AP CHEMISTRY

Summer Assignment 2019
due Thursday, August 29th

1. Read Chapter 1, and 2.

   Pay particular attention to **dimensional analysis and to significant figures.**

   In Chapter 2, pay particular attention to **naming compounds.**

2. Complete the attached POGIL activities.

3. Complete the following questions from the text:

   Ch 1: 39, 42, 59, 66, 78, 87

   Ch2: 7, 12, 26, 36, 54, 56, 70, 74, 98, 105, 109

   be sure to complete all parts of #105 (8 rows in total)

As will be true all year, **show all your work and include units** in any problem involving calculations.

4. MEMORIZE:

The fundamental SI units

SI Fundamental Units

Quantity	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Amount of substance	mole	mol
Electric current	ampere	A

The italicized prefixes

SI Prefixes

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{-1}	*deci*	d	10^{12}	tera	T
10^{-2}	*centi*	c	10^{9}	giga	G
10^{-3}	*milli*	m	10^{6}	*mega*	M
10^{-6}	*micro*	μ	10^{3}	*kilo*	K
10^{-9}	*nano*	n	10^{2}	hecto	h
10^{-12}	pico	p	10^{1}	deka	da
10^{-15}	femto	f			
10^{-18}	atto	a			

MEMORIZE:

The formulas, names and charges of polyatomic ions

1- ions

ClO^-	hypochlorite ion	NO_2^-	nitrite ion
ClO_2^-	chlorite ion	NO_3^-	nitrate ion
ClO_3^-	chlorate ion	OH^-	hydroxide ion
ClO_4^-	perchlorate ion	CN^-	cyanide ion
HCO_3^-	hydrogen carbonate (bicarbonate) ion		
MnO_4^{1-}	permanganate ion		

2- ions

SO_3^{-2}	sulfite ion
SO_4^{-2}	sulfate ion
CO_3^{-2}	carbonate ion
CrO_4^{-2}	chromate ion
$Cr_2O_7^{-2}$	dichromate ion

3- ions

PO_3^{-3}	phosphite ion
PO_4^{-3}	phosphate ion

1+ ions

NH_4^+	ammonium ion

There will be a **test on Chapter 1 & 2 within the first two weeks of September**

Mastery of the following mathematical and problem solving skills is essential to your success in the AP Chemistry course:

Solving algebraic equations, logarithms, exponential functions, quadratic equations, and using graphical methods.

We look forward to an exciting year with you. Meanwhile have a great summer!

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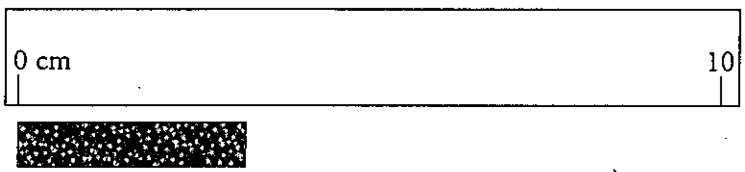
Significant Digits and Measurement

What digits are significant when recording a measurement?

Why?

Scientists do a lot of measuring. When scientists use an instrument (such as a ruler, graduated cylinder, spectrophotometer or balance) to measure something, it is important to take full advantage of the instrument. However, they can't cheat and record a better measurement than the instrument is capable of. There is an understanding among scientists of the proper way to record valid measurements from any instrument. When you are the scientist, you must record data in this way. When you are reading other scientists' work, you must assume they recorded their data in this way.

Model 1 – Ruler A



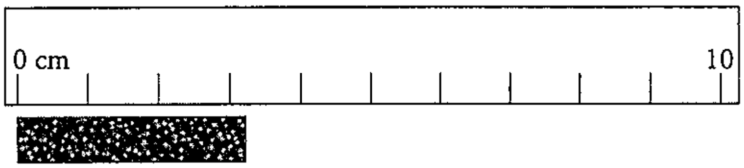
Susan	3 cm
Maya	2 cm
Jonah	2.5 cm
Tony	3.00 cm
Emily	3¼ cm
Dionne	3.33 cm

1. What distances can you be certain of on the ruler in Model 1?

2. Six students used the ruler in Model 1 to measure the length of a metal strip. Their measurements are shown at the right. Were all of the students able to agree on a single value (1, 2, 3…) for any digit (ones place, tenths place, etc.) in the measurement? If yes, which value and digit did they agree on?

3. The ruler in Model 1 is not very useful, but a measurement can be estimated. Discuss in your group how each student might have divided up the ruler "by eye" in order to get the measurement that he or she recorded.

Model 2 – Ruler B



Susan	3.2 cm
Maya	3.1 cm
Jonah	3.3 cm
Tony	3 cm
Emily	3.25 cm
Dionne	3.20 cm

4. The students obtained a better ruler, shown in Model 2. What distances can you be certain of on this ruler?

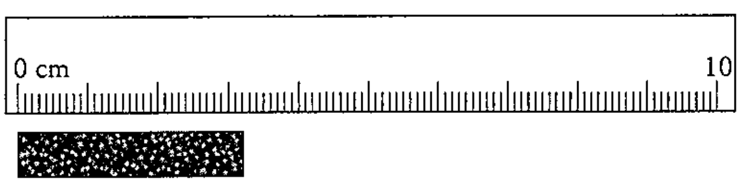
5. Were the students able to agree on a single value (1, 2, 3...) for any digit (ones place, tenths place, etc.) in their measurements using the ruler in Model 2? If yes, what value in what digit did they agree on?

6. What feature of the ruler in Model 2 made it possible for the students to agree on a value in that digit?

7. There will always be uncertainty in any measurement. This causes variation in measurements even if people are using the same instrument. Compare the variation in the measurements made by the six students using the rulers in Models 1 and 2. Which ruler resulted in greater variation? Explain why that ruler caused more variation.

