SCH 3UI Unit 6 Outline:
Quantities in Chemistry, Moles

Lesson	Topics Covered	Homework Questions and Assignments
1	**Introduction to Significant Digits**	• Read through the rules for using significant digits • Complete practice problems on Worksheet: Significant Digits
2	**Take up any questions about sig digs** **Note: Percentage Composition** • Law of Constant Composition • calculating percent composition from experimental data	• Complete handout: Percentage Composition Problems. Check that all numbers have units, and you have rounded your final answer to the correct number of sig digs.
3	**Note: Atomic and Molecular Mass** • average atomic mass • relative atomic mass • molecular mass (aka formula mass) **Note: Calculating Percentage Composition from Atomic and Molecular Mass**	• Complete questions 1 – 5 on handout: Atomic and Molecular Mass, Practice Questions
4	**Lab #6: Percentage Composition of a Compound**	• work on lab report and calculations for Lab #6
5	**Note: Introduction to the Mole** • definition of the mole • Avogadro's number • calculating number of particles (atoms or molecules), given number of moles	• complete lab report for Lab #6 (due next class) • complete questions on handout: Introduction to the Mole
6	**Note: Moles and Molar Mass** • molar mass • calculating number of moles from the mass of a substance	• complete questions on handout: What's so Special About the Mole?
7	**Note: Moles, Molar Mass and Avogadro's Number** • fill in Moles Summary Sheet • working between # of particles, mass and moles	• complete handout: Using Avogadro's Number
8	**Note: Moles and the Volume of Gas** • SATP and STP • molar volume • calculating # of moles using volume of gas at STP	• complete handout: Moles and the Volume of Gas • complete handout: Mole Problems #1 • begin Moles Take-home Quiz
9	**Note: Empirical (Simplest) Formula** • definition • finding the simplest formula of a compound from experimental data • "special" decimals (.5, .33 and .67)	• complete questions on Simplest Formula on handout • complete Mole Problems #2 • complete Moles Take-home Quiz, due next class
10	**Note: Molecular Formulas** • finding molecular formulas using the simplest formula and molar mass	• complete handout: Simplest and Molecular Formulas, Practice Q • begin Unit #6 Review: Quantities in Chemistry (on line)

Uncertainty in Measurement: Introduction to Significant Digits

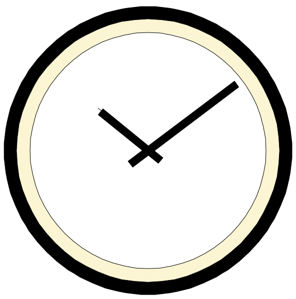
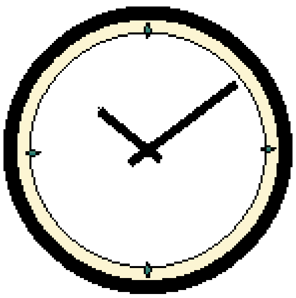
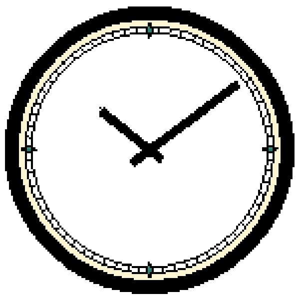
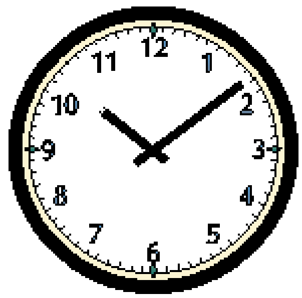
All measured values are _____________. There is some ________________ in every measurement due to the ________________ of the equipment and the ____________ of the person using it.

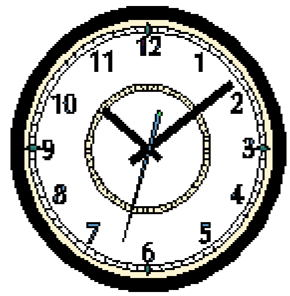
The **accuracy** of a measurement describes how close a measured value is to the ___________ or _______________ value. The difference between the ________________ (observed) value and the ___________ (accepted) value is called the **error**. The smaller the error, the ____________ the accuracy.

The **precision** of a measurement indicates the _________________ of a measurement and depends on the equipment used to make that measurement. A ruler can measure only to 0.1 mm but a micrometer can measure to 0.0001 mm. A micrometer gives a more precise or exact measurement.

The digits that can be reasonably reported for a measured value are called ____________________ __________ (_____________). The number of significant digits indicates the _______________ of a measurement. As a rule, estimate ________________ from in between the scale markings.

