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This is the most common type of stoichiometric problem in high school. There are four steps involved in solving these problems: Make sure you are working with a properly balanced chemical equation. Convert grams of the substance given in the problem to moles. Construct two ratios - one from the problem and one from the chemical equation and set them equal. The ratio from the problem will have an unknown, 'x.' Solve for "x." Convert moles of the substance just solved for into grams. Comments Double check the equation. The ChemTeam has seen lots of students go right ahead and solve using the unbalanced equation supplied in the problem (or test question for that matter). DON'T use the same molar mass in steps two and four. Your teacher is aware of this and, on a multiple choice test, will provide the answer arrived at by making this mistake. You have been warned! Don't multiply the molar mass of a substance by the coefficient in the problem BEFORE using it in one of the steps above. For example, if the formula says 2H2O in the chemical equation, DON'T use 36.0 g/mol, use 18.0 g/mol. Don't round off until the very last answer. In other words, don't clear your calculator after step two and write down a value of 3 or 4 significant figures to use in the next step. Round off only once after all calculations are done. STOP!!! Go back to the start of this file and re-read it. Notice that I give four steps (and some advice) in how to solve the example problems just below. My advice is to keep going back to those steps as you examine the examples below. Many teachers use a technique called dimensional analysis to solve problems like in this tutorial. I have provided some DA below. Click here to go to some examples where DA is used exclusively. Example #1: How many grams of hydrogen gas are needed to react completely with 54.0 g of oxygen gas, given the following unbalanced chemical reaction: H2 + O2 ---> H2O Solution: 1) Balance the chemical equation: 2H2 + O2 ---> 2H2O 2) Convert grams of the substance given: 54.0 g / 32.0 g/mol = 1.6875 mol of O2 Note the use of 32.0 and not 16.0. The chemical substance is O2. Students have been known to sometimes forget to write the subscript of 2 on a diatomic element (H2, N2, O2, F2, Cl2, Br2, I2) 3) Construct two molar ratios and set them equal to each other. The first molar ratio is from the coefficients of the balanced chemical equation. The two substances are: and the numerical ratio is this: 2 mol H2 ------- 1 mol O2 4) The second ratio is found within the problem statement. The H2 is our unknown because the problem says "how many grams of hydrogen" and the O2 mole amount is the other value. Like this: x ---------- 1.6875 mol O2 No unit is attached to the unknown 'x.' Note also that I did not round off. I'll do that at the end. 5) We need to set the two ratios equal to each other and solve: 2 mol H2 x ------- = ---------- 1 mol O2 1.6875 mol O2 x = 3.375 mol of H2 required 6) Convert the calculated moles from step #3 into grams: (3.375 mol) (2.016 g/mol) = 6.80 g (to three sig figs) Note: if you did not balance the equation, you'd wind up using an incorrect 1:1 molar ratio rather than the correct 2:1 ratio. 7) The above problem done in the style of dimensional analysis: 54.0 g O2 1 mol O2 2 mol H2 2.016 g H2 ------- x ------- x --- x ------- = 6.80 g H2 32.0 g O2 1 mol O2 1 mol H2 When doing DA, it is very helpful to identify each unit as being one chemical or the other. This will help cut down on confusion when you are placing values, deciding if a given value goes in the numerator or the denominator. Example #2: How many grams of hydrogen gas are needed to produce 105.0 grams of water, given the following unbalanced chemical reaction: H2 + O2 ---> H2O Solution: 1) Balance the chemical equation: 2H2 + O2 ---> 2H2O 2) Convert grams of the substance given: 105.0 g / 18.015 g/mol = 5.82848 mol of H2O I rounded off some, but I made sure to keep more digits than what I will round off to at the end. 3) Construct two molar ratios and set them equal to each