STOP

Model 3 – Ruler C



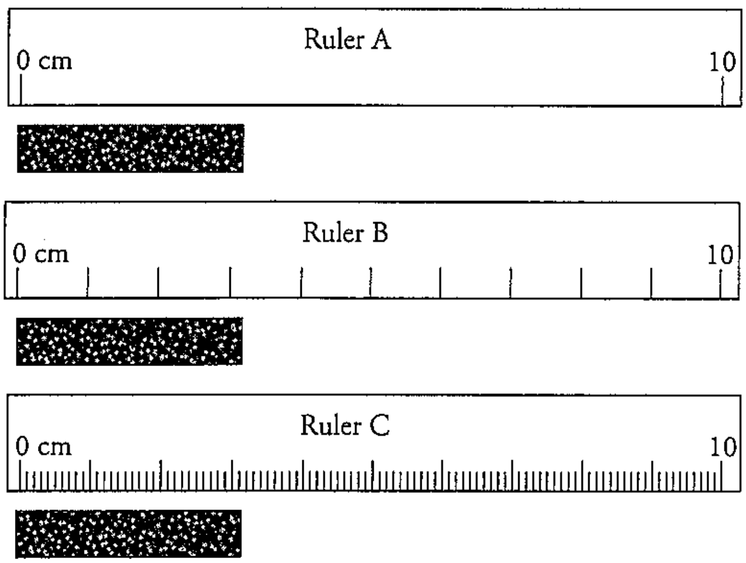
Susan	3.21
Maya	3.20 cm
Jonah	3.22 cm
Mark	3.2 cm
Emily	3.215 cm
Dionne	3.205 cm

8. The students obtained an even better ruler, shown above in Model 3.
   a. Were the students able to agree on a single value for any of the digits in their measurements using the new ruler? If yes, what value(s) did they agree on in which digits?
   b. What feature of the ruler in Model 3 made it possible for the students to agree on the values in those digits?

Read This!

When humans use measuring instruments, variation is expected. Everyone will estimate differently between marks on the instrument. On the other hand, digits that are certain (based on marks on the instrument) should not vary from person to person.

Model 4 – Valid Measurements



Valid Measurements	Invalid Measurements
3 cm	2.5 cm
2 cm	3.00 cm
	3¼ cm
	3.33 cm
3.2 cm	3 cm
3.1 cm	3.25 cm
3.3 cm	3.20 cm
3.21 cm	3.2 cm
3.22 cm	3.215 cm
3.20 cm	3.205 cm

9. The measurements taken in Models 1–3 have been combined in Model 4. The measurements that follow the rules of measurement agreed upon by scientists are in the "Valid Measurements" column. Those that do not follow the rules are in the "Invalid Measurements" column. For each valid measurement shown in Model 4, draw a square around the certain digits (if any) and circle the digits that were estimated (if any).

10. Based on the examples in Model 4, circle the best phrase to complete each sentence below.

    a. In a valid measurement, you record (zero, one, two) estimated digit(s).

    b. In a valid measurement, the estimated digit is the (first digit, second to last digit, last digit) in the measurement.

    c. In a valid measurement, the estimated digit corresponds to (the largest marks, the smallest marks, one tenth of the smallest marks) on the instrument.

11. Using Ruler B from Model 4, Tony recorded a measurement of 3 cm. Explain why this was an invalid measurement.

12. Using Ruler B from Model 4, Dionne recorded a measurement of 3.20 cm, which was invalid. But when Maya made the same measurement using Ruler C, it was considered valid. Explain why the zero was acceptable when using Ruler C, but not when using Ruler B.

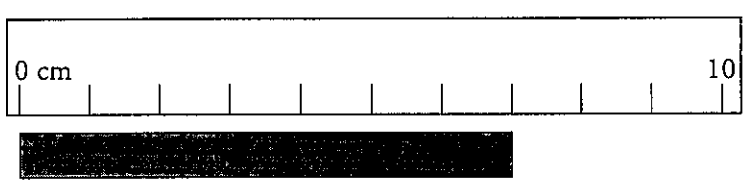
13. A student recorded the length of a test tube as 5.0 cm. Which ruler in Model 4 was the student using? Explain.

14. In Model 4, Ricky recorded his measurement 3.19 cm using Ruler C. His classmates thought he was wrong because his second digit was not "2." However, Ricky's recorded measurement is perfectly valid. Explain.

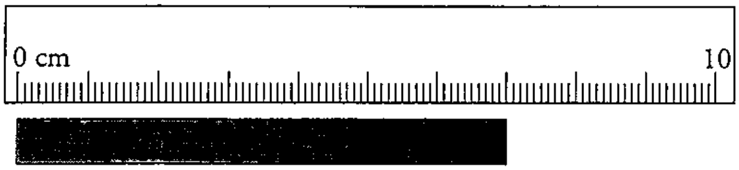
Read This!

When a measurement is recorded properly, all of the digits that are read directly (certain) and one estimated (uncertain) digit are called **significant digits**. The number of allowable significant digits is determined by the marks or gradations of the instrument. Sometimes a "0" is the estimated digit and must be recorded.

15. Record the length of the wooden splint to the proper number of significant digits.

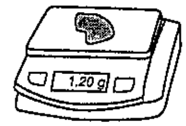


16. Record the length of the wooden splint to the proper number of significant digits.



Extension Questions

17. When using an electronic device, such as an electronic balance, the measurement displayed on the screen is assumed to have one estimated digit included. In fact, you'll often see the estimated digit changing rapidly, because there is fluctuation in the estimate. Explain why it is important to record the zero in the measurement shown to the right.

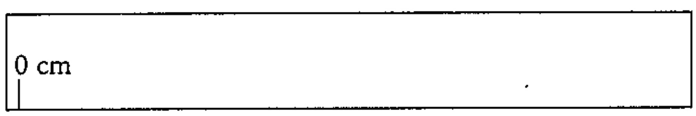


18. Consider a 1000-mL graduated cylinder with marks every 100 mL.

    a. A student records the volume of liquid in the cylinder as 750 mL. Is this a correct measurement? Explain.

    b. Are all of the digits in the described measurement of 750 mL significant? Explain.

19. A student properly records the length of a block as 120 cm. Draw the markings on the ruler that was used to measure the block.



Significant Zeros

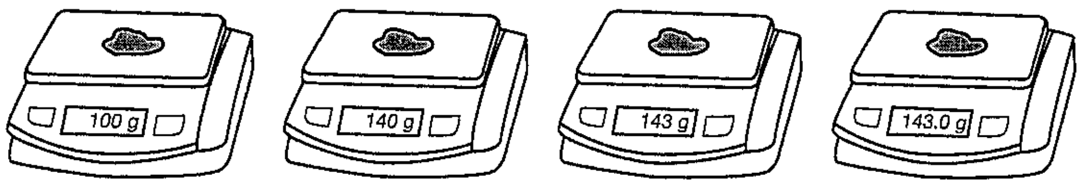
Which zeros are significant in a measurement, and which are simply important?

Why?

When working with measurements, it is important to know which digits in the measurement are significant and which are not. Non-zero digits are always significant. However, zeros can be tricky; some are significant, others are not. This activity will help you learn the rules for determining whether a zero digit is significant or not.