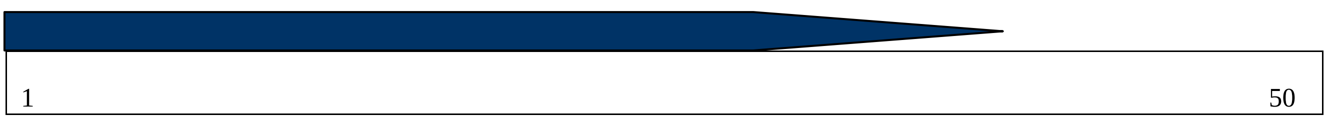
eg. Record the time with as much certainty as each clock permits:

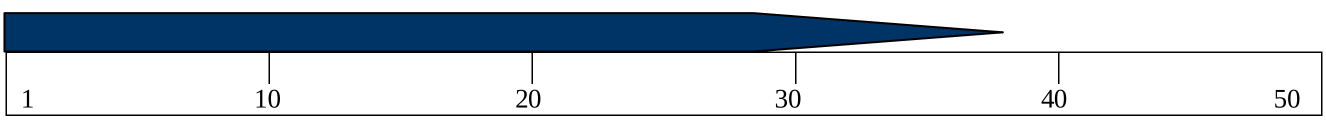





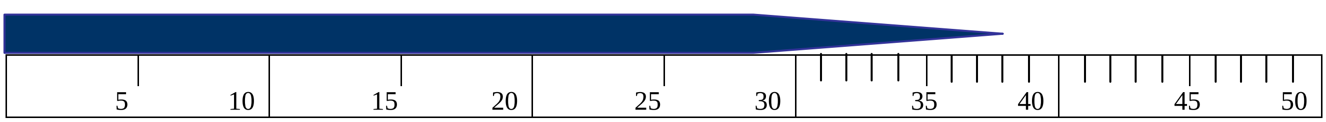


____________ ____________ ____________ ____________ ____________

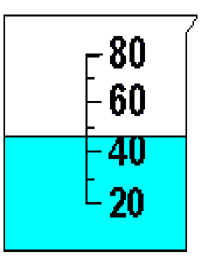
eg. Record the length of each pencil as much certainty as each ruler permits:

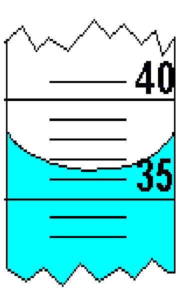


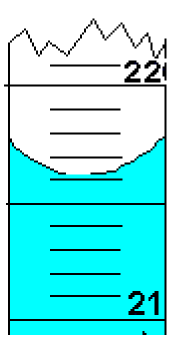


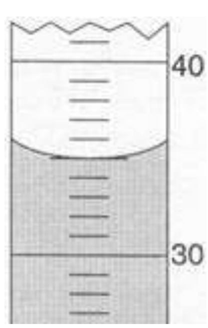


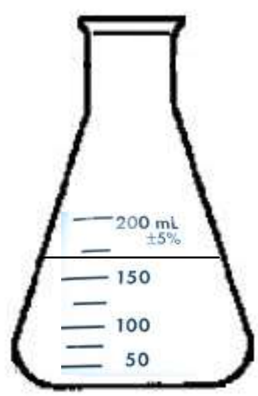
eg. Record each volume with as much certainty as each scale permits:











Determining the Number of Significant Digits

1. All non-zero digits and zeroes in the middle of a number are significant.

1.607 cm	_____ sig digs	61 m/s	_____ sig digs	3.1428571 h	_____ sig digs
371 mL	_____ sig digs	5.03 s	_____ sig digs	8006 feet	_____ sig digs

2. Leading zeroes (the ones at the beginning of a number) are not significant.

0.0055 cm	_____ sig digs	0.461 m/s	_____ sig digs	0.000 299 811	_____ sig digs
0.0172 mL	_____ sig digs	0.336 s	_____ sig digs	10056 feet	_____ sig digs

3. Trailing zeroes (the ones at the end of a number) are only significant if the number includes a decimal point.

60.00 cm	_____ sig digs	4.07800 m/s	_____ sig digs	2000 kg	_____ sig digs
100 mL	_____ sig digs	650 s	_____ sig digs	0.30050	_____ sig digs

4. Numbers that are whole counted numbers or are defined numbers (such as a conversion factor) have an infinite number (   ) of significant digits.

4 dogs	____ sig digs	1000 m in a km	_____ sig digs	9 carbon atoms	_____ sig digs
12 eggs in a dozen	____ sig digs	10 mm	_____ sig digs	60 min in an hour	___ sig digs
4.11 m	____ sig digs	0.0400 s	_____ sig digs	12 mos / year	_____ sig digs

5. When we do a calculation, the answer has the same number of sig digs as the least accurate measurement used in the calculation. You may need to convert the answer to scientific notation.

1.5224 x 173 = ____________________ rounds to ___________________ (____ sig digs)

1701 ÷ 288.76 = ____________________ rounds to ___________________ (____ sig digs)

3.1428571 x 12 = ____________________ rounds to ___________________ (____ sig digs)

6.200 x 10.1 = ____________________ rounds to ___________________ (____ sig digs)

30.95 x 000.822 = ____________________ rounds to ___________________ (____ sig digs)

6. In the middle of a calculation, carry two more sig digs than you will report in the final answer. Rounding off too early in a calculation can lead to significant error, so round once at the end.

1.347 cm rounded to 2 sig digs _______________	6.0045 s rounded to 3 sig digs _______________
5.55557 g rounded to 4 sig digs _______________	1078 min rounded to 2 sig digs ______________
4.9986 s rounded to 3 sig digs ________________	39585 cm rounded to 2 sig digs ______________

Practice:

1. Calculate the volume of a rectangular prism that is 1.5 cm long, 2.3 cm wide and 12.8 cm high.

2. Calculate the volume of a sphere that has a radius of 5.0 m. ($V_{sphere} = {}^4/_3\, \pi\, r^3$, where $\pi = 3.14159$)

3. The density of pure aluminum is 2.6989 g/mL. A piece of aluminum occupies a volume of 21.8 mL, what is the mass of the piece of aluminum? (D = m/V)

Rules for Significant Digits

The number of significant digits in a measured value is an indication of the precision of the measurement. For example, a mass of 12.324 g (5 sig digs) is much more precise than a measurement of 12 g (2 sig digs).

