Continue

This is a comprehensive, end-of-chapter set of practice problems on stoichiometry that covers balancing chemical equations, mole-ratio calculations, limiting reactants, and percent yield concepts. The links to the corresponding topics are given below. 1. Balance the following chemical equations: a) HCl + O2 → H2O + Cl2 b) Al(NO3)3 + NaOH → Al(OH)3 + NaNO3 c) H2 + N2 → NH3 d) PCl5 + H2O → H3PO4 + HCl e) Fe + H2SO4 → Fe2(SO4)3 + H2 f) CaCl2 + HNO3 → Ca(NO3)2 + HCl g) KO2 + H2O → KOH + O2 + H2O2 h) Al + H2O → Al2O3 + H2 i) Fe + Br2 → FeBr3 j) Cu + HNO3 → Cu(NO3)2 + NO2 + H2O k) Al(OH)3 → Al2O3 + H2O l) NH3 + O2 → NO + H2O m) Ca(AlO2)2 + HCl → AlCl3 + CaCl2 + H2O n) C5H12 + O2 → CO2 + H2O o) P4O10 + H2O → H3PO4 p) Na2CrO4 + Pb(NO3)2 → PbCrO4 + NaNO3 q) MgCl2 + AgNO3 → AgCl + Mg(NO3)2 r) KClO3 → KClO4 + KCl s) Ca(OH)2 + H3PO4 → Ca3(PO4)2 + H2O a) b) c) d) e) f) g) h) i) j) k) l) m) n) o) p) q) r) s) 2. Consider the balanced equation: C5H12 + 8 O2 → 5CO2 + 6H2O Complete the table showing the appropriate number of moles of reactants and products. mol C5H12 mol O2 mol CO2 mol H2O 2 2.5 3 5.4 3. How many grams of CO2 and H2O are produced from the combustion of 220. g of propane (C3H8)? C3H8(g) + 5O2(g) → 3CO2(g) + 4H2O(g) 4. How many grams of CaCl2 can be produced from 65.0 g of Ca(OH)2 according to the following reaction, Ca(OH)2 + 2HCl → CaCl2 + 2H2O 5. How many moles of O2 are formed when 75.0 g of Cu(NO3)2 decomposes according to the following reaction? 2Cu(NO3)2 → 2CuO + 4NO2 + O2 6. How many grams of MnCl2 can be prepared from 52.1 grams of MnO2? MnO2 + 4HCl → MnCl2 + Cl2 + 2H2O 7. Determine the mass of oxygen that is formed when an 18.3-g sample of potassium chlorate is decomposed according to the following equation: 2KClO3(s) → 2KCl(s) + 3O2(g). 8. How many grams of H2O will be formed when 48.0 grams H2 are mixed with excess hydrogen gas? 2H2 + O2 → 2H2O 9. Consider the chlorination reaction of methane (CH4): CH4(g) + 4Cl2(g) → CCl4(g) + 4HCl(g) How many moles of CH4 were used in the reaction if 51.9 g of CCl4 were obtained? 10. How many grams of Ba(NO3)2 can be produced by reacting 16.5 g of HNO3 with an excess of Ba(OH)2? 11. Ethanol can be obtained by fermentation - a complex chemical process breaking down glucose to ethanol and carbon dioxide. C6H12O6 → 2C2H5OH + 2CO2 glucose ethanol How many mL of ethanol (d =0.789 g/mL) can be obtained by this process starting with 286 g of glucose? 12. 36.0 g of butane (C4H10) was burned in an excess of oxygen and the resulting carbon dioxide (CO2) was collected in a sealed vessel. 2C4H10 + 13O2 → 8CO2 + 10H2O How many grams of LiOH will be necessary to consume all the CO2 from the first reaction? 2LiOH + CO2 → Li2CO3 + H2O 13. Limiting Reactant 13. Which statement about limiting reactant is correct? a) The limiting reactant is the one in a smaller quantity. b) The limiting reactant is the one in greater quantity. c) The limiting reactant is the one producing less product. d) The limiting reactant is the one producing more product. 14. Find the limiting reactant for each initial amount of reactants. 4NH3 + 5O2 → 4NO + 6H2O a) 2 mol of NH3 and 2 mol of O2 b) 2 mol of NH3 and 3 mol of O2 c) 3 mol of NH3 and 3 mol of O2 d) 3 mol of NH3 and 2 mol of O2 Note: This is not a multiple-choice question. Each row represents a separate question where you need to determine the limiting reactant. 15. How many g of hydrogen are left over in producing ammonia when 14.0 g of nitrogen is reacted with 8.0 g of hydrogen? N2(g) + 3 H2(g) → 2 NH3(g) 16. How many grams of PCl3 will be produced if 130.5 g Cl2 is reacted with 56.4 g P4 according to the following equation? 6Cl2(g) + P4(s) → 4PCl3(l) 17. How many grams of sulfur can be obtained if 12.6 g H2S is reacted with 14.6 g SO2 according to the following equation? 2H2S(g) + SO2(g) → 3S(s) + 2H2O(g) 18. The following equation represents the combustion of octane, C8H18, a component of gasoline: 2C8H18(g) + 25O2(g) → 16CO2(g) + 18H2O(g) Will 356 g of oxygen be enough for the complete combustion of 954 g of octane? 19. When 140.0 g of AgNO3 was added to an aqueous solution of NaCl, 86.0 g of AgCl was collected as a white precipitate. Which salt was the limiting reactant in this reaction? How many grams of NaCl were present in the solution when AgNO3 was added? AgNO3(aq) + NaCl(aq) → AgCl(s) + NaNO3(aq) 20. Consider the reaction between MnO2 and HCl: MnO2 + 4HCl → MnCl2 + Cl2 + 2H2O What is the theoretical yield of MnCl2 in grams when 165 g of MnO2 is added to a solution containing 94.2 g of HCl? 21. Percent Yield 21. In a chemistry experiment, a student obtained 5.68 g of a product. What is the percent yield of the product if the theoretical yield was 7.12 g? 22. When 38.45 g CCl4 is reacted with an excess of HF, 21.3 g CCl2F2 is obtained. Calculate the theoretical and percent yields of this reaction. CCl4 + 2HF → CCl2F2 + 2HCl 23. Iron(III) oxide reacts with carbon monoxide according to the following equation: Fe2O3(s) + 3CO(g) → 2Fe(s) + 3CO2(g) What is the percent yield of this reaction if 623 g of iron oxide produces 341 g of iron? 24. Determine the percent yield of the reaction if 77.0 g of CO2 are formed from burning 2.00 moles of C5H12 in 4.00 moles of O2. C5H12 + 8 O2 → 5CO2 + 6H2O 25. The percent yield for the following reaction was determined to be 84%: N2(g) + 2H2(g) → N2H4(l) How many grams of hydrazine (N2H4) can be produced when 38.36 g of nitrogen reacts with 6.68 g of hydrogen? 26. Silver metal can be prepared by reducing its nitrate, AgNO3 with copper according to the following equation: Cu(s) + 2AgNO3(aq) → Cu(NO3)2(aq) + 2Ag(s) What is the percent yield of the reaction if 71.5 grams of Ag was obtained from 132.5 grams of AgNO3 ? 27. Industrially, nitric acid is produced from ammonia by the Ostwald process in a series of reactions: 4NH3(g) + 5O2(g) → 4NO(g) + 6H2O(l) 2NO(g) + O2(g) → 2NO2(g) 2NO2(g) + H2O(l) → HNO3(aq) + HNO2(aq) Considering that each reaction has an 85% percent yield, how many grams of NH3 must be used to produce 25.0 kg of HNO3 by the above procedure? 