CHEMTUTOR

Every chemist has dreamed that atoms were large enough to see and manipulate one at a time. The same chemist realizes after considering it, that if individual molecules were available for manipulation, it would take far too long to get anything done. The view from the atom is very different from the view of trillions and trillions of atoms. The mass action of the atoms that we see on our ‘macro’ view of the world is the result of the action of an incredibly large number of atoms averaged in their actions. The most usual way we count the atoms is by weighing them. The mass of material as weighed on a balance and the atomic weight of the material being weighed is the way we have of knowing how many atoms or molecules we are working with. Instead of counting eggs, we can count cartons of eggs, each carton of which has a given number, a dozen. Instead of counting B-B’s, we can count liters of B-B’s and find out how many B-B’s are in a liter. Instead of counting oats, we buy train cars of oats and know the number of oats in a full train car.

WHY DO WE NEED MOLS?

There are less than one hundred naturally occurring elements. Each element has a characteristic atomic weight. Most Periodic Charts include the atomic weight of an element in the box with the element. The atomic weight is usually not an integer because it is close to being the number of protons plus the average number of neutrons of an element. Let’s use the atomic weight as a number of grams. This will give us the same number of any atom we choose. If we weigh out 1.008 grams of hydrogen and 35.45 grams of chlorine and 24.3 grams of magnesium, we will have the same number of atoms of each one of these elements. The neat trick with this system is that we can weigh the atoms on a grand scale of number of atoms and get a count of them. This number of atoms that is the atomic weight expressed in grams is Avogadro’s number, 6.022 E 23. The name for Avogadro’s number of ANYTHING is a mole or mol. A mol of aluminum is 27.0 grams of aluminum atoms. Aluminum is an element, so the particles of aluminum are atoms. There are Avogadro’s number of aluminum atoms in 27.0 grams of it. But 1.008 grams of hydrogen is NOT a mol of hydrogen! Why not? Remember that hydrogen is one of the diatomic gases. There is really no such thing as loose hydrogen atoms. The total mass of a single hydrogen diatomic molecule ($H2$) is 2. 016 AMU. A mol of hydrogen gas has a mass of 2.016 grams. In that 2.016 gram mass is Avogadro’s number of $H2$ molecules because that is the way hydrogen comes. A mol of water is 18.016 grams because each water molecule has two hydrogen atoms and one oxygen atom. A mol of water has in it Avogadro’s number of water molecules. Another way to view the same thing is that a formula weight is the total mass of a formula in AMU expressed with units of grams per mol.

So Avogadro’s number is just a number, like dozen or gross or million or billion, but it is a **very** large number. You could consider a mol of sand grains or a mol of stars. We are more likely to speak of a mol of some chemical, for which we can find the mass of a mol of the material by adding the atomic weights of all the atoms in a formula of the chemical. The unit of atomic weight or formula weight is grams/mol.

The chemical formula of a material should tell you; (a) which elements are in the material, (b) how many atoms of each element are in the formula, (c) the total formula weight, and (d) how the elements are attached to each other. The symbols of the elements tell you which elements are in the material. The numbers to the right of each symbol tells how many atoms of that element are in the formula. The type of atoms and their arrangement in the formula will tell how the elements are attached to each other. A metal and a nonmetal or negative polyatomic ion shows an ionic compound. A pair of non-metals are bonded by covalent bonds. Some crystals have water of hydration loosely attached in the crystal. This is indicated by the dot such as in blue vitriol, $Cu(SO4)\cdot 5H2O$, showing five molecules of water of hydration to one formula of cupric sulfate.

The unit of the formula weight or molecular weight or atomic weight is "grams per mol," so it provides a relationship between mass in grams and mols of material.

$$nF_w = m$$

'n' is the number of mols, 'Fw is the formula weight, and 'm' is the mass.

PERCENTS BY WEIGHT

All men weigh 200 pounds. All women weigh 125 pounds. What is the percent by weight of woman in married couples? A married couple is one man and one woman. The total weight is 325 pounds. The formula for percent is:

In this case the woman is the target.

125 # 325 #	x	100%	=	38.461%	=	36.5%

Notice that the units of pound cancel to make the percent a pure number of comparison.