Rules for Determining the Number of Significant Digits in Measured Values

1. All digits from 1 – 9 are significant, no matter where they are in a number.

2. Zeroes found in between other digits are significant.
   eg. 3009 has 4 sig digs   140012 has 6 sig digs

3. "Leading zeroes" (zeroes in front of a number) are **NOT** significant. They are place-holders. We know this because when you convert these numbers to scientific notation, the leading zeroes are not reported.
   eg. 0.00231 has 3 sig digs   (this number is 2.31×10^{-3} in scientific notation)
   0.1003 has 4 sig digs   (this number is 1.003×10^{-1} in scientific notation)

4. If there is **NO** decimal point in the number, then trailing zeroes (zeroes at the end of a number) are **NOT** significant.
   eg. 100 has only 1 sig dig   (this number is 1×10^{2} in scientific notation)
   45300 has 3 sig digs   (this number is 4.53×10^{4} in scientific notation)

5. If there **IS** a decimal point in the number, then trailing zeroes (zeroes at the end of a number) **ARE** significant. When you convert these numbers to scientific notation, report all trailing zeroes.
   eg. 103.00 has 5 sigs digs   (this number is 1.0300×10^{2} in scientific notation)
   0.02480 has 4 sig digs   (this number is 2.480×10^{-2} in scientific notation)
   250. has 3 sig digs   (the decimal is a "cheater" way to make the zero significant. Scientific notation is better: 2.50×10^{2})

6. Counted values and conversion factors are considered to be exact; that is, they are infinitely accurate and have an unlimited number of significant digits. Counted values and conversion factors do not limit the number of sig digs that can be reported.
   eg. 24 sheep is exactly 24 sheep (it means 24.0000000000000000000000000…)
   100 cm in a metre is exactly 100 (it means 100.0000000000000000000000…)

Rules for Calculations with Significant Digits

When measured values are used in calculations, the final calculated value can not be more accurate than the least accurate measured value.

For example, if density is calculated from a mass of 12.324 g and a volume of 12 mL, the density can have only 2 sig digs because the least accurate measurement (volume) has only 2 sig digs.

D = m/V
= 12.324 g)12 mL
= 1.027 g/mL
= 1.0 g/mL (2 sig digs)

1. In general, for calculations involving measured values, look at the data and determine which measured value has the fewest sig digs. Round the final answer to this number of sig digs.
2. For calculations that involve more than one step, carry two more sig digs than you will report in your final answer. Round **ONLY** the **final answer** to the correct number of sig digs.
3. If necessary, convert the final answer to scientific notation to correctly report the number of sig digs. All digits in scientific notation are significant.
4. Round the final answer only once.
   eg. 4.5578 rounded to three sig digs is 4.56
   539.45 rounded to two sig digs is 540 or 5.4×10^{2}
   1049.882 rounded to two sig digs is 1.0×10^{3}

Worksheet: Significant Digits

1. All digits from 1 – 9 and zeroes in the middle of a measured value are significant digits.

1.667 cm _____ sig digs 61 m/s _____ sig digs 3.506 miles _____ sig digs

307 mm _____ sig digs 3.1428571 _____ sig digs 10006 km _____ sig digs

2. "Leading zeroes" (zeroes at the beginning of a measured value) are not significant.

0.00667 cm _____ sig digs 0.002004 m/s _____ sig digs 0.506 miles _____ sig digs

00307.2 cm _____ sig digs 0.03 m _____ sig digs 000005.2 s _____ sig digs

3. "Trailing zeroes" (zeroes at the end of a measured value) are significant **ONLY IF** the number contains a decimal point.

16.00 ounces _____ sig digs 42 000 km _____ sig digs 0.6090 mm _____ sig digs

100 g _____ sig digs 0.0310 m _____ sig digs 500.20 s _____ sig digs

4. Counted values and conversion factors are considered to have an infinite number of sig. digs.

1000 m in a km _____ sig digs 12 eggs per dozen _____ sig digs 1 g = 1000 mg _____ sig digs

60 s per minute _____ sig digs 33 students _____ sig digs 1 marble _____ sig digs

5. When multiplying and/or dividing numbers, the answer must have the same number of significant digits as the measurement with the fewest number of significant digits.

1.5224 x 173 = ________________ 100.0 ÷ 33 = ___________________

1701 ÷ 288.76 = ________________ 1200 ÷ 2974 = ____________________

3.2 x 10.1 = _______________ 30.75 x 000.822 = ___________________

6. When adding and subtracting measured values, the answer must have the same number of decimal places as the measured number with the fewest number of ***decimal places***.