28. Aspirin (acetylsalicylic acid) is widely used to treat pain, fever, and inflammation. It is produced from the reaction of salicylic acid with acetic anhydride. The chemical equation for aspirin synthesis is shown below: In one container, 10.00 kg of salicylic acid is mixed with 10.00 kg of acetic anhydride. a) Which reactant is limiting? Which is in excess? b) What mass of excess reactant is left over? c) What mass of aspirin is formed assuming 100% yield (Theoretical yield)? d) What mass of aspirin is formed if the percent yield is 70.0 %? e) If the actual yield of aspirin is 11.2 kg, what is the percent yield? f) How many kg of salicylic acid is needed to produce 20.0 kg of aspirin if the percent yield is 85.0 %? a) b) c) d) e) f) Mole ratios refer to the ratio of moles of one substance to the number of moles of another substance in a chemical reaction. These ratios are determined by the coefficients in the balanced chemical equation for the reaction. Mole ratio calculation are part of mole concept. Mole Concept is a key concept in chemistry that enables scientists to count and quantify atoms and molecules. It is based on the concept of a mole, which is a unit used to express chemical quantities. Avogadro's number, represented by one mole, is 6.022 × 1023 particles. In this article, we are going to learn about mole ratios in detail and how to calculate them. What is Mole Concept? Mole Concept is a fundamental concept in chemistry that allows us to count and measure atoms and molecules. The concept is based on Avogadro's number (6.022 × 1023 particles), which represents a mole. This notion facilitates computations in chemical reactions. For example, one mole of carbon atoms weighs 12 kilos, whereas one mole of water molecules contains two moles of hydrogen and one mole of oxygen atoms. It helps scientists properly determine the amounts of chemicals, allowing for more exact experimentation and analysis. Avogadro's Number Avogadro's Number is a fundamental constant in chemistry that lets scientists determine the number of atoms or molecules in a substance. One mole of a substance contains approximately 6.022 × 1023 particles, including atoms, molecules, and ions. This number enables chemists to readily translate the mass of a substance to the number of its constituent particles, making calculations in a variety of chemical processes easier, including reactions and quantity determination in experiments. Molar Mass Molar mass is the mass of one mole of a substance, typically represented in grams per mole (g/mol). It is a valuable instrument in chemistry for determining the quantity of a chemical. To calculate the molar mass of a compound, sum the atomic masses of all the atoms in the chemical formula. This value enables chemists to readily convert the mass of a chemical to the number of moles it contains, which is useful in a variety of calculations and analysis. What are Mole Ratios in Chemistry? Mole ratios in chemistry relate to the proportionate relationship between the quantities of chemicals involved in a chemical reaction. They are represented in moles and represent the relative amount of reactants and products involved in a process. Mole ratios are important for identifying the stoichiometry of a reaction, which allows chemists to understand how reactants interact and products develop. They let scientists to forecast the amounts of substances eaten or created during a reaction, making experimental design and analysis more accurate. Unit of Mole Ratio The unit for mole ratio is simply "moles." It indicates the relative quantity of chemicals involved in a chemical process. Mole ratios are the number of moles of one substance divided by the number of moles of another in a chemical equation. For example, if one mole of material A reacts with two moles of substance B, the mole ratio between A and B is 1:2. These ratios help chemists understand how reactants mix to generate products in a reaction. What is Stoichiometry? Stoichiometry can be thought of as a chemical recipe. It is a method for determining how much of each substance is required in a chemical reaction and how much will be produced. Stoichiometry, like a recipe, tells you how many atoms, molecules, or moles of each material are required to complete a chemical reaction. It enables scientists to predict reaction outcomes and guarantee that the proper amounts of each material are used. How to Calculate Mole RatiosTo compute mole ratios in stoichiometric reactions, first create a balanced chemical equation. This equation depicts the reactants on the left and the products on the right, with coefficients representing the relative amounts of each substance involved. The coefficients in the balanced equation represent mole ratios. Let's consider some examples: The combustion of methane (CH4) follows a balanced equation: CH4 + 2O2 → CO2 + 2H2 The mole ratio of methane (CH4) and oxygen (O2) is 1:2 due to their coefficients of 1 and 2, respectively. The equation for the formation of water (H2O) from hydrogen (H2) and oxygen (O2) is balanced. 2H2 + O2 → 2H2O In this reaction, the mole ratio of hydrogen (H2) and oxygen (O2) is 2:1 since the coefficients of H2 and O2 are 2 and 1, respectively. The balanced equation for the formation of ammonia (NH3) from nitrogen (N2) and hydrogen (H2) is: N2 + 3H2 → 2NH3 The mole ratio of nitrogen (N2) to hydrogen (H2) is 1:3 due to the coefficients of N2 and H2 being 1 and 3, respectively. To find the mole ratio of any two compounds, simply divide their coefficients in the balancing equation. For instance, in the initial reaction, the mole ratio of CH4 to O2 is 1:2. To ensure a stoichiometric reaction, two moles of O2 are required for every mole of CH4 consumed. Conclusion Mole ratios are important in chemistry because they explain how compounds interact during reactions. They describe the proportions of different substances involved, similar to the coefficients in a balanced chemical equation. Chemists can forecast the amount of reactants required and the products produced in a reaction by calculating mole ratios. Mole ratios make stoichiometric calculations easier and assist estimate the efficiency of chemical processes. Overall, they serve an important role in directing reactions and attaining desired results in chemistry. Sample Problems on Mole Ratios Problem 1: Consider the reaction 2H2 + O2 → 2H2O. Calculate the mole ratio between hydrogen (H2) and oxygen (O2). Solution: The mole ratio of H2 and O2 is 2:1. For every