The weights of atoms are the atomic weights. What is the percentage of chloride in potassium chloride? The atomic weight of potassium is 39.10 g/mol. The atomic weight of chlorine is 35.45 g/mol. So the formula weight of potassium chloride is 74.55 g/mol. The chloride is the target and the potassium chloride is the total. 35.45 g/mol / x 100% = 47.55198 % or 47.6 % to three significant figures.

35.45~~g/mol~~ 74.55~~g/mol~~	x	100%	=	47.5520%	=	47.6%

You can do that with any part of a compound. What is the percentage of sulfate in beryllium sulfate tetrahydrate?

Notice that the examples here are done to two decimal points of the atomic weights. The problems in the practice bunch at the end of this chapter are done to one decimal point of the atomic weight.

BASIC STOICHIOMETRY

Pronounce stoichiometry as "stoy-kee-ah-met-tree," if you want to sound like you know what you are talking about, or "stoyk:," if you want to sound like a real geek. Stoichiometry is just a five dollar idea dressed up in a fifty dollar name. You can compare the amounts of any materials in the same chemical equation using the formula weights and the coefficients of the materials in the equation. Let's consider the equation for the Haber reaction, the combination of nitrogen gas and hydrogen gas to make ammonia.

N2 + 3 H2 2 NH3

The formula for nitrogen is N_2 and the formula for hydrogen is $H_{2.}$ They are both diatomic gases. The formula for ammonia is NH_3

The balanced equation requires one nitrogen molecule and three hydrogen molecules to make two ammonia molecules, meaning that one nitrogen molecule reacts with three hydrogen molecules to make two ammonia molecules or one MOL of nitrogen and three MOLS of hydrogen make two MOLS of ammonia. Now we are getting somewhere. The real way we measure amounts is by weight (actually, mass), so (to two significant digits) 28 grams (14 g/mol times two atoms of nitrogen per molecule) of nitrogen and 6 grams of hydrogen (1 g/mol times two atoms of hydrogen per molecule times three mols) make 34 grams of ammonia. Notice that no mass is lost or gained, since the formula weight for ammonia is 17 (one nitrogen at 14 and three hydrogens at one g/mol) and there are two mols of ammonia made. Once you have the mass proportions, any mass-mass stoichiometry can be done by good old proportionation. What is the likelihood you will get just a simple mass-mass stoich problem on your test? You should live so long. Well, you should get ONE.

Rather than thinking in terms of proportions, think in mols and mol ratios, a much more general and therefore more useful type of thinking. A mol ratio is just the ratio of one material in a chemical equation to another material in the same equation. The mol ratio uses the coefficients of the materials as they appear in the balanced chemical equation. What is the mol ratio of hydrogen to ammonia in the Haber equation? 3 mols of hydrogen to 2 mols of ammonia. Easy. In the standard stoichiometry calculations you should know, ALL ROADS LEAD TO MOLS. You can change any amount of any measurement of any material in the same equation with any other material in any measurement in the same equation. That is powerful. The setup is similar to Dimensional Analysis.

1. Start with what you know (GIVEN), expressing it as a fraction.
2. Use definitions or other information to change what you know to mols of that material.

3. Use the mol ratio to exchange mols of the material given to the mols of material you want to find.
4. Change the mols of material you are finding to whatever other measurement you need.

How many grams of ammonia can you make with 25 grams of hydrogen? (Practice your mol math rather than doing this by proportion. Check it by proportion in problems that permit it.)

You are given the mass of 25 grams of hydrogen. Start there.

Visual for solving stoichiometry problems in a Dimensional Analysis style.

25 g H_2/1 Change to mols of hydrogen by the formula weight of hydrogen 1 mol of H_2 = 2.0 g. (The 2.0 g goes in the denominator to cancel with the gram units in the material given.) Change mols of hydrogen to mols of ammonia by the mol ratio. 3 mols of hydrogen = 2 mols of ammonia. (The mols of hydrogen go in the denominator to cancel with the mols of hydrogen. You are now in units of mols of ammonia.) Convert the mols of ammonia to grams of ammonia by the formula weight of ammonia, 1 mol of ammonia = 17 g. (Now the mols go in the denominator to cancel with the mols of ammonia.) Cancel the units as you go.