15.224 + 173.6 = ________________ 100 – 33 = ___________________

2500.2 – 389.753 = ________________ 200.5 + 29.498 = ____________________

3.1428571 – 12 = ________________ 10 – 62.344 = ____________________

7. Complete the following calculations and round your answer to the correct number of sig.digs:

a) 22.4 h x 0.1 km/h =

f) $\dfrac{\text{465 km}}{\text{5.21 h}}$ =

b) 18 cm^3 x 1.10 g/cm^3 =

g) 72.5 m/s x 45.9 s =

c) 17.5 mL + 95 mL + 8.25 mL =

h) 32.1 m + 960 m + 20.02 m =

d) 0.2 cm + 23.91 cm + 0.62 cm =

i) 13.63 h - 0.5 h =

e) $\dfrac{\text{567 m}}{\text{86 s}}$

j) 15.9994 µ + 1.00794 µ + 65.39 µ =

Percentage Composition

Hundreds of years ago, early chemists carefully took compounds apart to see what they were made of. Scientists reported their results as a percentage by weight and they started to notice patterns:

- Bauxite (aluminum oxide) was always: __________ aluminum and __________ oxygen, by mass
- Salt (sodium chloride) was always: __________ sodium and __________ chlorine, by mass
- Cinnabar (mercury (II) sulfide) was always: __________ mercury and __________ sulfur, by mass

From results like these, Joseph Proust (1734 – 1794) stated the **Law of Definite Proportions**: a specific compound always contains the ________________________ in definite, constant proportions, by ________.

% composition = ________________________________ x 100%
(by mass)

Calculating Percentage Composition

eg. Iron and sulfur react to produce iron sulfide. Use the following data to find the percentage composition of the compound (i.e. calculate the percentage of iron and the percentage of sulfur).

A.	mass of empty crucible	30.6 g
B.	mass of crucible and iron	41.8 g
C.	mass of crucible and iron sulfide	48.2 g

mass of iron = ______________________
= ______________________
= ______________________

mass of iron sulfide = ______________________
= ______________________
= ______________________

eg. 63.40 g of a compound is analyzed and found to contain 24.04 g of nickel, 13.14 g of sulfur and the remainder is oxygen. Calculate the percentage composition by mass of this compound.

Percentage Composition Problems

For all calculations, show a complete solution (equation, substitution and final answer). Include units for all numbers. Round your final answer to the appropriate number of significant digits.

1. Mercury (II) oxide decomposes when heated to produce pure mercury and oxygen gas.
a) Write the balanced chemical equation for this reaction, including the states of all reactants and products.
b) Use the data given below to calculate the percentage by mass of mercury in the compound.

mass of empty test tube	12.25 g
mass of test tube and mercury (II) oxide	13.68 g
mass of test tube and mercury	13.57 g

2. A small amount of lead is heated strongly with sulfur to produce the compound lead (II) sulfide.
a) Write the balanced chemical equation for this reaction, including the states of all reactants and products.
b) Using the following data, calculate the percentage by mass of lead in lead (II) sulfide.

mass of crucible	23.1 g
mass of crucible and lead metal	25.1 g
mass of crucible and lead sulfide	25.4 g

3. A compound of nitrogen and oxygen is found to contain 4.20 g of nitrogen and 12.0 g of oxygen. What is the percentage composition by mass of each element in this compound?

4. When a compound of copper (II) oxide is heated, it is converted to pure copper. In an experiment 16.35 g of copper (II) oxide yielded 13.06 g of copper.
a) Write the balanced chemical equation for this reaction, including the states of all reactants and products.
b) Calculate the percentage by mass of oxygen in copper oxide.

5. Heating 2.43 g of magnesium in air produces 4.03 g of magnesium oxide.
a) Write the balanced chemical equation for this reaction, including the states of all reactants and products.
b) Calculate the percentage by mass of magnesium in magnesium oxide.
c) Calculate the percentage by mass of oxygen in magnesium oxide.

6. A certain compound contains 30.1% oxygen by mass. What mass of oxygen is there in 5.0 g of the compound?

Answers:
1b) 92.31% 4 sig digs
2b) 87.0 % 3 sig digs
3) 25.9% nitrogen and 74.1% oxygen, 3 sig digs
4b) 20.12% 4 sig digs
5b) 60.3 % 3 sig digs
5c) 39.7 % 3 sig digs
6) 1.5 g of oxygen, 2 sig digs

Atomic and Molecular Mass, Practice Questions

1. Define (average) atomic mass, molecular mass
2. Why is "average atomic mass" also known as "relative atomic mass"? What are atomic masses measured relative to?
3. Use your Periodic Table to find the **atomic mass** of the following atoms. Round to two decimal places and include units.

   a) silver ___________ e) gold ___________

   b) potassium ___________ f) iodine ___________

   c) oxygen ___________ g) sodium ___________

   d) chromium _____________ h) fluorine ____________

4. Use your Periodic Table to calculate the **molecular mass** of the following compounds. Remember to use the criss-cross rule to find the chemical formula. Use atomic masses rounded to two decimal places and include units.

   a) magnesium chloride

   b) barium sulfite

   c) iron (III) nitrate

   d) ammonium phosphate

   e) gold (III) perchlorate

5. Using atomic and molecular masses, calculate the % composition by mass of the following compounds. Show an equation, substitution and final answer, rounded to the correct number of sig digs.

   a) nitrogen in sodium nitrate

   b) carbon in C_8H_{18} (octane in gasoline)

   c) oxygen in potassium permanganate

   d) hydrogen in $C_6H_{12}O_6$ (glucose, sugar)