two moles of H2 used, one mole of O2 is required. Problem 2: Determine the mole ratio of nitrogen (N2) and hydrogen (H2) in the reaction: N2 + 3H2 → 2NH3. Solution: The mole ratio of N2 and H2 is 1:3. This means that for every mole of N2, 3 moles of H2 are required. Problem 3: Determine the reaction: CH4 + 2O2 → CO2 + 2H2O. Calculate the mole ratio of CH4 to O2. Solution: The mole ratio of CH4 and O2 is 1:2. This means that for every mole of CH4 absorbed, two moles of O2 are needed. Problem 4: Solve the equation 4NH3 + 5O2 = 4NO + 6H2O. Calculate the mole ratio between ammonia (NH3) and oxygen (O2). Solution: The mole ratio of NH3 to O2 is 4:5. This means that for every 4 moles of NH_3, 5 moles of O2 are required. The mole ratio is the fixed ratio between two species in a chemical reaction. It comes from the coefficients in front of the formulas in a balanced chemical equation.The mole ratio describes the fixed proportions between reactants and products in a chemical reaction. It is important in stoichiometry, particularly when used as a conversion factor in mole to gram conversions. Here is the mole ratio definition, with examples showing how to find the ratio and use it.The mole ratio is the ratio between any two substances in a chemical reaction. It is the ratio between two coefficients in a balanced chemical equation. The mole ratio is also known as the molar ratio or mole-to-mole ratio.Find the mole ratio between any two components of a chemical reaction using the coefficients of the chemical formulas. The coefficients are the numbers in front of the formula.For example, in the equation for the reaction between hydrogen and oxygen to make water:2 H2(g) + O2(g) → 2 H2O(g)The coefficient for hydrogen is 2. For oxygen, there isn't a coefficient, which stands for 1. The coefficient for water is 2.The mole ratio between hydrogen and oxygen is 2:1. The mole ratio between oxygen and water is 1:2. The mole ratio between hydrogen and water is 2:2, but you can reduce this to 1:1.To write a mole ratio, you need a balanced equation. If you are given an unbalanced equation, balancing it is your first step.For example, consider the reaction that converts ozone into oxygen:O3 → O2This chemical equation is unbalanced. How do you know? A balanced equation has the same number and type of atoms on both sides of the reaction arrow. In the given equation, there are 3 oxygen atoms on the left side of the arrow and two oxygen atoms on the right side of the arrow. Balance the equation by adding coefficients in front of the reactants and products until the number of atoms is the same on both sides.The balanced equation is:2O3 → 3O2Now, get the mole ratio using the coefficients. The ratio is 2 ozone molecules to 3 oxygen molecules or 2:3.A ratio is just a way of showing a relationship between two things. In chemistry, its importance is that you can use the ratio to solve stoichiometry problems.For example, let's say you're asked to find out how many moles of oxygen you get by reacting 4 moles of ozone. One way to solve this is to set up the ratio like equivalent fractions:4 moles ozone / x moles oxygen = 2 moles ozone / 3 moles oxygenSolving for "x":x moles oxygen = (4 moles ozone)*(3 moles oxygen)/2 moles ozonex moles oxygen = 6Note the "units" for moles of ozone cancels out, leaving moles of oxygen. Double-check your work! The most common mistake students make in this calculation is setting the fractions up so that the units don't cancel out.Usually, you'll get a value in grams and be asked for an answer in grams. The mole ratio does not work with mass units, like grams. So, you get to do algebra and the gram-to-mole and mole-to-gram conversion. Combining all these skills takes practice.For example, find how many grams of oxygen you get from reacting 0.2 grams of ozone.First, get a balanced equation for the reaction that makes oxygen from ozone. From this, write the mole ratio.Next, find the number of moles in 0.2 g of ozone. To do the mole to gram conversion, look up the atomic mass of oxygen on the periodic table. There are 16.00 grams of oxygen per mole of oxygen.Solve the conversion problem:x moles = 0.2 grams * (1 mole/16.00 grams) = 0.0125 molesUse the mole ratio to find how many moles of oxygen form from 0.125 moles of ozone.moles of oxygen = 0.125 moles ozone * (3 moles oxygen/2 moles ozone)moles of oxygen = 0.01875 moles oxygen gasNow, convert the moles of oxygen gas into grams of oxygen gas to get the final answer:grams of oxygen gas = 0.01875 moles * 16.00 grams/molegrams of oxygen gas = 0.3 gramsIn this case, you actually could have saved yourself some math because only one type of atom (oxygen) occurred on both sides of the chemical equation. But, it's good practice to follow all the steps. Also, remember to report your answer using the correct number of significant figures.Finally, recognize you could be given any reactant or product and can use the same technique to find the amount of any other reactant or product. Sometimes you'll have two quantities and use the mole ratio to find the limiting reactant.In stoichiometry, the mole ratio is the ratio between moles of species in a balanced chemical equation, but the mole ratio is also a unit of concentration in some disciplines. For example, in atmospheric chemistry, the mole ratio is the value obtained by dividing the moles of the constituent of interest by the total number of moles of a substance:ri = ni / ntotHere, ri is the mole ratio of i, ni is the number of moles of i, and ntot is the total number of moles. To avoid confusion, the concentration unit may be known as the mole fraction rather than the mole ratio.Related Posts Example Problem: Using Mole Ratios in a ReactionProblem: In the reaction below, how many moles of H2O\text{H}_2\text{O}H2O are produced if 4.0 moles of O2\text{O}_2O2 react completely?