The math on the calculator should be the last thing you do. 2 5 ÷ 2 . 0 x 2 ÷ 3 x 1 7 = and the number you get (141.66667) will be a number of grams of ammonia as the units in your calculations show. Round it to the number of significant digits your instructor requires (often three sig. figs.) and put into scientific notation if required. Most professors suggest that scientific notation be used if the answer is over one thousand or less than a thousandth. The answer is 142 grams of ammonia.

The calculator technique in the preceding paragraph illustrates a straightforward way to do the math. If you include all the numbers in order as they appear, you will have less chance of making an error. Many times students have been observed gathering all the numbers in the numerator, gathering all the numbers in the denominator, presenting a new fraction of the collected numbers, and then doing the division to find an answer. While this method is not wrong, the extra handling of the numbers has seen to produce many more errors.

See the Stoichiometry Roadmap for a way to consider this idea graphically. This example starts at "mass given" and goes throught the mol ratio to "mass find."

mass1--Fw1--mol1--mol ratio2/1--mol2--Fw2--mass2

Notice by the chart above we may get the number of mols of material given if we change the mass by the formula weight, but in our continuous running math problem, we don't have to stop and calculate a number of mols. Students who insist on doing so tend to get more calculator errors.

The more traditional formula for converting mols to mass would be, where Fw is the formula weight, m is the mass, and n is the number of mols: n x Fw = m. You should be able to "see" these formula relationships on the roadmap.

DENSITY TIMES MASS OF A PURE MATERIAL

Density multiplied by the volume of a pure material is equal to the mass of that material. If we know the density of a material and the volume of the pure material, with D = density and V = volume, DV = m so:

D1V1--mass1--Fw1--mol1--mol ratio2/1--mol2--Fw2--mass2--1/D2=V2

If you were given the density and volume of pure material you could calculate the volume of another material in that equation if you know it's density. Notice that the density must be inverted to cancel the units properly if you want the volume to find. If you need to find the density, the volume must be inverted.

See the Stoichiometry Roadmap for a graphic view of this idea. Start with "Given density times volume of a pure material.

ATOMS OR MOLECULES TO MOLS

One of the hardest ideas for some students is that the individual particles of a material are a single one of a formula of that material. Copper element comes only in the form of atoms. Water only comes in the form of a molecule with one oxygen and two hydrogen atoms. A mol, then is Avogadro's number of individual particles of whatever type of pure material the substance is made. There is no such thing as a mol of mud because mud is a mixture. There is no one mud molecule.

The word "pure" also can be misunderstood. We do not mean that a material is one hundred percent the same material for us to use it, but that we are only considering the amount of that material.

The formula behind this relationship is: where n is the number of mols, A is Avogadro's number, and # is the number of individual particles of material,

A x n =

Refer to the Stoichiometry Roadmap for a graphic view of this idea.

CONCENTRATION TIMES VOLUME OF A SOLUTION

A *solution* is a mixture of a fluid (often water, but not always) and another material mixed in with it. The material mixed in with it is called the *solute*. There is more on solutions in the chapter devoted to that. The volume of a solution, V, is measured the same way the volume of a pure liquid is measured. The concentration can be expressed in a number of ways, the most common in chemistry is the M, molar. One molar is one mol of solute in a liter of fluid. It is important to notice that the fluid is usually nothing more than a diluting agent. For most of the reactions, the fluid does not participate in any reaction.

Concentration times volume is number of mols of the solute material.

C x V = n

The "given" side of concentration times volume is easy. As with density times volume of a pure material, but the "find" side may need more work. You need one or the other of the concentration and volume before you can calculate the other. At the end of the Dimensional Analysis if you want concentration, you will be using the volume inverted. If you want the volume, you will be using the concentration inverted. This is not so difficult because the units will guide you.

Refer to the Stoichiometry Roadmap for a graphic view of this idea.