Answers

2. a C-12 atom, which has been assigned a mass of exactly 12.000000000000000…u

3. a) 107.87 u e) 196.97 u
   b) 39.10 u f) 126.90 u
   c) 16.00 u g) 22.99 u
   d) 52.00 u h) 19.00 u

4. a) $MgCl_2$: 95.21 u
   b) $BaSO_3$: 217.40 u
   c) $Fe(NO_3)_3$: 241.88 u
   d) $(NH_4)_3PO_4$: 149.12 u
   e) $Au\ (ClO_4)_3$: 495.32 u

5. a) $NaNO_3$: 16.48 % N
   b) C_8H_{18} : 84.09 % C
   c) $KMnO_4$: 40.50 % O
   d) $C_6H_{12}O_6$: 6.73 % H

Introduction to the Mole

A mole is the name of a very, very large number:

- the number of things in a mole is always 6.02×10^{23}
- this is also called Avogadro's number (N_A)
- in expanded form, it looks like this: 602 000 000 000 000 000 000 000
- mole is abbreviated "mol"

It is hard to imagine how big this number is:

- if there was one mole of marbles on the Earth, it would make a layer of marbles 80 km thick over the entire planet
- if Earth can support 7 billion people, there would have to be 86 trillion Earths to hold one mole of people
- if you spent one billion dollars every day, it would take more than a trillion years to spend a mole of dollars
- if a computer executes 26 million instructions per second, the computer would have to work non-stop for 733 million years to execute a mole of instructions

Because a mole is so big, it is used to count very tiny particles like atoms and molecules.

If	1.00 mole	=	6.02×10^{23} particles (atoms or molecules)		
then	2.00 moles	=	2.00 moles x 6.02×10^{23} particles/mole	=	_______________ particles
	5.00 moles	=	_________ x 6.02×10^{23} particles/mole	=	_______________ particles
	0.75 moles	=	_________ x 6.02×10^{23} particles/mole	=	_______________ particles

This relationship can be expressed as a conversion factor:

1 mole = 6.02×10^{23} particles (atoms or molecules)

1. Calculate the number of particles in:

a) 4.55 moles of S atoms — (2.74×10^{24} atoms)
b) 0.772 moles of water molecules — (4.65×10^{23} molecules)
c) 364 moles of H_2 molecules — (2.19×10^{26} molecules)
d) 5.00×10^{-10} moles of gold atoms — (3.01×10^{14} atoms)

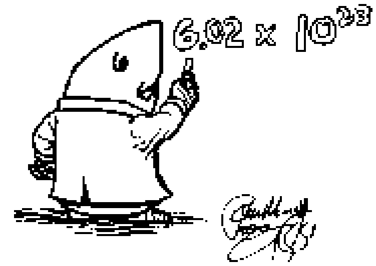
2. Calculate the number of moles in:

a) 4.67×10^{16} molecules of chlorine — (7.76×10^{-8} mol)
b) 3.90×10^{33} atoms of gold — (6.48×10^{9} mol)
c) 8.69×10^{9} crystals of silicon dioxide (sand) — (1.44×10^{-14} mol)
d) 7.44×10^{55} molecules of ammonia — (1.24×10^{32} mol)

3. To convert from the # of molecules of a substance to the # of atoms of an element in that substance: multiply the # of molecules by the # of atoms per molecule.

a) How many atoms of S are there in 100 molecules of Fe_2S_3? — (300 atoms of S)
b) How many atoms of Fe are there in 100 molecules of Fe_2S_3? — (200 atoms of Fe)
c) How many atoms, in total, are there in 100 molecules of Fe_2S_3? — (500 atoms total)
d) How many atoms of O are there in 1.20×10^{6} molecules of $Al(ClO_3)_3$? — (1.08×10^{7} atoms of O)
e) How many atoms of Pb are there in 6.02×10^{23} molecules of $Pb_3(PO_4)_4$? — (1.81×10^{24} atoms of Pb)
f) How many atoms of Pb are there in 5.00 moles of $Pb_3(PO_4)_4$ molecules? — (9.03×10^{24} atoms of Pb)

What's so Special About the Mole?



A **mole** is defined as ________________________ things.

- A mole is just a number! A very, very large number.
- Because a mole is so large, it is used to count ____________________ _________________ like ____________ and __________________.

The mole is significant because of a special relationship that was defined by _________________________:

Average Atomic Mass or Molecular Mass (the mass of one atom or molecule in amu)	**Molar Mass (MM) (the mass of 1 mole of atoms or molecules in grams)**
1 sodium atom weighs	1 mole of sodium atoms weighs
1 helium atom weighs	1 mole of helium atoms weighs
1 water molecule weighs	1 mole of water atoms weighs
1 ammonia molecule weighs	1 mole of ammonia molecules weighs

Molar Mass (   ) is defined as the ____.

The molar mass of a substance is the same as its atomic or molecular mass, except that atomic mass and molecular mass are measured in ________ (   ) while the molar mass is measured in ________________.

If one mole of helium atoms weighs ____________ g, then

- Two moles of helium atoms weighs __________________________________ or _______________
- Four moles of helium atoms weighs __________________________________ or _______________
- One half mole of helium atoms weighs __________________________________ or _______________

As a conversion factor:

1 mole = 1 molar mass (MM) of a substance in grams

1. Calculate the **molar mass** (MM) of the following. Include correct units and round to 2 decimal places.

a) CO_2
b) $AlBr_3$
c) $Na_4Fe(CN)_6$
d) ammonium chloride
e) iron(II) sulfate
f) cobalt (III) acetate

2a) What is the molar mass of ammonia, NH_3?
b) What is the mass of 12.0 moles of ammonia?
c) What is the mass of 0.250 moles of ammonia?
d) How many moles is 345 grams of ammonia?
e) How many moles is 5.0 grams of ammonia?