$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$Solution:Write and Balance the Equation:The equation is already balanced.Identify the Mole Ratio:The mole ratio of O_2 to H_2O is 1:2, as indicated by the coefficients.Set Up the Conversion:To find the moles of H_2O from 4.0 moles of O_2, use the mole ratio:$4.0 \, \text{moles O}_2 \times \frac{2 \, \text{moles H}_2\text{O}}{1 \, \text{mole O}_2} = 8.0 \, \text{moles H}_2\text{O}$Answer: 8.0 moles of H_2O are produced. In a chemical reaction, compounds react in a set ratio. If the ratio is unbalanced, there will be leftover reactant. To understand this, you need to be familiar with the molar ratio or mole ratio. The molar ratio compares the number of moles in a balanced equation.This is the comparison between the coefficients in front of the chemical formulas.If a formula lacks a coefficient, it is the same as saying there is 1 mole of that species.Molar ratios are used to predict how much product a reaction forms or to determine how much reactant is needed to make a set amount of product. A molar ratio is the ratio between the amounts in moles of any two compounds involved in a chemical reaction. Molar ratios are used as conversion factors between products and reactants in many chemistry problems. The molar ratio may be determined by examining the coefficients in front of formulas in a balanced chemical equation. Also known as: The molar ratio is also called the mole ratio or the mole-to-mole ratio. Molar ratio units are either mole:mole or else it is a dimensionless number because the units cancel out. For example, it's fine to say a ratio of 3 moles of O2 to 1 mole of H2 is 3:1 or 3 mol O2: 1 mol H2. For the reaction:2 H2(g) + O2(g) → 2 H2O(g) The molar ratio between O2 and H2O is 1:2. For every 1 mole of O2 used, 2 moles of H2O are formed. The molar ratio between H2 and H2O is 1:1. For every 2 moles of H2 used, 2 moles of H2O are formed. If 4 moles of hydrogen were used, then 4 moles of water would be produced. For another example, let's start with an unbalanced equation: O3 → O2 By inspection, you can see this equation is not balanced because mass is not conserved. There are more oxygen atoms in ozone (O3) than there are in oxygen gas (O2). You cannot calculate the molar ratio for an unbalanced equation. Balancing this equation yields: 2O3 → 3O2 Now you can use the coefficients in front of ozone and oxygen to find the molar ratio. The ratio is 2 ozone to 3 oxygen, or 2:3. How do you use this? Let's say you are asked to find how many grams of oxygen are produced when you react 0.2 grams of ozone. The first step is to find how many moles of ozone are in 0.2 grams. (Remember, it's a molar ratio, so in most equations, the ratio is not the same for grams.) To convert grams to moles, look up the atomic weight of oxygen on the periodic table. There are 16.00 grams of oxygen per mole. To find how many moles there are in 0.2 grams, solve for: x moles = 0.2 grams * (1 mole/16.00 grams). You get 0.0125 moles. Use the molar ratio to find how many moles of oxygen are produced by 0.0125 moles of ozone: moles of oxygen = 0.0125 moles ozone * (3 moles oxygen/2 moles ozone). Solving for this, you get 0.01875 moles of oxygen gas. Finally, convert the number of moles of oxygen gas into grams for the answer: grams of oxygen gas = 0.01875 moles * (16.00 grams/mole) grams of oxygen gas = 0.3 grams It should be fairly obvious that you could have plugged in the mole fraction right away in this particular example because only one type of atom was present on both sides of the equation. However, it's good to know the procedure for when you come across more complicated problems to solve. Himmelblau, David (1996). Basic Principles and Calculations in Chemical Engineering (6th ed.). ISBN 978-0-13-305798-0.International Bureau of Weights and Measures (2006). The International System of Units (SI) (8th ed.). ISBN 92-822-2213-6.Rickard, James N.; Spencer, George M.; Bodner, Lyman H. (2010). Chemistry: Structure and Dynamics (5th ed.). Hoboken, N.J.: Wiley. ISBN 978-0-470-58711-9.Whiteman, D.N. (2015). Encyclopedia of Atmospheric Sciences (2nd ed.). Elsevier Ltd. ISBN 978-0-12-382225-3.Zumdahl, Steven S. (2008). Chemistry (8th ed.). Cengage Learning. ISBN 0-547-12532-1. Mole Ratio worksheets curated by WorksheetzoneWith Mole Ratio Worksheets PDF, engaging practice is always within reach, no matter your schedule or setting. Designed for early learners through middle grades, these Mole Ratio Worksheets PDF deliver high-impact worksheets that support key milestones and curriculum objectives. Each resource is professionally formatted for clarity, consistency, and ease of use, saving educators and parents hours of prep time. Forget the frustration of scattered, low-quality materials; Mole Ratio Worksheets PDF give you a cohesive collection that reinforces learning while building student confidence. Whether used for daily review, skill reinforcement, or enrichment, these worksheets make it easier to plan with purpose and teach with confidence. Elevate your instruction with targeted, ready-to-go resources that align with real learning needs. More additional Chemistry worksheets Return to Stoichiometry Menu The solution procedure used below involves making two ratios and setting them equal to each other. When two ratios are set equal, this is called a proportion and the whole technique (creating two ratios, setting them equal) is called ratio-and-proportion. One ratio will come from the coefficients of the balanced equation and the other will be constructed from the problem. The ratio set up from data in the problem will almost always be the one with an unknown in it. Key point: the two ratios have to be set up with equivalent things in the same relative place in each ratio. A bit confusing? I will elaborate on this below. After setting up the proportion, you will cross-multiply and divide to get the answer. What happens if the equation isn't balanced? Then your first step is to balance it. You cannot do these problems correctly without a balanced equation. The ChemTeam is constantly amazed at the number of people who forget to balance the equation first. One note: remember that there are chemical equations where all the coefficients have a value of one. These equations are already balanced. The term that is often used for these equations is "balanced as written." Here is the first equation we'll use: N2 + 3H2 ---> 2NH3 Example #1: When 2.00 mol of N2 reacts with sufficient H2, how many moles of NH3 will be produced? Comments prior to solving the example (a) The equation is already balanced. (b) The ratio from the problem will have N2 and NH3 in it. (c) How do you know which number goes on top or bottom