other. The two substances in in the first ratio are these: and the numerical ratio from the coefficients of the chemical equation is this: 2 mol H2 --------- 2 mol H2O 4) The second ratio comes from information in the problem: x ---------- 5.82848 mol H2O 5) Setting equal and solving: 2 mol H2 x --------- = ---------- 2 mol H2O 5.82848 mol H2O x = 5.82848 mol of H2 required Note: this can be an area of confusion. Since the ratio is a 1:1 ratio, the answer of 5.82848 mol is arrived at easily. However, many students will forget that the 5.82848 mol answer is now that of the OTHER substance, the hydrogen. It seems that, because the number (the 5.82848) didn't change, the student decides that the substance didn't change. Consequently, the student will enter the next (and last) step thinking the 5.82848 still refers to water. 6) Convert moles to grams: (5.82848 mol) (2.016 g/mol) = 11.75 g of H2 (to four sig figs) 7) The above problem done in the style of dimensional analysis: 105.0 g H2O 1 mol H2O 2 mol H2 2.016 g H2 ---------- x ---------- x ---------- x ------- = 11.75 g H2 18.015 g H2O 2 mol H2O 1 mol H2 Remember, in dimensional analysis, you cancel units on the diagonal, never up and down. This is why you write the substance in the unit. 'mol H2' and 'mol H2O' do not cancel. Example #3: How many grams of hydrogen gas are needed to produce 85.2 grams of ammonia, given the following unbalanced chemical reaction: N2 + H2 ---> NH3 Solution: 1) Balance the chemical equation: N2 + 3H2 ---> 2NH3 2) Convert the given grams to moles: 85.2 g / 17.0307 g/mol = 5.00273 mol 3) Construct two molar ratios and set them equal to each other. The two substances in our ratios are these: 4) The two ratios set equal to each other are (I deliberately left off the mol units): 3 x --- = ------- 2 5.00273 x = 7.504095 mol of H2 5) Convert the calculated moles to grams: (7.504095 mol) (2.016 g/mol) = 15.1 g (to three sig figs) 6) Here's the dimensional analysis of the above problem: 85.2 g NH3 1 mol NH3 3 mol H2 2.016 g H2 --------- x ---------- x --------- x --------- = 15.1 g H2 17.0307 g NH3 2 mol NH3 1 mol H2 Example #4: How many grams of chlorine can be liberated from the decomposition of 64.00 g. of AuCl3 by this reaction: AuCl3 ---> Au + Cl2 Solution: 1) The provided equation must be balanced correctly: 2AuCl3 ---> 2Au + 3Cl2 2) Convert grams of AuCl3 to moles: Let x = the moles of AuCl3 64.00 g x = ---------- 303.32 g/mol x = 0.210998 mol of AuCl3 The ChemTeam has heard many variations of this: "But how did you know to convert grams of AuCl3 to moles?" I picked AuCl3 to convert from grams to moles because a gram amount of AuCl3 was provided in the problem. 3) Use two molar ratio involving AuCl3 and Cl2: 4) The two molar ratios set equal to each other: 2 mol AuCl3 0.210998 mol AuCl3 ---------- = ---------- 3 mol Cl2 x x = 0.316497 mol of Cl2 This is the hardest step. Constructing the proper ratio and proportion can cause a great deal of confusion. 5) Convert the calculated moles to grams: (0.316497 mol) (70.906 g/mol) = 22.44 g (to four sig figs) 6) One question I often get is "Where did the value of 303.32 come from?" The answer is that it's the molar mass of AuCl3. Keep this answer in mind as you wonder about where other numbers come from in a given solution. Consider looking at the solution to the problem and try to fit it to the list of steps given above. 7) Dimensional analysis: 64.00 g AuCl3 1 mol AuCl3 3 mol Cl2 70.906 g Cl2 --------- x ---------- x --------- x --------- = 22.44 g Cl2 303.32 g AuCl3 2 mol AuCl3 1 mol Cl2 Example #5: Calculate the mass of AgCl that can be prepared from 200. g of AlCl3 and sufficient AgNO3, using this equation: 3AgNO3 + AlCl3 ---> 3AgCl + Al(NO3)3 Solution: 1) Since the chemical equation is already balanced, let us convert grams of AlCl3 to moles: 200. g ---------- = 1.499914 mol of AlCl3 133.341 g/mol I picked AlCl3 because it was the substance has a gram amount associated with it in the problem. 