3. Calculate the **mass** (**m**) of the following:
a) 12.4 mol of helium, He
b) 0.26 mol of butane, C_4H_{10}
c) 1.5×10^{-3} mol of calcium carbonate
d) 3.76×10^{5} mol of hydrogen gas, H_2

4. Calculate the number of **moles** in:
a) 0.012 g of sodium fluoride, NaF (the amount in a tube of toothpaste)
b) 60.0 mg of vitamin C, $C_6H_8O_6$ (the daily adult requirement)
c) 0.500 kg of table salt, NaCl (a "box" of salt)
d) 62 456 kg of gold (the amount mined annually in Canada)

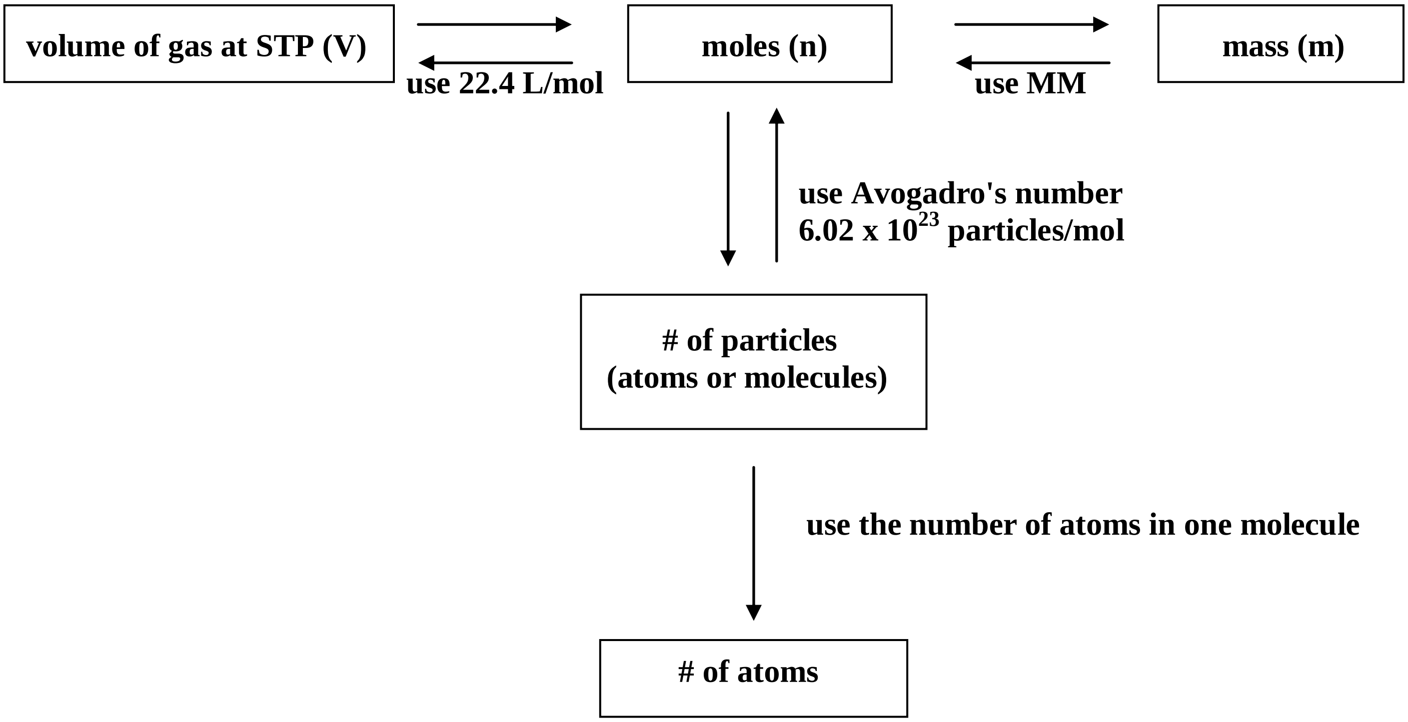
Answers:
1a) 44.01 g/mol
b) 266.68 g/mol
c) 303.93 g/mol
d) 53.50 g/mol
e) 151.92 g/mol
f) 236.08 g/mol

2a) 17.04 g/mol
b) 204 g
c) 4.26 g
d) 20.2 mol
e) 0.29 mol

3a) 49.6 g
b) 15 g
c) 0.15 g
d) 7.60×10^{5} g

4a) 2.9×10^{-4} mol
b) 3.41×10^{-4} mol
c) 8.56 mol
d) 3.1708×10^{5} mol

MOLES SUMMARY SHEET



CONVERSION FACTORS:

1 mole = 6.02×10^{23} particles (atoms or molecules)

1 mole = 1 molar mass (MM) of a substance (in grams)

1 mole = 22.4 L of gas at STP (Standard Temperature and Pressure, 0°C and 101.3 kPa)