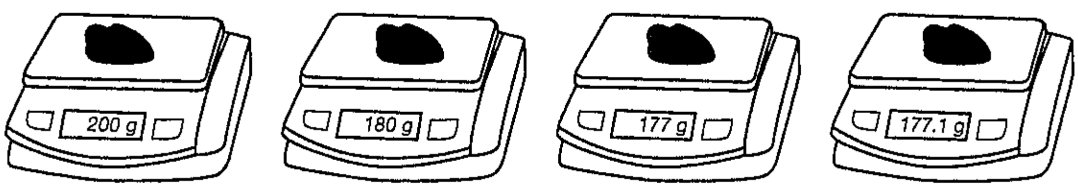
Model 1 – Mass of Rocks

Sample A



Econo-Balance | Good Balance | Balance Pro | Exacto-Balance

Sample B



Econo-Balance | Good Balance | Balance Pro | Exacto-Balance

1. For each balance in Model 1, circle the phrase below that best describes how closely the mass can be determined with that balance.

Econo-Balance	rounded to the nearest 100 g	rounded to the nearest 10 g	rounded to the nearest 1 g	rounded to the nearest 0.1 g
Good Balance	rounded to the nearest 100 g	rounded to the nearest 10 g	rounded to the nearest 1 g	rounded to the nearest 0.1 g
Balance Pro	rounded to the nearest 100 g	rounded to the nearest 10 g	rounded to the nearest 1 g	rounded to the nearest 0.1 g
Exacto-Balance	rounded to the nearest 100 g	rounded to the nearest 10 g	rounded to the nearest 1 g	rounded to the nearest 0.1 g

2. Which of the four balances in Model 1 is the best quality instrument? Explain.

3. Rock C is placed on the Econo-Balance. The balance reads 200 g.

   a. Does rock C have a mass larger, smaller or the same as sample A, or is it impossible to tell? Explain your reasoning.

   b. Does rock C have a mass larger, smaller or the same as rock B, or is it impossible to tell? Explain your reasoning.

4. The mass of rock C is then measured using the other three balances. The results are shown below.

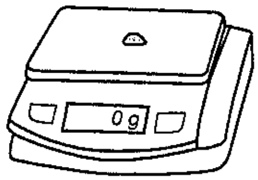
Econo-Balance	200 g	Balance Pro	177 g
Good Balance	180 g	Exacto-Balance	177.0 g

   a. Based on this additional information, does rock C have a mass larger, smaller or the same as rock B, or is it impossible to tell? Explain your reasoning.

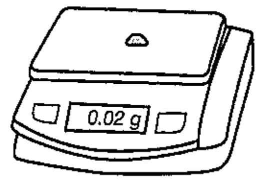
   b. Explain why the zero in the Exacto-Balance reading provides important information about the mass of rock C, but the zero in the Good Balance reading does not.

Model 2 – Mass of Pebbles

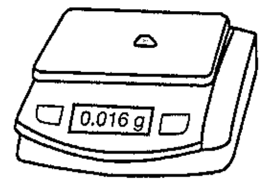
Pebble A



Balance Pro

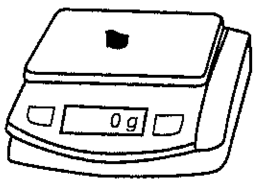


Centi-Balance

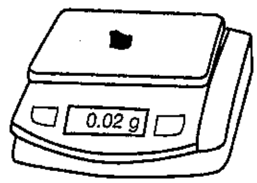


Super Balance

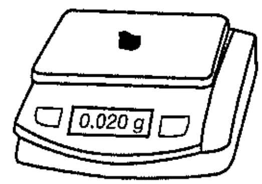
Pebble B



Balance Pro



Centi-Balance



Super Balance

5. For each balance in Model 2, write a phrase to describe how closely the mass of an object can be determined using that balance. The first one is done for you.

   Balance Pro: Rounded to the nearest 1 gram.

   Centi-Balance:

   Super Balance:

6. Pebble A and pebble B both have a mass of 0 g on the Balance Pro in Model 2. Do these pebbles really have no mass? If no, explain why the balance has this reading.

7. Which balance is sensitive enough to determine if pebble A has a mass larger or smaller than pebble B?

8. The mass reading of pebble B from the Super Balance is 0.020 g. This value is very close, but different than, the mass reading for pebble A on that same balance. Determine which of the three zeros in the mass reading for pebble B is the most significant in terms of determining whether pebble B has a different mass than pebble A, and circle the zero below.

   Mass pebble B = 0.020 g

Model 3 – Types of Zeros

200 g	180 g	140 g	100 g	**Placeholder Zeros**
0.02 g	0.016 g			
0.020 g	177.0 g	143.0 g		**Significant Zeros** (underlined)

9. Model 3 shows several of the measurements from Model 1 and Model 2. The zeros in those measurements are categorized into two types. List the two types.

10. Consider the term "placeholder" as it is used in the English language. Discuss two examples of this term in your group, and summarize them here.

11. Describe the two types of placeholder zeros shown in Model 3.

12. If you removed a placeholder zero from a number, would the numeric value of the number change?

13. Describe the location of significant zeros in a number relative to the decimal point.

14. If you removed a significant zero from the end of a number, would the numeric value of the number change?

Read This!

Placeholder zeros are very important—they help put the decimal point in the correct spot. However, they are ***not*** significant when it comes to the certainty of a measurement. In other words, placeholder zeros cannot be a certain or estimated digit in a measurement. They may show up in calculations however. For example, if you convert 29.3 m to 29,300 mm, the zeros that you add to the measurement were not read from the measuring instrument.

15. Determine if the zeros in the measurements below are significant or not. If a zero is significant, underline it.

a. 650 m *b.* 42.0 s *c.* 7000 L

d. 3.000 kg *e.* 0.008 mL *f.* 0.00560 cm

16. Here are five rules for determining which digits in a measurement are significant. Match each rule to a set of examples in the table below. The significant digits in each example are underlined.

Rule 1: All non-zero numbers are significant.

Rule 2: Sandwiched zeros (those that occur between two significant digits) are significant.

Rule 3: Zeros that are only placeholders for a decimal are not significant.

Rule 4: Zeros at the end of a number that also contains a decimal are significant.

Rule 5: Exact numbers (no doubt or uncertainty in the value) may be thought of as having an *infinite* number of significant digits. These include numbers that were counted or are defined values (*i.e.*, conversion factors).