GASES

Standard temperature is zero degrees Celsius. Standard pressure is one atmosphere. A mol of ANY gas at standard temperature and pressure (STP) occupies 22.4 liters. That number is good to three significant digits. The equation would be 1 mol gas = 22.4 L @STP. The conversion factor, the Molar Volume of Gas, is 1 mol gas/22.4 L @STP or 22.4 L @STP/1 mol gas

Where n is the number of mols, V is the volume of a gas, and MVG is the molar volume of gas,

V = n x MVG

Gases not at STP will require the Ideal Gas Law Formula,

P V = n R T

where P is the pressure of the gas in atmospheres, V is the volume of the gas in liters, n is the number of mols of gas, T is the Kelvin temperature of the gas, and R is the "universal gas constant" with the measurement of 0.0821 liter-atmospheres per mol-degree. We will have to do some algebra on the PV = nRT gas equation to do the gas portion of the stoichiometry problems.

In GIVEN we only need to solve for n. n = PV/RT. If we need to find the volume, pressure, or temperature of a gas, we need to solve for the unknown and include the "mols find" as the n. More about gases later. See the Chemtutor section on Gases for math problems using the gas laws.

The earmarks of a stoichiometry problem are: There is a reaction. (A new material is made.) You know the amount of one material and you are asked to calculate the amount of another matierial in the same equation.

HOW TO USE THE "ROADMAP" FOR SOLVING CHEMISTRY PROBLEMS

1. Write all the compounds and elements in the problem correctly.
2. Write the balanced chemical equation for the problem.
3. Write the MATERIAL you have enough information about to use as GIVEN. (This has been one of the major stumbling blocks in using the roadmap.) If you know the number of moles, the mass, or the number of molecules of a material, you have all you need to start the problem. You need CONCENTRATION AND VOLUME of a solution to have the amount of solute that reacts. You need VOLUME AND DENSITY of a solid or liquid to have an amount of that. You need VOLUME, PRESSURE AND TEMPERATURE of a gas to have a complete set of information. (Notice it is useful to understand the properties of the states of matter as you do this.)

4. Write what you need to FIND and all the other pertinent information about that material. For instance, if you need to find the volume of a gas, you must also list the pressure and temperature of that gas in FIND. In this manner: FIND V, volume of gas at 79 °C and 1.8 atm.
5. Sketch out an outline of the math according to the roadmap. You know there are some points in the roadmap that you miss on the outline because they are calculated in the process, for instance if you are given a mass of one material and asked to find the density of another material with its volume, you would start at the MASS GIVEN and use the FORMULA WEIGHT to get to the MOLES GIVEN, but MOLES GIVEN does not appear in the outline because it is already calculated. You next need the MOLE RATIO to get the MOLES FIND. Again, MOLES FIND does not appear in the outline.
6. Fill in the outline with the numbers, units and materials (for instance, 15 kg Mg) and do the calculations. Be careful of numbers that need to be inverted. You can tell the coefficients that need to be inverted by the units.

STOICHIOMETRY ROADMAP

One of the really nice things about the Stoichiometry Roadmap is that once you understand it thoroughly, it can be carried around with you between your ears. Just remember that ALL ROADS LEAD TO MOLS.

MOLE AND PERCENT WORKSHEET

1. How many pennies are in a mole of pennies? How many thousand-dollar bills (k-notes!) is that mole of pennies equal to?

2. NO_2 is the molecular formula for nitrous dioxide (also known as nitrogen dioxide). List the information available to you from this formula?.

3. C_2H_2 is the molecular formula for ethylyne (A.K.A. acetylene). (a) How many atoms are in one molecule? (b) Which atoms make up acetylene? (c) How many moles of atoms are in one molecule of acetylene? (d) How many molecules are in 5.3 moles of acetylene? (e) How many atoms are in a mole of acetylene?

4. Calculate the molar mass of a mole of the following materials: (a) Al (b) Ra (c) Co (d) CO (e) CO_2 (f) HCl (g) Na_2CO_3 (h) $Ca(NO_3)_2$(i) $(NH_4)_3(PO_4)$ (j) H_2O (k) Epsom salts - $Mg(SO_4)\cdot 7H_2O$ (m) blue vitriol - $Cu(SO_4)\cdot 5H_2O$?