2) Use a proportion with molar ratios involving AgCl and AlCl3: 3 mol AgCl x --------- = ---------- 1 mol AlCl3 1.499914 mol AlCl3 x = 4.499742 mol of AgCl The 'x' in the right-hand ratio is associated with the substance we are trying to calculate an amount for (the AgCl). Look for phrases like "Calculate the mass of . . ." or "Determine the mass of . . . " in the problem statement. 3) Convert moles to grams: (4.499742 mol) (143.323 g/mol) = 645 g (to three sig figs) 4) By the way, what if you had used the ratio of 1 over 3, with the AlCl3 value in the numerator? Then, the other ratio would have been reversed and the answer would have been the same. The ratio and proportion would have looked like this: 1 mol AlCl3 1.499914 mol AlCl3 ---------- = ---------- 3 mol AgCl x 5) Dimensional analysis: 200. g AuCl3 1 mol AlCl3 3 mol AgCl 143.323 g AgCl ---------- x ---------- x --------- x ---------- = 645 g AgCl 133.341 g AlCl3 1 mol AlCl3 1 mol AgCl Example #6: Given this equation: 2KI + Pb(NO3)2 ---> PbI2 + 2KNO3 calculate mass of PbI2 produced by reacting of 30.0 g KI with excess Pb(NO3)2 Solution: 1) The equation is balanced. Sometimes you're given an unbalanced equation on the test when all the classroom examples used already-balanced equations. Make sure you do these problems with a balanced chemical equation. 2) We are given 30.0 g of KI. Change it to moles: 30.0 g ---------- = 0.180725 mol of KI 165.998 g/mol 3) Construct a ratio and proportion: This ratio: comes from the coefficients of the balanced equation. This ratio: comes from a consideration of the data in the problem. Setting the two ratios equal to each other gives us the proportion to solve: 2 0.180725 -- = -------- 1 x x = 0.0903625 mol 2 The substance associated with the 'x' is not the one for which the grams are given in the problem statement. The 'x' is associated with the substance for which a phrase like "Determine how much . . ." is used. Notice that a third substance (the Pb(NO3)2) is mentioned, but the word excess is used to describe it. As you learn more about stoichiometry, the excess substance will be brought into the calculations. Not yet, however. Look for it in a section called 'limiting reagent.' 4) Convert moles to grams: (0.0903625 mol) (461.01 g/mol) = 41.6 g (to three sig figs) Example #7: If 92.0 g of aluminum is produced, how many grams of aluminum nitrate reacted? Al(NO3)3 + Mg ---> Mg(NO3)2 + Al Solution: 1) An unbalanced equation was given in the problem. It needs to be balanced: 2Al(NO3)3 + 3Mg ---> 3Mg(NO3)2 + 2Al 2) Grams of aluminum is given. Convert it to moles: 92.0 g ---------- = 3.4099 mol of Al 26.98 g/mol 3) Use a ratio and proportion involving aluminum and aluminum nitrate: 2 3.4099 -- = ------- 2 x x = 3.4099 mol 3)3, NOT moles of Al Warning: there will be a real temptation in the next step to use the wrong molar mass 4) Determine grams of the unknown, the aluminum nitrate: (3.4099 mol) (212.994 g/mol) = 726 g (to three sig figs) Comments about the ending step of Example #7: It is quite common in a problem like this for the student to use the molar mass of Al in this step. I think it is because they see the same value (the 3.4099 mol) in this step as in the second step. The conclusion is that it must be the same substance. And that is in error. In the second step, we had 3.4099 mol of aluminum, but after solving the ratio and proportion, we now have 3.4099 mol of aluminum nitrate. Be careful on the point, especially if the amount you got at the end equals the amount you had at the beginning (the 92 grams). Example #8: How many grams of AuCl3 can be made from 100.0 grams of chlorine by this reaction: 2Au + 3Cl2 ---> 2AuCl3 Solution: 1) The equation is balanced. Yay! 2) 100.0 g of chlorine is given in the problem. Convert it to moles: 100.0 g ---------- = 1.41032 mol of Cl2 70.906 g/mol Notice that the element chlorine is diatomic. Students sometimes forget to write the seven diatomics with the subscripted two. The seven diatomics are: H2, N2, O2, F2, Cl2, Br2, I2 3) The ratio and proportion will involve Cl2 and AuCl3: 3 1.41032 mol -- = ---------- 2 x x = 0.940213 mol Notice that the values associated with chlorine (3 and 1.41032) are in the numerator and the values associated with gold(III) chloride (2 and x) are in the denominator. If you were to flip one ratio, you'd have to flip the other. 