Set A	Set B	Set C
105 cm, 0.402 g, 4003.7 mL, 10.0 s	6300 mL, 400 m, 0.004 g, 0.097 kg	30.40 m, 1.620 s, 0.0400 L
Set D	**Set E**	
589 s, 45 kg, 5.68 g, 0.452 L	1 dozen = 12 1 m = 100 cm 29 students on a bus	

17. In the measurements below, the significant digits are underlined. Determine the rule(s) that were used to decide which digits were significant, and which were not significant.

a. 0.420 g *b.* 2100 g *c.* 51.0 m

d. 590 students *e.* 5,200.0 g *f.* 6020 mg

18. Underline all of the significant digits in the following values.

a. 94,000 m *b.* 7200 apples *c.* 0.004380 g

d. 400.0 kg *e.* 80,050 s *f.* 1000 g = 1 kg

STOP

Extension Questions

Model 4 – Scientific Notation (Significant digits are underlined.)

A. $\underline{3} \times 10^4$ m = $\underline{3}0{,}000$ m

$\underline{3.00} \times 10^4$ m = $\underline{30{,}0}00$ m

B. $\underline{7} \times 10^{-3}$ kg = $0.00\underline{7}$ kg

$\underline{7.00} \times 10^{-3}$ kg = $0.00\underline{700}$ kg

C. $\underline{4.1} \times 10^4$ m = $\underline{41}{,}000$ m

$\underline{4.10} \times 10^4$ m = $\underline{41{,}0}00$ m

D. $\underline{9.42} \times 10^{-3}$ kg = $0.00\underline{942}$ kg

$\underline{9.420} \times 10^{-3}$ kg = $0.00\underline{9420}$ kg

19. The measurements in Model 4 are written in both scientific notation and expanded notation. Copy one example of each below.

Scientific notation   Expanded notation

20. Refer to the two measurements in set A of Model 4.

a. Do the two measurements have the same numeric value?

b. Were the two measurements made using the same instrument? Explain.

21. Look at all of the measurements in Model 4. When a number in scientific notation is changed to expanded notation, are any of the added zeros significant? Give two examples to support your answer.

22. When a number in scientific notation contains a significant zero, is that zero also significant in the expanded notation? Give two examples to support your answer.

23. Write each of the measurements below in expanded notation and underline the significant digits.

a. 5.0780×10^6 g =

b. 4.800×10^{-4} L =

c. 0.7200×10^4 mm =

d. 3700×10^{-3} cm =

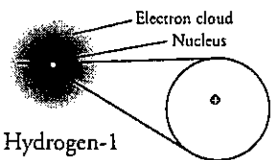
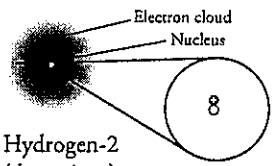
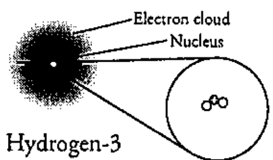
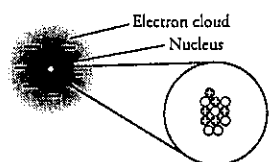
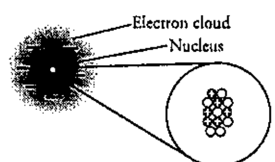
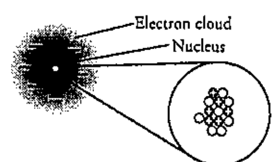
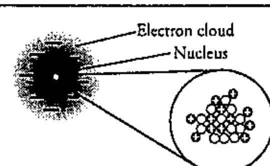
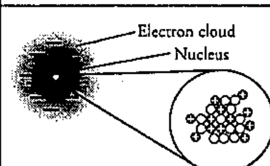
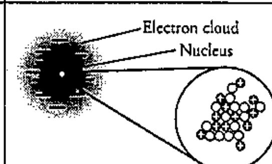
Isotopes

Are all atoms of an element alike?

Why?

The following activity will help you learn the important structural characteristics of an atom. How do we classify atoms? How does the combination of subatomic particles affect the mass and charge of an atom? What are isotopes? This is just a sampling of what we will address. Throughout this activity you will want to keep both Model 1 and a periodic table handy.

Model 1

Isotopes of Hydrogen			
Symbol	$^{1}_{1}H$	$^{2}_{1}H$	$^{3}_{1}H$
Atomic Diagram with Name	 Hydrogen-1 (protium)	 Hydrogen-2 (deuterium)	 Hydrogen-3 (tritium)
Number of Protons ⊕			
Number of Neutrons ○			
Isotopes of Carbon			
Symbol	$^{12}_{6}C$	$^{13}_{6}C$	$^{14}_{6}C$
Atomic Diagram with Name	 Carbon-12	 Carbon-13	 Carbon-14
Number of Protons ⊕			
Number of Neutrons ○			
Isotopes of Magnesium			
Symbol	$^{24}_{12}Mg$	$^{25}_{12}Mg$	$^{26}_{12}Mg$
Atomic Diagram with Name	 Magnesium-24	 Magnesium-25	 Magnesium-26
Number of Protons ⊕			
Number of Neutrons ○			

1. Refer to Model 1. What subatomic particles do the following symbols represent in the Atomic Diagrams?

   ▬ ⊕ ○

2. Complete the table in Model 1 by counting the protons and neutrons in each atomic diagram. Divide the work evenly among group members.

3. Find the three elements shown in Model 1 on your periodic table.

   a. What whole number shown in Model 1 for each element is also found in the periodic table for that element?

   Hydrogen — Carbon — Magnesium — *I*

   b. The whole number in each box of the periodic table is the atomic number of the element. What does the **atomic number** of an element represent?

   c. Refer to the isotope symbols in Model 1. Relative to the atomic symbol (H, C, or Mg), where is the atomic number located in the isotope symbol?

4. Refer to your periodic table.

   a. How many protons are in all chlorine (Cl) atoms?

   b. A student says "I think that some chlorine atoms have 16 protons." Explain why this student is not correct.

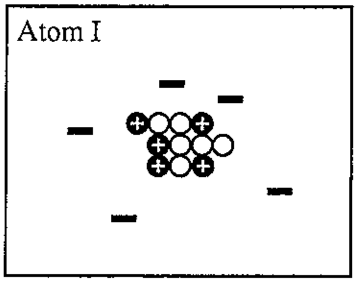
5. Refer again to Model 1. In the isotope symbol of each atom, there is a superscripted (raised) number. This number is also used in the name of the atom (*i.e.*, carbon-12). It is called the **mass number**.