5. Calculate the number of moles in: (a) 2.3 # of carbon (b) 0.014 g of Tin (c) a 5 Oz silver bracelet (d) a pound of table salt (e) a 350 kg cast iron engine block (f) a gal. of water (8.3 #) (g) a ton of sand (SiO_2) (h) 6.2 grams of blue vitriol (i) a pound of Epsom salts ?

6. Calculate the number of atoms in: (a) 100 g of Argon (b) 1.21 kg aluminum foil (c) a 28 # lead brick (d) the E7 kg of water in an olympic swimming pool (e) 7 kg of hydrogen gas (f) a tonne of calcium nitrate ?

7. What is the percentage composition of oxygen in each of the following materials: (a) CO (b) CO_2 (c) $(NO_3)^-$ (d) isopropyl alcohol C_3H_8O (e) calcium nitrate (f) blue vitriol - $Cu(SO_4)\cdot 5H_2O$?

8. What is the percentage composition of phosphate in each of the following materials: (a) phosphoric acid (b) sodium carbonate (c) ammonium phosphate (d) calcium phosphate ?

9. What is the percentage composition of sulfate in each of the following materials: (a) sulfuric acid (b) sodium sulfate (c) Epsom salts (d) aluminum sulfate ?

ANSWERS TO MOL AND PERCENT PROBLEMS

1a. 6.023 E23 pennies		**1b. 6.023 E18 k-Notes**		**2a. Covalent**
2b. Elements in it (N and O)		**2c. Number of atoms of each element**		
3a. 4	**3b. C & H**	**3c. 6.64 E-24**	**3d. 3.1922 E24**	**3e. 2.4092 E24**
4a. 27.0	**4b. 226.0**	**4c. 58.9**	**4d. 28.0**	**4e. 44.0**
4f. 36.5	**4g. 106.0**	**4h. 164.1**	**4i. 149.0**	**4j. 18.0**

4k. 246.4	**4m. 249.6**	**5a. 86.9**	**5b. 1.18 E-4**	**5c. 1.31**
5d. 7.75	**5e. 6.27 E3**	**5f. 210**	**5g. 1.51 E4**	**5h. 0.0248**
5i. 1.84	**6a. 1.51 E24**	**6b. 2.69 E25**	**6c. 3.69 E25**	**6d. 1.00 E33**
6e. 4.22E27	**6f. 3.30 E28**	**7a. 57.1%**	**7b. 72.7%**	**7c. 77.4%**
7d. 26.7%	**7e. 58.5%**	**7f. 57.7%**	**8a. 96.9%**	**8b. 0%**
8c. 63.8%	**8d. 61.2%**	**9a. 98.0%**	**9b. 67.6%**	**9c. 39.0%**
9d. 84.2%				

STP GAS AND MASS STOICHIOMETRY PROBLEMS (PRELIMINARY TO GAS LAW)

All of the problems below are stoichiometry problems with at least one equation participant as a gas at STP. (a) Write and balance the chemical equation. (2) Do the math in DA style using 1 mole gas at STP = 22.4 liters as a factor. In the following problems ALL GASES ARE AT STP. Click here for a general idea of how to do the problems in this set.

1. How many moles of nitrogen gas is needed to react with 44.8 liters of hydrogen gas to produce ammonia gas?
2. How many liters of ammonia are produced when 89.6 liters of hydrogen are used in the above reaction?
3. Ten grams of calcium carbonate was produced when carbon dioxide was added to lime water (calcium hydroxide in solution). What volume of carbon dioxide at STP was needed?
4. When 11.2 liters of hydrogen gas is made by adding zinc to sulfuric acid, what mass of zinc is needed?
5. What volume of ammonia at STP is needed to add to water to produce 11 moles of ammonia water?
6. How many grams of carbonic acid is produced when 55 liters of carbon dioxide is pressed into water?
7. magnesium hydroxide + ammonium sulfate magnesium sulfate + water + ammonia
    1. How much (grams) magnesium hydroxide do you need to use in the above reaction to produce 500 liters of ammonia?
8. How much strontium bromide is needed to add to chlorine gas to produce 75 liters of bromine?
9. What mass of ammonium chlorate is needed to decompose to give off 200 liters of oxygen?
10. Your car burns mostly octane, C_8H_{18}, as a fuel. How many liters of oxygen is needed to burn a kilogram of octane?
11. copper + sulfuric acid copper II sulfate + water + sulfur dioxide
    1. How many moles of copper are needed to produce 1000 L of SO_2?
12. What volume of oxygen is needed to burn a pound of magnesium?
13. How many grams of sodium do you have to put into water to make 30 liters of hydrogen at STP?
14. ammonia gas and hydrogen chloride gas combine to make ammonium chloride.
    1. What volume of ammonia at STP is needed to react with 47.7 liters of hydrogen chloride at STP?
15. How many liters of oxygen are needed to burn 10 liters of acetylene?

