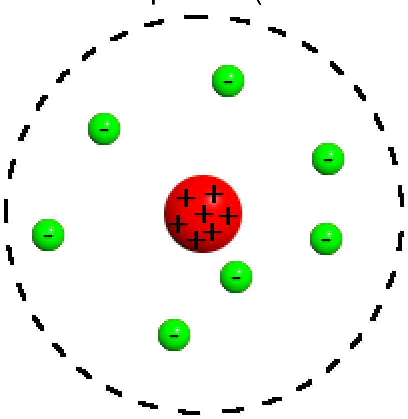
Rutherford Model

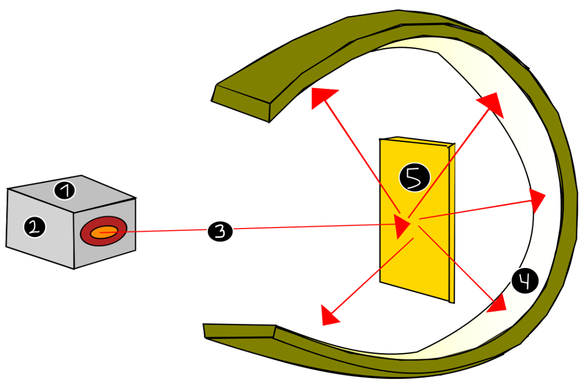
About 1909, another British physicist, Ernest Rutherford, probed deeper into the atom's structure. By bombarding gold atoms with positively charged particles, he discovered that an atom's positive charge was concentrated in a very small, heavy core—much smaller in diameter than the whole atom. (If a carbon atom were the size of a domed sports stadium, its core would be about the size of a peppercorn.) Rutherford called the atom's positively charged core the *nucleus*. In his atomic model, the nucleus was like a star around which one or more electrons orbited like planets (at various distances from that star).



Rutherford correctly proposed that the atom is held together by electrical attraction between the nucleus and the electrons. He later concluded, again correctly, that the nucleus is made up of positively charged particles and neutral, or "no-charge," particles. We now call these particles *protons* and *neutrons*. They are about the same size and are held together by what is called the "strong nuclear binding force."

Rutherford's solar-system model is all one needs to understand most of chemistry and everyday physics. But two problems remained. First, Rutherford's model allowed electrons to move in any of an infinite number of orbits. If this were actually so, different atoms of the same element could behave differently. (They do not.) Neither could his model explain why electrons do not lose energy and eventually spiral into the nucleus, like an exhausted satellite sucked into Earth's atmosphere by gravity.

Rutherford's gold foil experiment:



Significant Figures or Digits

Mathematics, 2016

Imagine that a nurse takes a child's temperature. However, the mercury thermometer being used is marked off in intervals of 1°. There is a 98°F mark and a 99°F mark, but nothing in between. The nurse announces that the child's temperature is 99°F. How does someone interpret this information? The answer becomes clear when one has an understanding of significant (or meaningful) digits.

The Importance of Precision

One possibility, of course, is that the mercury did lie exactly on the 99°F mark. What are the other possibilities? If the mercury were slightly above or below the 99°F mark (so that the child's actual temperature was, say, 99.1°F or 98.8°F), the nurse would probably still have recorded it as 99°F. However, if the child's actual temperature was 98.1°F, the nurse should have recorded it as 98°F. In fact, the temperature would have been recorded as 99°F only if the mercury lay within half a degree of 99°F—in other words, if the actual temperature was between 98.5°F and 99.5°F. (This interval includes its left endpoint, 98.5°F, but not its right endpoint, because 99.5°F would be rounded up to 100°F. However, any number just below 99.5°F, such as 99.49999°F, would be rounded down to 99°F.) One can conclude from this analysis that in the measurement of 99°F, only the first 9 is guaranteed to be accurate—the temperature is definitely 90-something degrees. The second 9 represents a rounded value.

To continue the example, once again, the child's temperature is being taken, but this time a more standard thermometer is being used, one that is marked off in intervals of one-tenth of a degree. Once again, the nurse announces that the child's temperature is 99°F. This announcement provides more information than did the previous measurement. This time, if the child's temperature were actually 98.6°F, it would have been recorded as such, not as 99°F. Following the reasoning of the previous paragraph, one can conclude that the child's actual temperature lies at most halfway toward the next marker on the thermometer—that is, within half of a tenth of a degree of 99°F. Therefore, the possible range of values this time is 98.95°F to 99.05°F—a much narrower range than in the previous case.