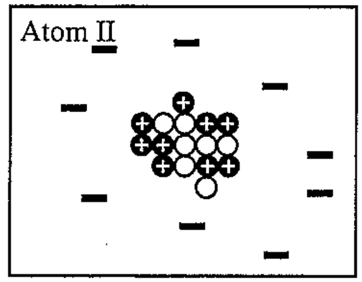
   a. How is the mass number determined?

   b. Why is this number called a "mass" number?

6. Fill in the table for Atom I and Atom II shown below.

	Atom I	Atom II
Number of Protons		
Number of Neutrons		
Mass Number		





7. Refer to Model 1.
   a. Which corner of the isotope symbol contains the mass number?

   b. How is the mass number of an isotope expressed in the name of an atom?

8. Write an isotope symbol (similar to those in Model 1) for each of the atoms in Question 6.

9. Write the name of the atom (similar to those in Model 1) for each of the atoms in Question 6.

STOP

10. Fill in the following table.

Isotope Symbol	$^{40}_{19}K$	$^{18}_{9}F$	
Atomic Number			16
Mass Number			
Number of Protons			
Number of Neutrons			15

11. Consider the examples in Model 1.
    a. Do all isotopes of an element have the same atomic number? Give at least one example or counter-example from Model 1 that supports your answer.

b. Do all isotopes of an element have the same mass number? Give at least one example or counter-example from Model 1 that supports your answer.

12. Considering your answers to Question 11, write a definition of **isotope** using a grammatically correct sentence. Your group must come to consensus on this definition.

STOP

13. Consult the following list of isotope symbols: $^{204}_{82}Pb$, $^{82}_{35}Br$, $^{78}_{35}Br$, $^{208}_{82}Pb$, $^{204}_{78}Pt$, $^{205}_{82}Pb$.

a. Which of the atoms represented by these symbols are isotopes of each other?

b. Which part(s) of the isotope symbol was the most helpful in answering part *a* of this question?

Extension Questions

14. Determine the number of electrons in each of the atomic diagrams in Model 1.
    a. In a neutral atom, how does the number of electrons compare to the number of protons?

    b. Discuss why this relationship is important in making a "neutral" atom.

15. Refer to the hydrogen isotopes in Model 1. Each isotope has a special name derived from Latin (protium, deuterium, and tritium). What structural feature do these names refer to in the atom?

16. Can two atoms with the same mass number ever be isotopes of each other? Explain.

17. All models have limitations. What characteristics of Model 1 are inconsistent with your understanding of what atoms look like?

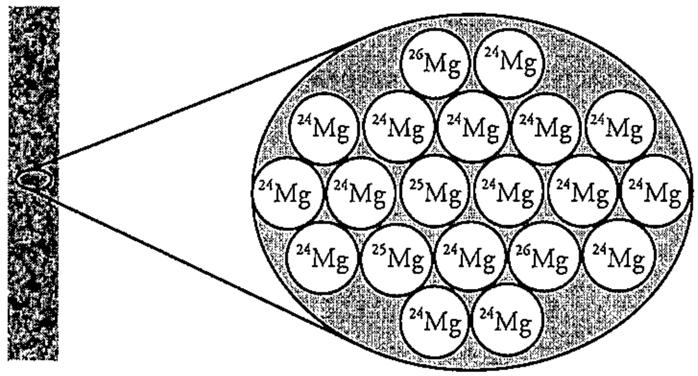
Average Atomic Mass

How are the masses on the periodic table determined?

Why?

Most elements have more than one naturally occurring isotope. As you learned previously, the atoms of those isotopes have the same atomic number (number of protons), making them belong to the same element, but they have different mass numbers (total number of protons and neutrons) giving them different atomic masses. So which mass is put on the periodic table for each element? Is it the most common isotope's mass? The heaviest mass? This activity will help answer that question.

Model 1 – A Strip of Magnesium Metal



1. Write in the atomic number for each Mg atom in Model 1.

2. What are the mass numbers of the naturally occurring isotopes of magnesium shown in Model 1?

3. Do all of the atoms of magnesium in Model 1 have the same atomic mass? Explain.

4. For the sample of 20 atoms of magnesium shown in Model 1, draw a table indicating the mass numbers of the three isotopes and the number of atoms of each isotope present.

5. Which isotope of magnesium is the most common in Model 1?

6. Based on Model 1 and the table you created in Question 4, for every 10 atoms of magnesium, approximately how many atoms of each isotope will be found?

Model 2 – Natural Abundance Information for Magnesium

Isotope	Natural Abundance on Earth (%)	Atomic Mass (amu)
^{24}Mg	78.99	23.9850
^{25}Mg	10.00	24.9858
^{26}Mg	11.01	25.9826

7. Consider the natural abundance information given in Model 2.
   a. Calculate the expected number of atoms of each isotope that will be found in a sample of 20 atoms of Mg. *Hint:* The number of atoms must be a whole number!

   b. Is Model 1 accurate in its representation of magnesium at the atomic level? Explain.

8. If you could pick up a single atom of magnesium and put it on a balance, the mass of that atom would most likely be ______ amu. Explain your reasoning.

9. Refer to a periodic table and find the box for magnesium.
   a. Write down the decimal number shown in that box.

   b. Does the decimal number shown on the periodic table for magnesium match any of the atomic masses listed in Model 2?

10. The periodic table does not show the atomic mass of every isotope for an element.
   a. Explain why this would be an impractical goal for the periodic table.

   b. Is it important to the average scientist to have information about a particular isotope of an element? Explain.

11. What would be a practical way of showing the mass of magnesium atoms on the periodic table given that most elements occur as a mixture of isotopes?

12. Propose a possible way to calculate the average atomic mass of 100 magnesium atoms. Your answer may include a mathematical equation, but it is not required.

STOP

Model 3 – Proposed Average Atomic Mass Calculations

Mary's Method

$$\frac{(78.99)(23.9850\text{ amu}) + (10.00)(24.9858\text{ amu}) + (11.01)(25.9826\text{ amu})}{100} = \_\_\_\_\_\_\_\_\_\_$$

Jack's Method

$$(0.7899)(23.9850\text{ amu}) + (0.1000)(24.9858\text{ amu}) + (0.1101)(25.9826\text{ amu}) = \_\_\_\_\_\_\_\_\_\_$$

Alan's Method

$$\frac{23.9850\text{ amu} + 24.9858\text{ amu} + 25.9826\text{ amu}}{3} = \_\_\_\_\_\_\_\_\_\_$$

13. Complete the three proposed calculations for the average atomic mass of magnesium in Model 3.

14. Consider the calculations in Model 3.

a. Which methods shown in Model 3 give an answer for average atomic mass that matches the mass of magnesium on the periodic table?

b. Explain why the mathematical reasoning was incorrect for any method(s) in Model 3 that did not give the correct answer for average atomic mass (the one on the periodic table).

c. For the methods in Model 3 that gave the correct answer for average atomic mass, show that they are mathematically equivalent methods.