ANSWERS TO STP GAS AND MASS STOICHIOMETRY PROBLEMS

1. 0.667 mol	2. 59.7 L	3. 2.24 L	4. 32.7 g
5. 246 L	6. 152 g	7. 651 g	8. 828 g
9. 604 g	10. 2.46 kL	11. 44.6 mol	12. 210 L

13. 61.6 g	14. 47.7 L	15. 25 L	

PROBLEMS ON CONCENTRATION AND DENSITY

WRITE AND BALANCE THE CHEMICAL EQUATION FOR THOSE PROBLEMS THAT NEED IT. SHOW ALL YOUR WORK. USE W5P OR DA METHOD ACCORDING TO THE ROADMAP.

1. The lead brick on my desk measures 3 by 5 by 11 cm. Lead has a density of 11.34 g/cc. How many lead atoms are in that block?
2. The lab technician at the Planter's Peanut packing factory takes a bag of peanuts, puts water into it to dissolve the salt, and dilutes the solution to one liter. She then takes ten ml of that solution and titrates it against 0.132 M silver nitrate. One bag sample takes 31.5 ml of silver nitrate to endpoint. What mass of salt was in the bag?
3. What is the concentration of sugar ($C_{12}H_{22}O_{11}$) if twenty grams are dissolved in enough water to make 2 liters?
4. Methyl alcohol (CH_3OH) has a density of 0.793 kg/l. What volume of it is needed to add to water to make five liters of 0.25 M solution?
5. Magnesium has a density of 1.741 g/cc. What volume of Mg will burn in 20 liters of oxygen at 2.1 atm and 0°C?
6. Uranium metal can be purified from uranium hexafluoride by adding calcium metal. Calcium metal has a density of 1.54 g/cc. Uranium has a density of 18.7 g/cc. What mass of uranium do you get for a Kg of Ca? What volume of uranium do you get for a cubic meter of calcium?
7. What volume of 0.27 M sodium hydroxide is needed to react with 29.5 ml of 0.55 M phosphoric acid?
8. What volume of carbon dioxide is produced at 1 atm and 87 °C when 1.6 liters of methyl alcohol burns? What volume of liquid water is produced in this reaction?
9. Seven kilograms of mercury II oxide decomposes into mercury and oxygen. Mercury has a density of 13.6 g/cc/ What volume of mercury is produced?
10. Water and calcium oxide produce calcium hydroxide. How many grams of calcium hydroxide are made if you add 275 liters of water to enough calcium oxide?
11. Gasoline (C_7H_{16}) has a density of 0.685 kg/liter. How many liters of oxygen at 37 °C and 950 mmHg are needed to burn 15 liters of gasoline?
12. Sodium hydroxide and hydrochloric acid combine to make table salt and water. 14 mL of 0.1 M sodium hydroxide is added to an excess of acid. How many moles of table salt are made? How many grams of salt is that?
13. 50 mL of 0.25 M copper II sulfate evaporates to leave $CuSO_4 \cdot 5H_2O$. (That is the pentahydrate crystal of copper II sulfate.) What is the mass of this beautiful blue crystal from the solution?
14. Chlorine gas is bubbled into 100 mL of 0.25 M potassium bromide solution. This produces potassium chloride and bromine gas. The bromine (which dissolves in water) is taken from the solution and measured at 27 °C and 825 mmHg. What is the volume of bromine?
15. 95.0 mL of 0.55 M sulfuric acid is put on an excess of zinc. This produces zinc sulfate and hydrogen. How many grams of zinc sulfate are made?
16. and some dissolved sodium nitrate. (a) How many moles of silver chloride are made? (b) How many grams of silver chloride is that? (c) How many moles of sodium nitrate are made? (d) What is the concentration of sodium nitrate in the final solution?
17. How many grams of potassium permanganate, $KMnO_4$, is needed to make 1.72 liters of 0.29 M solution?
18. By my calculations, a drop of ethyl alcohol, C_2H_5OH , in an olympic-sized swimming pool produces a 1.20 E-10 M solution of alcohol in water. A drop is a twentieth of a mL. How many molecules of ethyl alcohol are in a drop of the water in the pool?
19. 93.0 mL of 0.150 M magnesium hydroxide is added to 57.0 mL of 0.4 M nitric acid. (Magnesium nitrate and water are formed. What is the concentration of the magnesium nitrate after the reaction?