in the ratios? Answer: it does not matter, except that you observe the next point ALL THE TIME. (d) When making the two ratios, be 100% certain that numbers are in the same relative positions. For example, if the value associated with NH3 is in the numerator, then MAKE SURE it is in both numerators. (e) Use the coefficients of the two substances to make the ratio from the equation. (f) Why isn't H2 involved in the problem? Answer: the word "sufficient" removes it from consideration. Solution: 1) We will use this ratio to set up the proportion: 2) That means the ratio from the equation is: 2 mol NH3 -------- 1 mol N2 3) The ratio from the data in the problem will be: 4) The proportion (setting the two ratios equal) is: 2 mol NH3 x ---------- = ---------- 1 mol N2 2.00 mol N2 5) Solving by cross-multiplying and dividing gives: (1 mol N2) (x) = (2 mol NH3) (2 mol N2) (2 mol NH3) (2.00 mol N2) x = --------------------- 1 mol N2 x = 4.00 mol NH3 produced. Comment: Notice how the ratio-and-proportion is written. Written in this manner: x 2.00 mol N2 -------- = --------- 2 mol NH3 1 mol N2 is equally correct. Just make sure to keep the two quantities associated with the NH3 and the two associated with the N2 on the same side. The ChemTeam tends to not write the ratio and proportion in the style of the one just above, so you won't see it any more. Example #2: Suppose 6.00 mol of H2 reacted with sufficient nitrogen. How many moles of ammonia would be produced? Solution: 1) Let's use this ratio to set up the proportion: 2) That means the ratio from the equation is: 2 mol NH3 -------- 3 mol H2 3) The ratio from the data in the problem will be: 4) The proportion (setting the two ratios equal) is: 2 mol NH3 x -------- = ---------- 3 mol H2 6.00 mol H2 5) Solving by cross-multiplying and dividing gives: 3x = 12.00 mol x = 4.00 mol NH3 produced Example #3: We want to produce 2.75 mol of NH3. How many moles of nitrogen would be required? Before the solution, a brief comment: notice that hydrogen IS NOT mentioned in this problem. If any substance ISN'T mentioned in the problem, then assume there is a sufficient quantity of it on hand. Since that substance isn't part of the problem, then it's not part of the solution. Solution: 1) Let's use this ratio to set up the proportion: 2) That means the ratio from the equation is: 2 mol NH3 --------- 1 mol N2 3) The ratio from the data in the problem will be: 2.75 mol NH3 ---------- x 4) The proportion (setting the two ratios equal) is: 2.75 mol NH3 2 NH3 ----------- = ------- x 1 mol N2 5) Solving by cross-multiplying and dividing (plus rounding off to three significant figures) gives: x = 1.38 mol N2 needed. Here's the equation to use for the next three examples: 2H2 + O2 ---> 2H2O Example #4: How many moles of H2O are produced when 5.00 moles of oxygen are used? 1) Here are the two substances in the molar ratio I used: O2 1 mol O2 ---- and the ratio is --------- H2O 2 mol H2O 2) The molar ratio from the problem data is: 3) The proportion to use is: 5.00 mol O2 1 mol O2 ---------- = --------- x 2 mol H2O x = 10.0 mol of H2O are produced Example #5: If 3.00 moles of H2O are produced, how many moles of oxygen must be consumed? 1) Here are the two substances in the molar ratio I used: It's a 1:2 ratio. 2) The molar ratio from the problem data is: x ----------- 3.00 mol H2O 3) The proportion to use is: x 1 mol O2 ------------ = -------- 3.00 mol H2O 2 mol H2O x = 1.50 mol of O2 consumed For the examples below, I left off the mol unit on the ratio from the coefficients of the balanced equation. Also, I used a different way to format the ratios and the proportional set up. Example #6: How many moles of hydrogen gas must be used, given the data in example #5? Solution #1: 1) Here are the two substances in the molar ratio I used: 2) The molar ratio from the problem data is: 3) The proportion to use is: x = 3.00 mol of H2 was consumed Notice that the above solution used the answer from example #5. The solution below uses the information given in the original problem: Solution #2: The H2 / H2O ratio of 2/2 could have been used also. In that case, the ratio from the problem would have been 3.00 over x, since you were now using the water data and not the oxygen data. Example #7: Use the following equation: C3H8 + 3O2 ---> 3CO2 + 4H2 (a) How many moles of O2 are required to combust 1.50 moles of C3H8? (b) How many moles of CO2 are produced? (c) How many moles of H2 are produced? Solution to (a): 1) Use this ratio from the balanced chemical equation: 1⁄3 Note the style change! Just by the by, students often are confused when they see information presented to them in a different (but mathematically equivalent) style. Be aware! 2) Use this ratio from the problem: 1.50⁄x 3) Set equal and solve: 1⁄3 = 1.50⁄x x = 4.50 mol Solution to (b): Since CO2 has the same coefficient as O2, the answer will be the same: 4.50 moles of CO2 will be produced. Solution to (c): 1⁄4 = 1.50⁄x x = 6.00 mol Example #8: CuSO4 · 5H2O (a hydrated compound) is strongly heated, causing the water to be released. How many moles of water are produced when 1.75 moles of CuSO4 · 5H2O is heated? Solution: 1) The chemical equation of interest is this: CuSO4 · 5H2O ---> CuSO4 + 5H2O 2) Every one mole of CuSO4 · 5H2O that is heated releases five moles of water. The ratio from the chemical equation is this: 1⁄5 3) The ratio from the problem data is this: 1.75⁄x 4) Solving: 1⁄5 = 1.75⁄x x = 8.75 moles of water will be produced Example #9: 2.50 moles of K2CO3 · 1.5H2O is decomposed. How many moles of water will be produced? Solution: 2⁄3 = 2.50⁄x x = 3.75 Notice the use of a two-to-three ratio in place of a one-to-one-point-five ratio. Example #10: Carbon disulfide is an important industrial solvent. It is prepared by the reaction of carbon (called coke) with sulfur dioxide: 5C(s) + 2SO2(g) ---> CS2(ℓ) + 4CO(g) (a) How many moles of carbon are needed to react with 5.01 mol SO2? (b) How many moles of carbon monoxide form at the same time that 0.255 mol SO2 forms? (c) How many moles of SO2 are required to make 125 mol CS2? (d) How many moles of CS2 form when 4.1 mol C reacts? (e) How many moles of carbon monoxide form at the same time that 0.255 mol CS2 forms? Solution to (a): The molar ratio between C and SO2 is 5:2. The