1 molecule $A_xB_yC_z$ = x atoms of A + y atoms of B + z atoms of C

1 molecule $A_xB_yC_z$ = (x + y + z) atoms in total

DEFINITIONS:

Mole: ____

____

(Average) Atomic Mass: ____

____

Molecular Mass: ____

____

Molar Mass (MM): ____

____

Molar Volume (MV): ____

____

Using Avogadro's Number

1. How many molecules are there in 2.50 moles of water?

2. How many molecules are there in 10.0 g of hydrogen gas?

3. How many atoms are there in 10.0 g of hydrogen gas?

Questions:

1. How many molecules are there in:

a) 3.6 g of water	(1.2×10^{23} molecules)
b) 100.0 g of sodium chloride	(1.03×10^{24} molecules)
c) 50.0 g of sodium hydroxide	(7.53×10^{23} molecules)

2. Calculate the mass of:

a) 3.01×10^{23} atoms of gold	(98.5 g)
b) 9.03×10^{25} molecules of sugar ($C_{12}H_{22}O_{11}$)	(5.14×10^{4} g)
c) 1 molecule of sugar, in grams	(5.69×10^{-22} g)
d) 1 molecule of sugar, in amu (u)	(342.34 u)

3. Given 180.2 g of water:

a) How many atoms of H are there?	(1.20×10^{25} atoms of H)
b) How many atoms of O are there?	(6.02×10^{24} atoms of O)
c) How many atoms are there in total?	(1.81×10^{25} atoms in total)

Moles and the Volume of Gas at STP

SATP stands for ____. This is another way of saying "normal room conditions," or ________ ºC and ________kPa.

STP stands for ____. The conditions for STP are ________ ºC and ________kPa.

At **STP**, one mole of **any gas** has a volume of ____________. This is known as the _________________.

For example:

- one mole of oxygen gas, $O_{2(g)}$ at STP has a volume of ____________
- one mole of nitrogen gas, $N_{2(g)}$ at STP has a volume of ____________
- one mole of carbon dioxide gas, $CO_{2(g)}$ at STP has a volume of ____________
- one mole of methane (natural gas) $CH_{4\,(g)}$ at STP has a volume of ____________
- one mole of water vapour, $H_2O_{(v)}$ at STP has a volume of ____________
- two moles of hydrogen gas, $H_{2\,(g)}$ at STP has a volume of ____________
- three moles of hydrogen gas, $H_{2\,(g)}$ at STP has a volume of ____________

As a conversion factor: **1 mole of gas at STP = 22.4 L**

eg. What is the volume of 5.00 moles of carbon monoxide gas at STP?

eg. What is the volume of 4.00 g of oxygen gas at STP?

Questions: Use conversion factors, including all units, to answer the following questions. Round your final answer to the appropriate number of significant digits.

1. Calculate the volume, at STP, of:

a) 2.00 moles of H_2 gas (44.8 L, 3 sd)
b) 0.075 moles of water vapour (1.7 L, 2 sd)
c) 5.00 g of CO_2 (2.54 L, 3 sd)
d) 100.0 g of sulfur dioxide gas (35.0 L, 3 sd)
e) 6.02×10^{24} molecules of nitrogen gas (224 L, 3 sd)
f) $1.20 \text{ X } 10^{22}$ molecules of carbon monoxide (0.447 L, 3 sd)

2. How many moles are there in the following volumes of gases at STP:

a) 1008 L of methane (45.0 mol, 3 sd)
b) 2000.0 mL of dinitrogen tetroxide gas (2000.0 mL = 2.0000 L; 0.0893 mol, 3 sd)
c) 2.24×10^6 L of benzene vapour (1.00×10^5 mol, 3 sd)
d) 14.56 L of Freon ™ vapour, CF_2Cl_2 (0.650 mol, 3 sd)

Mole Problems #1

(The answers report the correct number of significant digits)

1. Calculate the volume at STP of:

a) 2.00 moles of oxygen gas, O_2 (44.8 L)

b) 5.0 g of carbon dioxide, CO_2 (2.5 L)

c) 1.2×10^{22} molecules of CO gas (0.45 L)

2. What is the mass of 100.0 L of SO_2 gas at STP? (286 g)

3. How many molecules are there in 4.48 L of ammonia gas, NH_3 at STP? (1.20×10^{23} molecules)

4. At STP, how many hydrogen atoms are there in 1.000 m^3 (1000. L) of natural gas, CH_4 ?
(2.6875×10^{26} molecules CH_4; times 4 atoms of H per molecule = 1.08×10^{26} atoms of H)

5. Calculate the number of moles in:

a) 360.0 g of H_2O (19.98 mol)

b) 0.585 g of sodium chloride (0.0100 mol)

c) 1.20×10^{25} atoms of uranium (19.9 mol)

d) 1.00×10^{9} (1 billion) molecules of CH_4 (1.66×10^{-15} mol)

6. Calculate the mass, in grams, of:

a) 25.0 mol of sodium carbonate (2649.75 g rounds to 2.65×10^{3} g or 2650 g)

b) 1000.0 mol of sugar, $C_{12}H_{22}O_{11}$ (342340 g, 5 sd)

c) 2.4×10^{9} molecules of CH_4 (3.9867×10^{-15} mol, 6.4×10^{-14} g)

d) 1 atom of carbon (1 atom is a counted value so it has unlimited sig digs)
(1.9950×10^{-23} g which rounds to 2.00×10^{-23} g)