ANSWERS TO PROBLEMS ON CONCENTRATION AND DENSITY

1. 5.44 E24 atoms	2. 24.3 g	3. 0.0292 M	4. 0.0504 L
5. 52.3 ml(cc) Mg	6a. 1.98 kg of U	6b. 1.63 E6 mL	7. 180 mL
8a. 1.17 kL CO_2	8b. 1.43 L	9. 0.477 L	10. 1.13 E 6 g

11. 23.0 kL	12a. 1.4 E-3 mols	12b. 0.0819 g	13. 3.12 g
14. 284 mL	15. 8.44 g	16a. 5.24E-3 mol	16b. 0.752 g
16c. 5.24E-3 mols	16d. 122 mmolar	17. 78.8 mg	18. 3.61E9 molecules
19. 0.152 M			

PROBLEMS USING COMPLETE ROADMAP

1. How many liters of ammonia at 0 °C and 25 atm. are produced when 10 g of hydrogen is combined with nitrogen?
2. How many milliliters of hydrogen at 0 deg C and 1400 mmHg are made if magnesium reacts with 15 mL of 6 M sulfuric acid?
3. How many atoms are in 25 liters of fluorine gas at 2.85 atm and 450 °C?
4. Liquid butane (C_4H_{10}) has a density of 0.60 g/cc. It burns to make carbon dioxide at 120 °C. What volume of carbon dioxide is produced at one atm when 350 liters of liquid butane burns?
5. Isopropyl alcohol, C_3H_7OH , makes a good fuel for cars. What volume of oxygen at 785 mmHg and 23 °C is needed to burn 8.54 E25 molecules of isopropyl alcohol?
6. How many moles of $NaCl$ are in a liter of a 0.15 M $NaCl$ solution? (0.15 M $NaCl$ is physiological saline when sterilized.)
7. How many grams of NaCl must you put into a 50 liter container to make a physiological saline solution?
8. Chlorine gas is bubbled into 100 mL of 0.25 M potassium bromide solution. This produces potassium chloride and bromine gas. The bromine dissolves completely in the water. What is the concentration of bromine?
9. 95 mL of 0.55 M sulfuric acid is put on an excess of zinc. This produces zinc sulfate and hydrogen. How many grams of zinc sulfate are made?
10. Methyl alcohol (CH_3OH) has a density of 0.793 Kg/L. What volume of it is needed to add to water to make twenty-five liters of 0.15 M solution?
11. Magnesium has a density of 1.741 g/cc. What volume of Mg will burn to produce a kilogram of magnesium oxide?
12. What volume of water vapor is produced at 716 mmHg and 87°C when 2.6 liters of methyl alcohol burns?

ANSWERS TO PROBLEMS USING COMPLETE ROADMAP

1. 2.99 L	2. 1.10 E3 mL	3. 1.45 E24 atoms	4. 4.67 E5 L
5. 1.50 E4 L	6. 0.15 moles	7. 439 g	8. 0.125 M
9. 8.44 g	10. 151 mL	11. 0.346 L	12. 1.29 E5 L

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