4) Convert moles of AuCl3 to grams: (0.940213 mol) (303.329 g/mol) = 285 g Example #9: Aluminum foil 1.00 cm square and 0.540 mm thick react with bromine to form aluminum bromide. (a) How many grams of bromine were consumed? (b) How many grams of aluminum bromide were produced? Solution: 1) Let us determine the mass, then moles, of Al present: volume of Al foil ---> (1.00 cm) (1.00 cm) (0.0540 cm) = 0.0540 cm3 Note the change of mm to cm. mass of Al ---> (2.70 g/cm3) (0.0540 cm3) = 0.1458 g Note the use of the density of aluminum. moles of Al ---> 0.1458 g / 26.98154 g/mol = 0.0054037 mol 2) The equation for the reaction is this: 2Al + 3Br2 ---> 2AlBr3 The Al to Br2 molar ratio of 2:3 will be used to answer (a). The Al to AlBr3 molar ratio of 2:2 will be used to answer (b). 3) Use the Al to Br2 molar ratio to determine moles of Br2 consumed: 2 0.0054037 mol ---- = ---------- 3 x x = 0.00810555 mol (of Br2) 4) Determine grams of Br2: (0.00810555 mol) (159.808 g/mol) = 1.30 g (to three sig figs) 5) Use the Al to AlBr3 molar ratio to determine moles of AlBr3 produced: 2 0.0054037 mol ---- = ---------- 2 x x = 0.0054037 mol (of AlBr3) 6) Determine grams of AlBr3: (0.0054037 mol) (266.694 g/mol) = 1.44 g (to three sig figs) Example #10: How many grams of oxygen are in a sample of Ca3(PO4)2 that contains 66.0 g of calcium? Comment: stoichiometric problems are usually of the "I have one chemical substance, how much of another chemical substance"? variety. But, they don't have to be. Here is an example of a mass-mass stoichiometric problem based on the relationships within one chemical substance. Solution: 1) Determine moles of calcium: 66.0 g / 40.078 g/mol = 1.6468 mol 2) Determine moles of oxygen in the sample, based on a 3:8 ratio between Ca and O: 3 8 --------- = --- 1.6368 mol x x = 4.3648 mol 3) Determine mass of oxygen: (4.3648 mol) (16.00 g/mol) = 69.8 g Bonus Example: Solid lithium hydroxide is used in space vehicles to removed exhaled carbon dioxide from the living environment by forming solid lithium carbonate and liquid water. (a) What mass of gaseous carbon dioxide can be absorbed by 1.00 kg of lithium? (b) At STP, what is the volume of CO2 produced? Solution: 1) Write the balanced chemical equation for the described reaction: 2LiOH + CO2 ---> Li2CO3 + H2O 2) However, there is a possible problem. The question asks for 1.00 kg of lithium, not lithium hydroxide. We need to know the molar relationship between Li and CO2. So, let's make LiOH from Li: 2Li + 2H2O ---> 2LiOH + H2 3) If I add the two reactions, I obtain this: 2Li + CO2 + H2O ---> Li2CO3 + H2 Note that two LiOH and one H2O cancel out. This third reaction gives me the Li to CO2 as 2 to 1, so I am now ready to continue on. 4) Determine moles of Li that react: 1000 g / 6.941 g/mol = 144.07 mol 5) Using the 2:1 molar ratio, I can determine the moles of CO2 consumed: 2 144.07 mol --- = --------- 1 x x = 72.035 mol (of CO2) 6) Convert moles to grams to get the answer for (a): (72.035 mol) (44.009 g/mol) = 3170 g 7) To determine the volume at STP, we can use either PV = nRT or molar volume: PV = nRT (1.00 atm) (V) = (72.035 mol) (0.08206 L atm / mol K) (273.15 K) V = 1614.6 L (to three sig figs, this would be 1610 L) molar volume (22.414 L/mol) (72.035 mol) = 1614.6 L (1610 L to three sig figs) AnswerVerifiedHint: The mass –mass stoichiometry calculation involves the converting the given mass of the reactant into moles of the reactants and then by using mole ratio the mole of the product is determined which is then converted to mass.Complete step by step answer:The stoichiometry is derived from a Greek word “stoichen” which means element and “metron” means measure. So, stoichiometry deals with determining the amount of reactants and products which are consumed and produced within a given chemical reaction.The stoichiometry is based on the principles of law of conservation of mass. The Law of conservation of mass states that the matter