15. Use one of the methods in Model 3 that gave the correct answer for average atomic mass to calculate the average atomic mass for oxygen. Isotope information is provided below. Show all of your work and check your answer against the mass listed on the periodic table.

Isotope	Natural Abundance on Earth (%)	Atomic Mass (amu)
^{16}O	99.76	15.9949
^{17}O	0.04	16.9991
^{18}O	0.20	17.9992

STOP

Read This!

Recall that all isotopes of an element have the same physical and chemical properties, with the exception of atomic mass (and for unstable isotopes, radioactivity). Therefore, the periodic table lists a weighted **average atomic mass** for each element. In order to calculate this quantity, the natural abundance and atomic mass of each isotope must be provided.

16. Consider the individual atomic masses for magnesium isotopes given in Model 2.

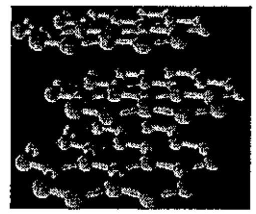
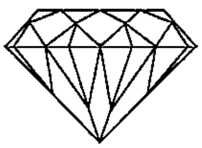
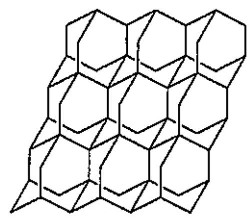
    a. Which isotope has an atomic mass closest to the average atomic mass listed on the periodic table?

    b. Give a mathematical reason for your answer to part *a*.

17. Boron has two naturally occurring isotopes: boron-10 and boron-11. Which isotope is more abundant on Earth? Use grammatically correct sentences to explain how your group determined the answer.

Extension Questions

Model 4 – Allotropes of Carbon

Natural Sample	Properties	Structure	Composition
 Graphite	Black Soft Conductive		98.89% Carbon-12 1.11% Carbon-13
 Diamond	Colorless Very hard Insulator		98.89% Carbon-12 1.11% Carbon-13

18. Consider the information about carbon provided in Model 4.

    a. Are diamonds and graphite made from the same element?

    b. Can the existence of isotopes explain the difference in properties between diamond and graphite? Explain.

    c. Propose an explanation for the difference in properties between diamond and graphite.

19. O_2 and O_3 (ozone) are allotropes of oxygen. Buckminsterfullerene (C_{60}) is another allotrope of carbon. Based on these statements and the information in Model 4, propose a definition for **allotrope**.

20. Two common forms of phosphorus are red and white. Red phosphorus is fairly stable at room temperature in air, but white phosphorus can ignite easily when exposed to air. Is this difference in properties due to the existence of different isotopes of phosphorus or different allotropes? Explain.

Ions

How are ions made from neutral atoms?

Why?

You have learned that not all atoms of an element are the same. Variation in the number of neutrons results in different isotopes of the element. In this activity we will explore another variation that can take place—the loss and gain of electrons. The exchange of electrons between atoms is a very common way for chemical change to take place. We will see it many times throughout the year.

1. Use Model 1 to complete the following table.

	Metal or Nonmetal	**Is the number of protons the same in the atom and the ion?**	**Is the number of neutrons the same in the atom and the ion?**	**Is the number of electrons the same in the atom and the ion?**	**Charge on the ion**
Lithium	metal				1+
Magnesium					2+
Aluminum		yes			3+
Fluorine				no	1–
Oxygen	nonmetal		yes	no	2–
Nitrogen					3–

2. Based on the table you completed in Question 1, what distinguishes a neutral atom from an ion?

3. Examine the isotope symbols in Model 1.

   a. Where is the ion charge located in the isotope symbol?

   b. Is a charge indicated on the neutral atoms? If yes, where is it located?

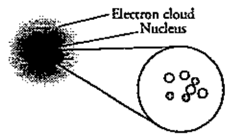
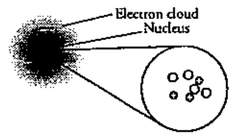
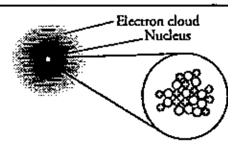
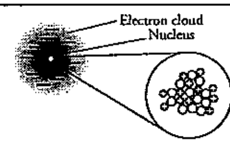
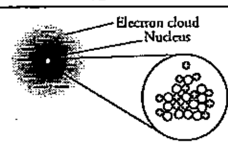
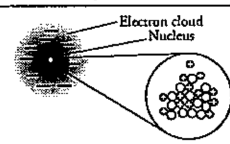
4. Which subatomic particle carries a positive charge?

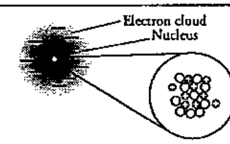
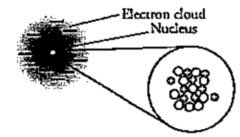
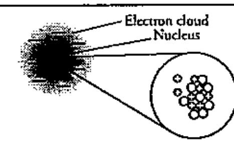
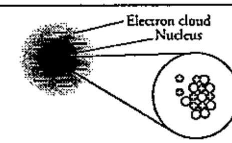
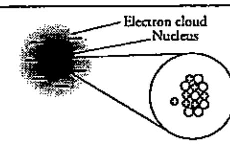
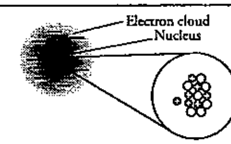
5. Which subatomic particle carries a negative charge?

6. Propose a mathematical equation to calculate the charge on an ion from the number of protons and electrons in an ion. Confirm that your equation works using two positive ion examples and two negative ion examples from Model 1.