ratio and proportion to be used is this: 5 is to 2 as x is to 5.01 x = 12.5 mol (to three sig figs) Solution to (b): The molar ratio between CO and SO2 is 4:2. The ratio and proportion to be used is this: 4 is to 2 as x is to 0.255 x = 0.510 mol (to three sig figs) Short commentary: when I solved part b, I simply multiplied 0.255 by 2. You may ponder why that was so. Also, when I solved all the problems in this example, I went to a piece of paper and wrote the ratio and proportion thusly [using (b) for an example]: For myself personally, it gives me a better feel for solving the problem to look at the above formulation as opposed to this: 4 is to 2 as x is to 0.255 You need to be able to translate the "in a line" style to the "ratios written as fractions" style. Lastly, note how in (b), I used the compounds "right to left" from the chemical equation as opposed to the other three where the reading of the compounds is "left to right." It's just a stylistic thing, but I do tend more to the "left to right" reading. Solution to (c): The SO2:CS2 molar ratio is 2:1 The proper ratio and proportion is this: x = 250. (to three sig figs, note the explicit decimal point) Solution to (d): C:CS2 is 5:1 5 is to 1 as 4.1 is to x x = 0.82 mol (to two sig figs) Solution to (e): CO:CS2 molar ratio is 4:1 x = 1.02 mol Example #11: 2NO(g) + O2(g) ---> 2NO2(g) (a) How many moles of O2 combine with 500. moles of NO? (b) How many moles of NO2 are formed from 0.250 mole of NO and sufficient O2? (c) How many moles of O2 are left over if 80.0 moles of NO is mixed with 200. moles of O2 and the mixture reacts? Solution to (a): NO and O2 react in a 2:1 molar ratio 2 500. mol ---- = ------- 1 x x = 250. mol Solution to (b): NO and NO2 are in a 2:2 molar ratio 2 0.250 mol ---- = -------- 2 x x = 0.250 mol Comment: be aware that a 2:2 ratio is the same as a 1:1 ratio. Often, a teacher will use a 1:1 ratio and students will become confused. "Where did the one-to-one ratio come from?" The answer is that a two-to-two ratio reduces to a one-to-one ratio. The teacher simply reduced it without mentioning it. Solution to (c): We first need to determine how many moles of oxygen are used when 80.0 moles of NO reacts. NO and O2 react in a 2:1 molar ratio. 2 80.0 mol ---- = -------- 1 x x = 40.0 mol Now, we can determine how much oxygen remains after the NO is used up. 200. − 40.0 = 160. mol of O2 left over. Example #12: Consider the following reaction: 4Al(s) + 3O2(g) ---> 2Al2O3(s) (a) Write the 6 mole ratios that can be derived from this equation. Write the first using the chemical formulas and, secondly, using the coefficients of the equation. (b) How many moles of aluminum are needed to form 3.75 mol Al2O3? Solution to (a): Al:O2 Al to O2 Al/O2 Al:Al2O3 Example #13: Consider the reaction: 4Al(s) + 3O2(g) ---> 2Al2O3(s) (a) If 8.00 moles of aluminum react with an excess of oxygen, how many moles of aluminum oxide are produced? (b) The production of 0.438 moles of aluminum oxide requires the reaction of ______ moles of aluminum and _____ moles of oxygen? (c) When 1.830 moles of aluminum reacts, ______ moles of oxygen are consumed. Solution to (a): The molar ratio between Al and Al2O3 is 2:1. Note that I reduced it from 4:2 2 8.00 mol ---- = ------- 1 x x = 4.00 mol Solution to (b): First, aluminum Al to Al2O3 molar ratio is 2:1 2 x ---- = --------- 1 0.438 mol x = 0.876 mol of Al required. Second, oxygen O2 to Al2O3 molar ratio is 3:2 3 x ---- = --------- 2 0.438 mol x = 0.657 mol of oxygen required Solution to (c): Al to O2 molar ratio is 4:3 4 1.830 mol ---- = --------- 3 x x = 1.3725 mol To, four sig figs, this is 1.372 mol (the rule for rounding with a five applies). Example #14: In a chemical reaction between phosphoric acid and aqueous calcium chloride, the products are hydrochloric acid and a precipitate of calcium phosphate. (a) How many moles of calcium chloride are required to react in order to produce 0.570 moles of calcium phosphate? (b) How many moles of phosphoric acid are required to react with 1.37 moles of calcum chloride? Solution: 1) Write a balanced chemical equation: 2H3PO4(ℓ) + 3CaCl2(aq) ---> Ca3(PO4)2(s) + 6HCl(aq) 2) Part (a) CaCl2 to Ca3(PO4)2 molar ratio is 3:1 3 x ---- = --------- 1 0.570 mol x = 1.71 mol of CaCl2 required. 2) Part (b) H3PO4 to CaCl2 molar ratio is 2:3 2 x ---- = --------- 3 1.37 mol x = 0.913 mol of H3PO4 required. Example #15: Given the reaction: 4NH3(g) + 5O2(g) ---> 4NO(g) + 6H2O(ℓ) When 1.20 mole of ammonia reacts, the total number of moles of products formed is: (a) 1.20(b) 1.50(c) 1.80(d) 3.00(e) 12.0 Solution: The correct answer is d. The NH3 / (NO + H2O) molar ratio is 4:10 4 / 10 = 1.20 / x x = 3.00 mol Return to Stoichiometry Menu A mole ratio is the ratio between the amounts in moles of any two compounds involved in a balanced chemical reaction. The balance chemical equation provides a comparison of the ratios of the molecules necessary to complete the reaction. We cannot calculate mole ratio for an unbalanced equation.Mole ratios are used as conversion factors between products and reactants in many chemistry problems. Table of contents What is a mole? In chemistry the mole is a fundamental (SI) unit used to measure the amount of a substance. This quantity is sometimes referred to as the chemical amount. A mole is defined as the amount of a substance that contains exactly 6.022 x 1023 'elementary entities' of the given substance. A mole contains 6.023 x 1023 units. These units can be atoms, molecules, ions, electrons or anything else. Examples: 1 mole of hydrogen atom = 6.023 x 1023 hydrogen atoms 1 mole of hydrogen molecule = 6.023 x 1023 hydrogen molecules. 1 mole of electrons means = 6.023 x 1023 electrons. 1 mole of sodium ions = 6.023 x 1023 sodium ions. How much does one mole weigh? The mass of one mole atom of any element is exactly equal to the atomic mass in grams of that element. Similarly, the mass of 1 mole molecule of any substance is equal to its molecular mass in grams or gram molecular mass. Examples: Mass of 1 mole hydrogen atom = 1 g Mass of 1 mole of hydrogen molecule = 2 g Mass of 1 mole of oxygen atom = 16 g Mass of 1 mole of water (H2O) molecule = 18 g ∴ Mole of the substance = (Mass of the substance in gm / Gram molecular mass of that substance) Also read ⇒ Mole concept Determination of mole ratio in stoichiometric reaction Stoichiometry is an important concept in chemistry that helps us use balanced chemical equations to calculate amounts of reactants and products. Here, we make use of ratios from the balanced equation. In general, all the reactions that take place are dependent on one main factor, how much substance is present. We cannot calculate the mole ratio for an unbalanced equation. 