can neither be created nor be destroyed. Therefore, the mass of each element present in the products side of the chemical reaction should be equal to the mass of each present in the reactants side.To solve the mass stoichiometry problem, first we need to balance the chemical equation. With the help of a balanced chemical equation, the mole ratio can be determined.Now from the given mass of the reactant first we need to determine the moles of the reactants by using the molecular weight of the compound. In the formula used to calculate the number of moles of the reactant the given mass is divided by the molecular weight. Once the moles is determined, the moles of the product is calculated using the mole ratio. After getting the moles of the product, the mass of the product is calculated by multiplying the moles with the molecular weight.Note:The stoichiometry method is also helpful in determining the limiting reactant or the reagent and the excess reactant which is present in the chemical reaction even after the completion. Narwhals are well adapted to the arctic marine environment in which they live. Narwhals have a streamline body with two dorsal flippers and lack a dorsal fin. Propulsion comes from their tail. They have a thick layer of blubber to protect their bodies from the cold (Williams et al. How do narwhals survive in the… Conveniently deposit cash and up to 30 checks. Where can I load money to my Chase account? Deposit checks and cash at Chase branches and ATMs. Use Chase QuickDeposit℠ to take a picture and deposit a check through the Chase Mobile® app. Transfer money from another bank. Set up direct deposit from your employer. Can… Virtual CloneDrive is a free Windows program that creates a virtual CD/DVD drive on your computer. ISO, BIN, or CCD image files can be mounted on this drive virtually and behave as if they were inserted from a CD/DVD drive. Virtual CloneDrive is a faster and more convenient alternative to burning . Who made virtual… You do not need to have an original signed copy of the standard contractual clauses to comply with the GDPR rules on restricted transfers. A scanned signed version of the complete contract is sufficient evidence. Do the new SCCs need to be signed? The SCCs explicitly state that this does not necessarily require completing and… Your Time Capsule works with AirPort Utility, installed in the Utilities folder in the Applications folder on a computer using Mac OS X, and in Start > All Programs > AirPort on a computer using Windows. If AirPort Utility isn’t installed on your computer, you can download it from www.apple.com/support/airport. Does AirPort Time Capsule need… Like the rest of its officers, people with disabilities work all across the CIA in everything from intelligence collection to support for operations. What disqualifies you from working for the CIA? Recent involvement in criminal or unethical behavior can disqualify you from getting a clearance. This includes pending criminal charges, felony convictions, and a dishonorable… No, you don’t need to sign a cover letter. However, if you’re mailing a hard copy as part of your application, you should sign your cover letter because it’s professional and requires little effort. Are you: Sending an email cover letter? How do you sign a letter of application? Sincerely. Sincerely yours. Regards. Best. Best… How Many UPC Codes do I Need for my Products? Each individual product that you are planning on selling will need its own unique UPC Code. Each variant of product will require a unique UPC so products of different size and colors will each be unique represented with an individual UPC. Do different stores have… Physical prompts are used when the toddler does not respond to less restrictive prompts (e.g., modeling, verbal, visual). Physical prompting is useful when teaching motor behaviors (Alberto & Troutman, 1999). How do you use autism prompting? Prompting is used to increase desired behaviors and skill acquisition. When delivering prompts, the instructor should be mindful of… The actual injection itself may be painful occasionally