STOP

Model 1 – Atoms and Ions

	Neutral Atoms	Ions
	Atom of Lithium	Ion of Lithium
Symbol	$^{7}_{3}Li$	$^{7}_{3}Li^{1+}$
Atomic Diagram		
No. of Protons ⊕	3	3
No. of Neutrons ○	4	4
No. of Electrons ▬	3	2
	Atom of Magnesium	Ion of Magnesium
Symbol	$^{24}_{12}Mg$	$^{24}_{12}Mg^{2+}$
Atomic Diagram		
No. of Protons ⊕	12	12
No. of Neutrons ○	12	12
No. of Electrons ▬	12	10
	Atom of Aluminum	Ion of Aluminum
Symbol	$^{27}_{13}Al$	$^{27}_{13}Al^{3+}$
Atomic Diagram		
No. of Protons ⊕	13	13
No. of Neutrons ○	14	14
No. of Electrons ▬	13	10

	Neutral Atoms	Ions
	Atom of Fluorine	Ion of Fluorine
Symbol	$^{19}_{9}F$	$^{19}_{9}F^{1-}$
Atomic Diagram		
No. of Protons ⊕	9	9
No. of Neutrons ○	10	10
No. of Electrons ▬	9	10
	Atom of Oxygen	Ion of Oxygen
Symbol	$^{16}_{8}O$	$^{16}_{8}O^{2-}$
Atomic Diagram		
No. of Protons ⊕	8	8
No. of Neutrons ○	8	8
No. of Electrons ▬	8	10
	Atom of Nitrogen	Ion of Nitrogen
Symbol	$^{14}_{7}N$	$^{14}_{7}N^{3-}$
Atomic Diagram		
No. of Protons ⊕	7	7
No. of Neutrons ○	7	7
No. of Electrons ▬	7	10

Read This!

Chemists refer to positively charged ions as **cations.** Chemists refer to negatively charged ions as **anions.**

7. Fill in the following table.

Symbol	$^{88}_{38}Sr^{2+}$	$^{32}_{16}S^{2-}$		
Atomic Number				35
Mass Number			70	
Number of protons			31	
Number of electrons			28	36
Number of neutrons				45
Cation or anion				

8. Could a +3 ion of aluminum be made by adding three protons to an aluminum atom? Explain.

9. One of your classmates is having trouble understanding ions. He explains the formation of a cation like this:

   "When you add an electron, you get a positive charge because adding is positive in math."

   a. As a group, explain in a grammatically correct sentence why this student is incorrect.

   b. Provide a better description of how math relates to electrons and ion formation.

Model 2 – Ion Charges for Selected Elements

	I	II					III	IV	V	VI	VII	VIII
1	H^{+}											
2	Li^{+}								N^{3-}	O^{2-}	F^{1-}	
3	Na^{+}	Mg^{2+}	transition elements				Al^{3+}		P^{3-}	S^{2-}	Cl^{1-}	
4	K^{+}	Ca^{2+}	Fe^{2+} Fe^{3+}	Ni^{2+} Ni^{3+}	Cu^{+} Cu^{2+}	Zn^{2+}	Ga^{3+}				Br^{1-}	
5	Rb^{+}	Sr^{2+}			Ag^{1+}			Sn^{2+} Sn^{4+}			I^{1-}	
6		Ba^{2+}				Hg_2^{2+} Hg^{2+}		Pb^{2+} Pb^{4+}				

← CATIONS → ← ANIONS →

10. Draw a stair-step line in Model 2 to separate the metals and nonmetals.

11. Consider the ions listed in Model 2.
    a. In general, do nonmetals form anions or cations?

    b. In general, do metals form anions or cations?

    c. Which nonmetal appears to be an exception to these guidelines?

Extension Questions

12. Name the family of elements that make 1– anions as shown in Model 2.

13. Name the family of elements that make 2+ cations as shown in Model 2.

14. For the main group elements (excluding the transition elements), is it necessary to memorize the type of ion each element makes or could you predict the ion charge using a periodic table? Explain.

15. In Model 2 there are several elements whose atoms make more than one type of ion. Where in the periodic table are these elements usually found?

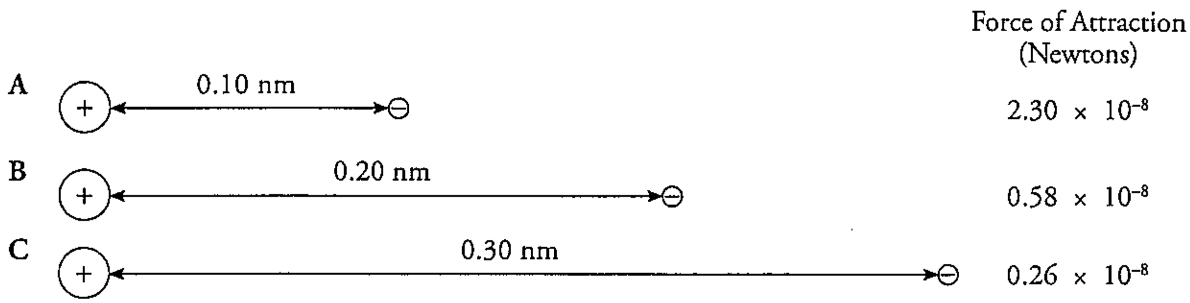
Coulombic Attraction

What variables will affect the force of attraction between charged particles?

Why?

Coulombic attraction is the attraction between oppositely charged particles. For example, the protons in the nucleus of an atom have attraction for the electrons surrounding the nucleus. This is because the protons are positive and the electrons are negative. The attractive force can be weak or strong. In this activity, you will explore the strength of attraction between protons and electrons in various atomic structures.

Model 1 – Distance and Attractive Force



1. What subatomic particles do these symbols represent in Model 1?

   (+) ⊖

2. Would you expect to observe attraction or repulsion between the subatomic particles in Model 1?

3. Consider the data in Model 1.

   a. What are the independent and dependent variables in the data?

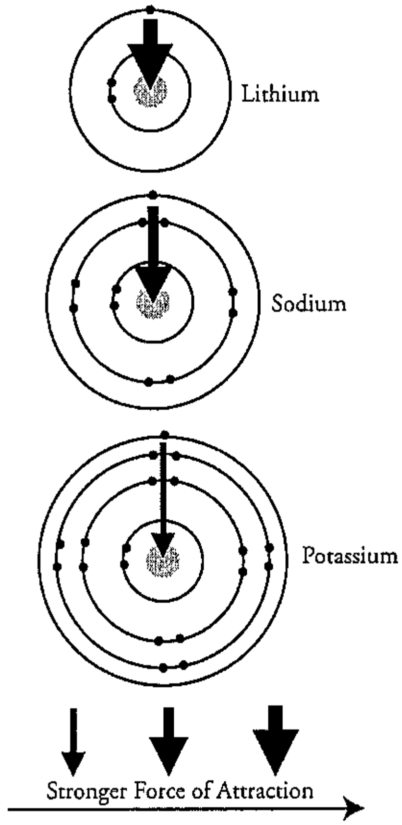
   b. Write a complete sentence that describes the observed relationship between the independent and dependent variables in Model 1.