1. Let us consider a balanced chemical equation N2 + 3H2 → 2NH3 Here the coefficients of N2 =1 The coefficients of H2 = 3 The coefficients of NH3 = 2 This coefficient provided the molecular information for the chemical equation. In this chemical equation 1mole of nitrogen (N2) reacts with 3 moles of hydrogen (H2) to produce 2moles of ammonia (NH3). To determine the mole ratio of any two components of the equation, compare the coefficients of each component in the equation. Mole ratio between N2 and H2 = (1 mole of N2 / 3 mole of H2) = 1:3 Mole ratio between N2 and NH3 = (1 mole of N2 / 2 mole of NH3) = 1:2 Mole ratio between H2 and NH3 = (3 mole of H2 / 2 mole of NH3) = 3:2 Mole ratio between H2 and N2 = (3 mole of H2 / 1 mole of N2) = 3:1 Mole ratio between NH3 and N2 = (2 mole of NH3 / 1 mole of N2) = 2:1 Mole ratio between NH3 and H2 = (2 mole of NH3 / 3 mole of H2) = 2:3 2. Consider the balanced reaction 2H2 + O2 → 2H2O Here the coefficients of N2 =2 The coefficients of O2 = 1 The coefficients of H2O = 2 In this reaction 2 mole of H2 react with 1 mole of O2 producing 2 moles of H2O. Mole ratio between H2 and O2 = (2 mole of H2 / 1 mole of O2) = 2:1 Mole ratio between H2 and H2O = (2 mole of H2 / 2 mole of H2O) = 2:2 Mole ratio between O2 and H2O = (1 mole of O2 / 2 mole of H2O) = 1:2 Unit of mole ratio Mole ratio is a dimensionless unit. Because it produces mole:mole, so units of moles are cancelled out. Problem practice on mole ratio 1. How many moles of Fe molecules will react with 0.27 moles of O2 molecules in the given equation? 4Fe + 3O2 → 2Fe2O3 Solution: In the given chemical equation 4Fe + 3O2 → 2Fe2O3 4 moles of Fe react with 3 mole of O2 produces 2 mole of Fe2O3 Mole ratio of Fe and O2 Fe : O2 = 4:3 Let the 0.27 moles of O2 react 'x' mole of Fe molecule, now Fe : O2 = x : 0.27 By comparing both we can find out x value 4:3 = x : 0.27 ⇒ x = {4 * (0.27)} / 3 = 0.36 mole ∴ 0.36 mole of Fe molecules will react with 0.27 mole of O2. 2. How many moles of ammonia are produced if 4.20 moles of hydrogen are reacted with an excess of nitrogen? Solution: The balanced equation of formation of ammonia is N2 + 3H2 → 2NH3 Here 1 mole of nitrogen reacts with 3 moles of hydrogen to produce 2 moles of ammonia. For 4.20 mole of hydrogen produces the number of moles ammonia is From the equation the mole ratio of hydrogen and ammonia is H2 : NH3 = 3:2 It means 3 moles of H2 produces 2 moles of NH3 Let 4.20 moles of H2 will produce 'x' moles of NH3 . Now H2 : NH3 = 4.20 : x By comparing both we can find out x value 3 : 2 = 4.20 : x ⇒ x = 4.20 (⅔) = 2.8 moles ∴ 4.20 moles of H2 will produce 2.8 moles of NH3 A mole ratio is the ratio between the amounts in moles of any two compounds involved in a balanced chemical reaction In the balanced chemical equation of ammonia is N2 + 3H2 → 2NH3, the mole ratio between N2 and H2 is 1:3 In the balanced chemical equation of zinc to sulfuric acid is Zn + H2SO4 → ZnSO4 + H2, the mole ratio between Zn and H2SO4 is = 1:1 Mole ratios allow comparison of the amounts of any two materials in a balanced equation. Calculations can be made to predict how much product can be obtained from a given number of moles of reactant. Stoichiometry is an important concept in chemistry that helps us use balanced chemical equations to calculate amounts of reactants and products. Here, we can use mole ratios from the balanced equation. Chemistry isn't just about mixing colorful liquids in beakers and waiting for an explosion—it's a world of ratios, reactions, and relationships. At the heart of understanding this fascinating world lies the concept of the molar ratio, a key player in predicting the outcomes of chemical reactions. But what exactly is a molar ratio, and why is it so important? Simply put, it quantifies the proportions of reactants and products in a chemical equation, and accounts for every atom according to the law of conservation of mass. Remember learning about balanced equations? It's time to put that knowledge into action. In this blog post, we'll dive deep into the world of molar ratios, from what they are to how to find them using balanced equations. Whether you're a budding chemist or just curious about the science behind the reactions, you're in the right place to uncover the secrets of how to find the molar ratio. Imagine you're following a recipe to bake a cake. You wouldn't just throw in random amounts of flour, sugar, and eggs, right? Just like in baking, chemistry requires precise measurements to get the desired outcome. This is where the concept of the molar ratio comes into play, acting as the "recipe" for chemical reactions. Chemistry is more than mixing chemicals together. It's about creating substances. A molar ratio is the proportion of moles of one substance to the moles of another substance in a chemical reaction. The coefficients of the substances in a balanced chemical equation show the molar ratio relationship. For example, in the reaction to produce water (2H_2 + O_2 \rightarrow 2H_2O), the molar ratio of H_2 to O_2 is 2:1. This means that two moles of hydrogen gas react with one mole of oxygen gas to produce water. So, why is this important? Chemists predict how much of each reactant they need to produce a certain amount of product without any waste by using molar ratio. It ensures that every atom of the reactants has a place in the products, adhering to the law of conservation of mass, which states that matter cannot be created or destroyed in a chemical reaction. Understanding molar ratios is crucial for anyone looking to delve into the world of chemistry, whether it's synthesizing a new compound in a research lab or figuring out the right amount of baking soda to add to your volcano science project. By mastering this concept, you'll unlock the ability to navigate through chemical equations with