may be accompanied by nerve irritation. The biggest criticism of cortisone injections from physical therapists is that they do not address the cause of a patient’s symptoms. They serve as temporary relief to help overcome a significant barrier during rehab. Who can give cortisone? A cortisone injection… Minors need consent of a parent or guardian. The general rule is that minors do not have capacity to make certain decisions. What is required for a consent quizlet? Expressed consent must be expressed (written), signed/dated by the patient or another person authorized to grant consent on the patients behalf. Implied consent is acceptable only… Doctors recommend yearly checkups that focus on the female reproductive system, starting between the ages of 13 and 15. Often called well-woman visits, they can catch small issues before they become big ones. What do doctors do in a female physical? Female Physical Exam A woman’s annual exam might include: Breast exam. Feeling for abnormal… You can change the mailing address for your Social Security benefits and information at any time, including after a disaster. What documents are needed when filing for Social Security? Your Social Security card or a record of your number. Your original birth certificate, a copy certified by the issuing agency, or other proof of your… Instead, the supervising PT must bill using his or her own credentials. And no matter what your state practice act says, the supervising therapist should always co-sign the billing note to ensure that the PTA’s services are being billed correctly. Can PT students treat Medicare patients in California? PTAs and physical therapy students cannot bill… Children worldwide aren’t getting enough physical activity. That’s the main conclusion of a new World Health Organization (WHO) study released today. The researchers report that slightly more than 80 percent of adolescents ages 11 to 17 were insufficiently physically active in 2016. Do students exercise enough? Most teens are not exercising enough, and researchers say… You may be wondering why physical therapy is necessary if the fracture has healed. When you fracture a bone, you will need to rest the area in order for the bone to heal. During this time, you will likely lose strength, mobility, and flexibility in the area. Physical therapy will help you regain these abilities…. No. Most allopathic medical schools (at least in the U.S.) do not require calculus as a prerequisite subject. Although a few schools do (more on this later), math is mainly just a preference. Should I take algebra-based physics or calculus-based physics? Calculus-based physics is generally the more “physical” approach to understanding physics. Honestly, it depends… #6: NBA Physical Therapist Non-athletes can be physical therapists despite the misconceptions. Many NBA teams hire full-time therapists who work in tandem with athletic trainers and team physicians. Do physical therapists help athletes? Physical therapy works to assist an athlete to rebuild strength and movement after an injury through different exercises, stretches, and specialized techniques…. A physical partition is the smallest unit of storage space allocation and is a contiguous space on a physical volume. Physical volumes inherit the volume group’s physical partition size, which you can set only when you create the volume group (for example, using the mkvg -s command). How do you initialize a physical volume? pvcreate… A typical number of patients seen by each therapist in this setting in a regular 8- hour day is approximately 12-16. The average amount of hands on time with the physical therapist is 15-30 minutes, depending on the company. In what year was physical therapy established as a field of study answer in numeric form?… Video showing how to solve stoichiometry problems that give a number of grams of a substance in a chemical equation, and ask you to find a number of grams of a different substance in a chemical equation. Take notes, stop, start, rewind, and use the video over and over if necessary to follow the steps to solve the problems.