4. If the distance between a proton and electron is 0.50 nm, would you expect the force of attraction to be greater than or less than 0.26×10^{-8} N?

5. If two protons are 0.10 nm away from one electron, would you expect the force of attraction to be greater than or less than 2.30×10^{-8} N?

STOP

Model 2 – The Alkali Metals



6. Consider the diagrams in Model 2.
   a. What do the arrows represent?

   b. How does the thickness of the arrows relate to the property given in part *a*?

7. Using a periodic table, locate the elements whose atoms are diagrammed in Model 2. Are the elements in the same column or the same row?

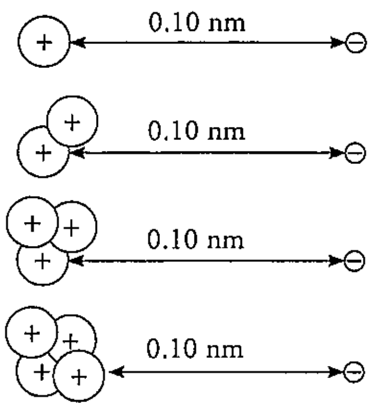
8. Circle the outermost electron in each of the diagrams in Model 2.
   a. As you move from the smallest atom to the largest atom in Model 2, how does the distance between the outermost electron and the nucleus change?

   b. As you move from the smallest atom to the largest atom in Model 2, how does the attractive force between the outermost electron and the nucleus change?

   c. Are your answers to parts *a* and *b* consistent with the information in Model 1?

STOP

Model 3 – Number of Protons and Attractive Force



	Force of Attraction (Newtons)
A	2.30×10^{-8}
D	4.60×10^{-8}
E	6.90×10^{-8}
F	9.20×10^{-8}

9. Consider the data in Model 3.

   a. What are the independent and dependent variables in the data?

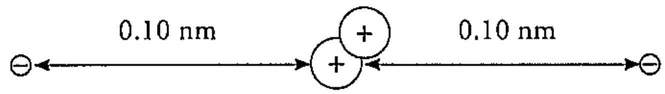
   b. Write a complete sentence that describes the relationship between the independent and dependent variables in Model 3.

10. What would be the attractive force on a single electron if five protons were in the nucleus of an atom? Show mathematical work to support your answer.

11. Imagine that a second electron were placed to the left of a nucleus containing two protons (Model 3, set D). Predict the force of attraction on both the original electron and the second electron. Explain your prediction with a complete sentence.

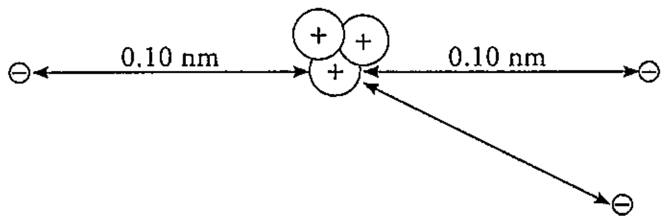
Read This!

The attractive and repulsive forces in an atom are rather complex. An electron is attracted to the protons in the nucleus, but it is also repelled by the other electrons in the atom. It is important to note however that the attractive force of the nucleus is NOT divided up among the electrons in the atom. Each electron gets approximately the full attractive force of the nucleus (minus the repulsive effects of other electrons). Compare the diagram below to set D in Model 3. Notice the similarity in attractive force.

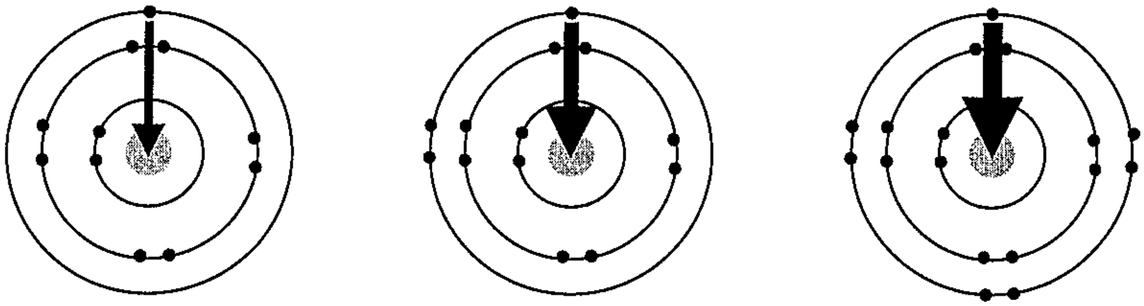


approx. 4.60×10^{-8}
(on each electron)

12. What is the approximate attractive force on each electron below?



Model 4 – Period 3 Elements



Sodium Aluminum Chlorine

13. Using the periodic table, locate the elements whose atoms are diagrammed in Model 4. Are the elements in the same column or the same row?

14. Circle the outermost electron(s) in each of the atoms in Model 4.

15. Which of the three atoms diagrammed in Model 4 has the strongest attraction for its outermost electron(s)?

16. Consider the information in Model 4.

a. As you move from the smallest atom to the largest atom, does the distance between the outermost electron(s) and the nucleus change significantly?

b. Can the differences in the attractive force shown by the arrows be explained by a change in the distance between the electron(s) and the nucleus?

c. On the diagrams in Model 4, write the number of protons located in the nucleus of each atom.

d. Can the differences in attractive forces shown by the arrows in Model 4 be explained by a change in the number of protons in the nucleus? If yes, explain the relationship in Model 4.

STOP

17. For each set of elements below, circle the element whose atoms will have a stronger attractive force between their outermost electron(s) and the nucleus.

a. Ba and Ca *b.* Cr and Cu *c.* Ar and Xe

Extension Questions

18. Consider the atom diagrams in Model 2.

    a. On each diagram write the number of protons in the nucleus of the atom.

    b. When comparing elements in the same column of the periodic table, which factor—distance to the nucleus or number of protons in the nucleus—seems to be the dominant factor for determining the attractive force between the outermost electron(s) and the nucleus? Explain.

19. Consider the data presented in Models 1 and 3.

    a. Describe the mathematical relationship between the distance (d) and the attractive force (F) between protons and electrons.

    b. Describe the mathematical relationship between the number of protons in the nucleus (Z) and the attractive force (F) between the nucleus and electrons.