When recording a patient's temperature in a medical chart, it may not be necessary to make it clear whether a measurement is precise to one-half of a degree or one-twentieth of a degree. But in the world of scientific experiments, such precision can be vital. It is clear that simply recording a measurement of 99°F does not, by itself, give any information as to the level of precision of this measurement. Thus, a method of recording data that will incorporate this information is needed. This method is the use of significant digits (also called significant figures).

In the second of the two scenarios described earlier, the nurse is able to round off the measurement to the nearest tenth of a degree, not merely to the nearest degree. This fact can be communicated by including the tenths digit in the measurement—that is, by recording the measurement as 99.0°F rather than 99°F. The notation 99.0°F indicates that the first two digits are accurate and that the third is a rounded value, whereas the notation 99°F indicates that the first digit is accurate and that the second is a rounded value. The number 99.0°F is said to have three significant digits, and the number 99°F is said to have two.

What Is Significant?

When someone looks at a measurement, how can he or she tell how many significant digits it has? Any number between one and nine is a significant digit. When it comes to zeros, the situation is a little more complicated. To see why, the person can assume that a certain length is recorded to be 90.30 meters long. This measurement has four significant digits—the zero on the end (after the three) indicates that the nine, first zero, and three are accurate and that the last zero is an estimate. Now suppose that the person needs to convert this measurement to kilometers. The measurement now reads 0.09030 kilometers. He or she now has five digits in the measurement, but has not suddenly gained precision simply by changing units. Any zero that appears to the left of the first nonzero digit (the nine, in this case) cannot be considered significant.

Now suppose that the person wants to convert that same measurement to millimeters so that it reads 90,300 millimeters. Once again, he or she has not gained any precision, so the rightmost zero is not significant. However, the rule to be deduced from this situation is less clear. How should he or she consider zeros that lie to the right of the last nonzero digit? The zero after the three in 90.30 is significant because it gives information about precision—it is not a "necessary" zero in the sense that mathematically 90.30 could be written as 90.3. However, the two zeros after the three in 90300 are mathematically necessary as placeholders; 90300 is not the same number as 9030 or 903. Thus, one cannot conclude that the zeros are there to convey information about precision. They might be—in the example, the first one is and the second one is not—but it is not guaranteed. The following rules summarize the previous discussion:

1. Any nonzero digit is significant.
2. Any zero that lies between nonzero digits is significant.
3. Any zero that lies to the left of the first nonzero digit is not significant.
4. If the number contains a decimal point, then any zero to the right of the last nonzero digit is significant.
5. If the number does not contain a decimal point, then any zero to the right of the last nonzero digit is not significant.

Here are some examples:

0.030700—five significant digits (all but the first two zeros)

400.00—five significant digits

400—one significant digit (the four)

5030—three significant digits

Here is one more example. In an earlier discussion, the zero in the ones column could not be considered significant, because the measurement may have been rounded to the nearest multiple of 10. If, however, someone is measuring with an instrument that is marked in intervals of one unit, then recording the measurement as 5030 does not convey the full level of precision of the measurement. One cannot record the measurement as 5030.0, because that indicates a jump from three to five significant digits, which is too many. In such a circumstance, one can avoid the difficulty by recording the measurement using scientific notation (i.e., writing 5030 as 5.030×10^3). Now the final zero lies to the right of the decimal point. Therefore, by Rule 4, it is a significant digit.

Calculations Involving Significant Figures

Often when one is doing a scientific experiment, it is necessary not only to record data but also to do computations with the information. The main principle involved is that one can never gain significant digits when computing with data; a result can only be as precise as the information used to get it.

In the first example, two pieces of data, 10.30 and 705, are to be added. Mathematically, the sum is 715.30. However, the number 705 does not have any significant digits to the right of the decimal point. Thus, the three and the zero in the sum cannot be assumed to have any degree of accuracy, in which case the sum is written simply as 715. If the first piece of data was 10.65 instead of 10.30, then the actual sum would be 715.65. In this case, the sum would be rounded up and recorded as 716. The rule for numbers to be added (or subtracted) with significant digits is that the sum/difference cannot contain a digit that lies in or to the right of any column containing an insignificant digit.