7. Calculate the number of **atoms** in:

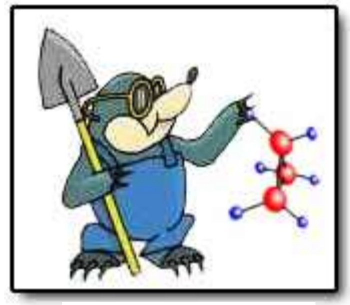
a) 2.00 mol of oxygen gas, O_2 (2.41×10^{24} atoms)

b) 0.635 g of copper, Cu (6.02×10^{21} atoms)

c) 3.91 g of potassium, K (6.02×10^{22} atoms)

d) 180.0 g of water, H_2O (6.0133×10^{24} molecules of H_2O; and each water contains 3 atoms for a total of 1.80×10^{25} atoms)

Mole Problems #2



Do ya dig it??

1. What is the **mass**, in grams, of:

a)	0.0100 mol of K_2CO_3	(1.38 g)
b)	6.0 mol of NaOH	(240 g)
c)	0.50 mol of H_2SO_4	(49 g)
d)	3.60×10^{24} molecules of H_2O	(108 g)
e)	1.00×10^{23} molecules of $C_6H_{12}O_6$	(29.9 g)
f)	1.0×10^{20} atoms of chlorine	(0.0059 g or 5.9×10^{-3} g)
g)	44.8 L of Cl_2 gas at STP	(142 g)
h)	1.00 L of CO_2 gas at STP	(1.96 g)

2. At STP, what is the **volume**, in litres, of:

a)	2.65 mol of butane, C_4H_{10}	(59.4 L)
b)	2.65 g of butane	(1.02 L)
c)	2.65×10^{24} molecules of butane	(98.6 L)

3. Calculate the following (assume all gases are at STP):

a)	the molar mass of $Pb(NO_3)_2$	(331.22 g/mol)
b)	the mass of 0.250 mol of NaOH	(10.0 g)
c)	the total number of atoms in one molecule of $K_4Fe(CN)_6$	4(K)+1(Fe)+6(C)+6(N) =17 atoms
d)	the number of molecules in exactly two moles of $C_5H_{11}OH$	(1.20×10^{24} molecules)
e)	the mass, in grams, of a single molecule of CCl_4	(2.55×10^{-22} g)
f)	the number of moles in 20.0 grams of $CaCO_3$	(0.200 mol)
g)	the number of moles if there are 9.632×10^{21} molecules	(0.0160 mol or 1.60×10^{-2} mol)
h)	the number of moles in 60.0 litres of NO_2 gas at STP	(2.68 mol)
i)	the number of moles of carbon in 10.0 g of C_2H_6	(0.665 moles of C)
j)	the number of oxygen atoms in 4.40 g of NO_2 gas	(1.15×10^{23} atoms of O)
k)	the volume of 9.0×10^{25} molecules of hydrogen gas	(3348.84 L of gas = 3.3×10^{3} L)
l)	the mass of sodium in 2.5 g of NaCl	(0.98 g of sodium)
m)	the mass of 1.2×10^{23} atoms of aluminum	(5.4 g)
n)	the mass, in grams, of exactly one atom of hydrogen	(1.68×10^{-24} g)
o)	the volume of 8.0 grams of propane gas, C_3H_8	(4.1 L)
p)	the number of bromine atoms in 20.0 g of $CaBr_2$	(1.20×10^{23} atoms)

Simplest and Molecular Formulas, Practice Questions

A. Simplest (Empirical) Formulas

1. Calculate the simplest formulas for compounds with:

a) 70.9% K and 29.1 % S

b) 56.4% P and 43.6% O

c) 43.4% P and 56.6% O

d) 26.6% K, 35.4% Cr & 38.0% O

B. Molecular Formulas

1. Find the molecular formulas for these compounds.

a) 39.9% C, 6.7% H, 53.4% O	Molar Mass	120.0 g/mol
b) 40.3% B, 52.2% N, 7.5% H	Molar Mass	80.4 g/mol
c) 20.2% Al, 79.8% Cl	Molar Mass	267.0 g/mol

2. The composition of nicotine is 74.0% carbon, 8.7% hydrogen and 17.3% nitrogen. The molar mass of the compound is 162 g/mol. Find the molecular formula of nicotine.

3. A gaseous compound contains 82.7% carbon and 17.3% hydrogen by weight. 1.00 litre of this compound weighs 2.59 grams at STP. What is the molecular formula of the substance?

4. 1.0 gram of a compound containing 30.5% nitrogen and 69.5% oxygen occupies 243 mL measured at STP. What is the molecular formula of this compound?

Answers:

A. Simplest Formulas

1a) K_2S b) P_2O_3 c) P_2O_5 d) $K_2Cr_2O_7$

B. Molecular Formulas

1a) $C_4H_8O_4$ b) $B_3N_3H_6$ c) Al_2Cl_6

2. $C_{10}H_{14}N_2$

3. C_4H_{10}

4. Simplest formula is NO_2, # of moles = vol/22.4 L/mol = 0.0108 mol
Then, molar mass = mass / # of moles = 1.0 g / 0.0108 mol = 92.6 g/mol
Then, use MM to find molecular formula, which is N_2O_4