In a second example, two pieces of data, 10.30 and 705, are to be multiplied. Mathematically, the product is 7261.5. Which of these digits can be considered significant? Here the rule is that when multiplying or dividing, the product/quotient can have only as many significant digits as the piece of data containing the fewest significant digits. So in this case, the product may have only three significant digits and would be recorded as 7260.

In the final example, the diameter of a circle is measured to be 10.30 centimeters. To compute the circumference of this circle, the quantity must be multiplied by π. Since n is a known quantity, not a measurement, it is considered to have infinitely many significant digits. Thus, the result can have as many significant digits as 10.30—that is, four. (To do this computation, one must take an approximation of π to as many decimal places as necessary to guarantee that the first four digits of the product will be accurate.) A similar principle applies if someone wants to do strictly mathematical computations with data. For instance, if someone wants to compute the radius of a circle whose diameter he or she has measured, the person must multiply by 0.5. The answer, however, may still have four significant digits, because 0.5 is not a measurement and hence is considered to have infinitely many significant digits.

Cominskey, Michael J., editor. *The Number System and Common and Decimal Fractions.* New York: Rosen, 2015.

"Significant Figures." *The Economist Numbers Guide: The Essentials of Business Numeracy,* edited by Richard Stutely, 242. 6th ed. London: Profile Books, 2014.

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Klarreich, Naomi. "Significant Figures or Digits." *Mathematics*, edited by Mary Rose Bonk, 2nd ed., vol. 4, Macmillan Reference USA, 2016, pp. 14-17. *Science in Context*, link.galegroup.com/apps/doc/CX3630100271/SCIC?u=mino34663&xid=c74720d5. Accessed 26 Apr. 2017.

Accuracy and Precision

Mathematics, December 13, 2010

Accuracy and precision both concern the quality of a measure. However, the terms have different meanings and should not be used as substitutes for one another.

Precision

Precision depends on the unit used to obtain a measure. The smaller the unit, the more precise the measure. Consider measures of time, such as 12 seconds and 12 days. A measurement of 12 seconds implies a time between 11.5 and 12.5 seconds. This measurement is precise to the nearest second, with a maximum potential error of 0.5 seconds. A time of 12 days is far less precise. Twelve days suggests a time between 11.5 and 12.5 days, yielding a potential error of 0.5 days, or 43,200 seconds! Because the potential error is greater, the measure is less precise. Thus, as the length of the unit increases, the measure becomes less precise.

The number of decimal places in a measurement also affects precision. A time of 12.1 seconds is more precise than a time of 12 seconds; it implies a measure precise to the nearest tenth of a second. The potential error in 12.1 seconds is 0.05 seconds, compared with a potential error of 0.5 seconds with a measure of 12 seconds.

Although students learn that adding zeros after a decimal point is acceptable, doing so can be misleading. The measures of 12 seconds and 12.0 seconds imply a difference in precision. The first figure is measured to the nearest second--a potential error of 0.5 seconds. The second figure is measured to the nearest tenth--a potential error of 0.05 seconds. Therefore, a measure of 12.0 seconds is more precise than a measure of 12 seconds.

Differing levels of precision can cause problems with arithmetic operations. Suppose one wishes to add 12.1 seconds and 14.47 seconds. The sum, 26.57 seconds, is misleading. The first time is between 12.05 seconds and 12.15 seconds, whereas the second is between 14.465 and 14.475 seconds. Consequently, the sum is between 26.515 seconds and 26.625 seconds. A report of 26.57 seconds suggests more precision than the actual result possesses.

The generally accepted practice is to report a sum or difference to the same precision as the least precise measure. Thus, the result in the preceding example should be reported to the nearest tenth of a second; that is, rounding the sum to 26.6 seconds. Even so, the result may not be as precise as is thought. If the total is actually closer to 26.515 seconds, the sum to the nearest tenth is 26.5 seconds. Nevertheless, this practice usually provides acceptable results.

Multiplying and dividing measures can create a different problem. Suppose one wishes to calculate the area of a rectangle that measures 3.7 centimeters (cm) by 5.6 cm. Multiplication yields an area of 20.72 square centimeters. However, because the first measure is between 3.65 and 3.75 cm, and the second measure is between 5.55 and 5.65 cm, the area is somewhere between 20.2575 and 21.1875 square centimeters. Reporting the result to the nearest hundredth of a square centimeter is misleading. The accepted practice is to report the result using the fewest number of significant digits in the original measures. Since both 3.7 and 5.6 have two significant digits, the result is rounded to two significant digits and an area of 21 square centimeters is reported. Again, while the result may not even be this precise, this practice normally produces acceptable results.

Accuracy

Rather than the absolute error to which precision refers, accuracy refers to the relative error in a measure. For example, if one makes a mistake by 5 centimeters in measuring two objects that are actually 100 and 1,000 cm, respectively, the second measure is more accurate than the first. The first has an error of 5 percent (5 cm out of 100 cm), whereas the second has an error of only 0.5 percent (5 cm out of 1,000 cm).

How Are Precision and Accuracy Different?

To illustrate the difference between precision and accuracy, suppose that a tape measure is used to measure the circumference of two circles--one small and the other large. Suppose a result of 15 cm for the first circle and 201 cm for the second circle are obtained. The two measures are equally precise; both are measures to the nearest centimeter. However, their accuracy may be quite different. Suppose the measurements are both about 0.3 cm too small. The relative errors for these measures are 0.3 cm out of 15.3 cm (about 1.96 percent) and 0.3 cm out of 201.3 cm (about 0.149 percent). The second measurement is more accurate because the error is smaller when compared with the actual measurement. Consequently, for any specific measuring tool, one can be equally precise with the measures. But accuracy is often greater with larger objects than with smaller ones.

Confusion can arise when using these terms. The tools one uses affect both the precision and accuracy of one's measurements. Measuring with a millimeter tape allows greater precision than measuring with an inch tape. Because the error using the millimeter tape should be less than the inch tape, accuracy also improves; the error compared with the actual length is likely to be smaller. Despite this possible confusion and the similarity of the ideas, it is important that the distinction between precision and accuracy be understood.

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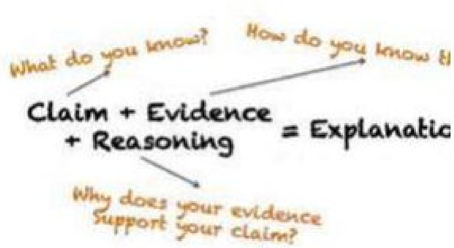
CER Writing:



A CER (Claim, Evidence, Reasoning) is a format for writing about science. It allows you to think about your data in an organized, thorough manner. See below for a sample.

Claim: a conclusion about a problem
Evidence: scientific data that is appropriate and sufficient to support the claim
Reasoning: a justification that shows why the data counts as evidence to support the claim and includes appropriate scientific principles

Sample # 1 WHAT ARE FACTORS THAT AFFECT PLANT GROWTH?

Claim: The rate of pumpkin plant growth increases as the temperature increases.
Evidence: Our control group was growing at normal room temperature, while our experimental group was growing in a hot greenhouse for one week. Over the course of the week, we observed that the experimental plant was healthier looking, had more leaves, and grew taller than the control plant. The mass of the experimental plant increased from 10 g to 20 g, while the control plant increased from 10 g to 15 g. The experimental group grew from 14 cm to 18 cm (increase of 4 cm), and the control group grew from 12 cm to 14 cm (increase of 2 cm). The experimental plant got five new leaves and the control only got two new leaves.
Reasoning: Pumpkin plants are sensitive to the temperature of their surroundings. All plants grow best within a certain temperature range (some plants would actually grow better in at cool temperatures than warm temperatures). Maybe pumpkin plants originated in a habitat with a warm climate. Plants need energy to grow, and their energy comes from photosynthesis. Maybe pumpkin plants are able to do photosynthesis faster at warm temperatures, so they are able to grow more. I would have thought that the only factors influencing plant growth are water, sunlight, and soil nutrients, but this experiment illustrated that other factors can affect growth, too. I wonder if anything besides the temperature difference could affect the growth rate. Maybe there was more carbon dioxide in the greenhouse than the classroom. Maybe the glass window in the classroom filters out some kind of light that plants need, while the plastic greenhouse does not. There are some factors that we could not control, so I guess we don't know for sure that temperature was the ONLY difference.