ease, paving the way for exciting experiments and discoveries. In order to truly grasp the concept of molar ratio, let's dive into some example problems that highlight how to use this tool in real chemical equations. Curious about how to find the molar ratio? These examples will show you step-by-step how to calculate molar ratios and apply them to predict the amounts of reactants and products in a chemical reaction. Example 1: Combustion of Propane The combustion of propane (C_3H_8) in oxygen (O_2) is a common reaction that produces carbon dioxide (CO_2) and water (H_2O). The balanced chemical equation for this reaction is: C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O Question: What is the molar ratio of O_2 to CO_2 in the combustion of propane? Solution: To find molar ratio, look at the coefficients in your balanced equation. By looking at the balanced equation, we can see that 5 moles of O_2 produce 3 moles of CO_2. Therefore, the molar ratio of O_2 to CO_2 is 5:3. Example 2: Formation of Ammonia The Haber process combines nitrogen (N_2) and hydrogen (H_2) gas to form ammonia (NH_3), a crucial component in fertilizers. The balanced equation for this reaction is: N_2 + 3H_2 \rightarrow 2NH_3 Question: If you start with 4 moles of N_2 how many moles of H_2 are needed to react completely based on the molar ratio? Solution: From the balanced equation, the molar ratio of N_2 to H_2 is 1:3. This means for every mole of N_2, they require 3 moles of H_2 to react. For 4 moles of N_2, we need: 4\text{ moles of }N_2 \times \frac{3\text{ moles of }H_2 }{1 \text{ mole of }N_2} = 12 \text{ moles of }H_2 Therefore, 12 moles of H_2 completely react with 4 moles of N_2. Now that you've seen how to find molar ratio and how to use them through example problems, it's your turn to try solving some on your own. These practice problems will test your understanding of molar ratios and how to apply them to different chemical reactions. Work through these on your own, then scroll down for solutions. When hydrogen gas (H_2) reacts with oxygen gas (O_2) water (H_2O) forms. The balanced equation for this reaction is: 2H_2 + O_2 \rightarrow 2H_2O If you have 6 moles of H_2, how many moles of O_2 are needed to react completely, and how many moles of H_2O will be produced? Potassium chlorate (KClO_3) decomposes upon heating to produce potassium chloride (KCl). The balanced equation for this reaction is: 2KClO_3 \rightarrow 2KCl + 3O_2 How many moles of O_2 can be produced from the decomposition of 4 moles of KClO_3? Ethanol (C_2H_5OH) combusts in oxygen to produce carbon dioxide and water. The balanced chemical equation is: C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O If 2 moles of C_2H_5OH are combusted, how many moles of O_2 are required, and what amounts of CO_2 and H_2O are produced? Ammonium nitrate (NH_4NH_3)is produced by the reaction of ammonia (NH_4) with nitric acid (HNO_3). The balanced chemical equation for this reaction is: NH_3 + HNO_3 \rightarrow NH_4NO_3 If a fertilizer company needs 5 moles of ammonium nitrate, how many moles of ammonia and nitric acid are required to achieve this? Magnesium (Mg) reacts with oxygen (O_2) to form magnesium oxide (MgO). The balanced equation for this reaction is: 2Mg + O_2 \rightarrow 2MgO During a lab experiment, a student reacts 6 moles of magnesium with excess oxygen. How many moles of magnesium oxide does the reaction produce, and how many moles of oxygen are consumed in the reaction? Tips for Solving: Start by identifying the molar ratios between the reactants and products from the balanced chemical equations. Use the molar ratios to calculate the amounts of reactants or products as needed. Remember to check your work and ensure that the law of conservation of mass is satisfied in your calculations. Are you ready to see how you did? Review below to see the solutions for the molar ratio practice problems. When hydrogen gas (H_2) reacts with oxygen gas (O_2) water (H_2O) forms. The balanced equation for this reaction is: 2H_2 + O_2 \rightarrow 2H_2O If you have 6 moles of H_2, how many moles of O_2 are needed to react completely, and how many moles of H_2O will be produced? Remember, to find molar ratio, use the coefficients in the balanced equation. The molar ratio of H_2 to O_2 is 2:1, meaning 2 moles of H_2 react with 1 mole of O_2. You will use this ratio to determine how many moles of O_2 are needed to react completely. 6 \text{ moles of }H_2 \times \frac{1 \text{ mole of }O_2}{2 \text{ moles of }H_2} = 3 \text{ moles of }O_2 The molar ratio of H_2 to H_2O is 2:2, which can be simplified to 1:1. Therefore, if 6 moles of H_2 reacts, it produces 6 moles of H_2O. Potassium chlorate (KClO_3) decomposes upon heating to produce potassium chloride (KCl). The balanced equation for this reaction is: 2KClO_3 \rightarrow 2KCl + 3O_2 How many moles of O_2 can be produced from the decomposition of 4 moles of KClO_3? The molar ratio of KClO_3 to O_2 is 2:3. Hence, 2 moles of KClO_3 react with 3 moles of O_2. You will use this to determine how many moles of O_2 will be produced. 4 \text{ moles of }KClO_3 \times \frac{3 \text{ mole of }O_2}{2 \text{ moles of }KClO_3} = 6 \text{ moles of }O_2 Ethanol (C_2H_5OH) combusts in oxygen to produce carbon dioxide and water. The balanced chemical equation is: C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O If 2 moles of C_2H_5OH are combusted, how many moles of O_2 are required, and what amounts of CO_2 and H_2O are produced? This question has three different parts. The first is determining how many moles of O_2 are needed to react completely with 2 moles of C_2H_5OH. Initially, you must find the molar ratio. The ratio of O_2 to C_2H_5OH is 3:1. 2 \text{ moles of }C_2H_5OH \times \frac{3 \text{ mole of }O_2}{1 \text{ mole of }C_2H_5OH} = 6 \text{ moles of }O_2 The second part asks how much CO_2 is produced from 2 moles of C_2H_5OH. The ratio of CO_2 to C_2H_5OH is 2:1. 2 \text{ moles of }C_2H_5OH \times \frac{2 \text{ mole of }CO_2}{1 \text{ mole of }C_2H_5OH} = 4 \text{ moles of }O_2 The third part asks how much H_2O the reaction produces from 2 moles of C_2H_5OH. The ratio of H_2O to C_2H_5OH is 3:1. 2 \text{ moles of }C_2H_5OH \times \frac{3 \text{ mole of }H_2O}{1 \text{ mole of }C_2H_5OH} = 6 \text{ moles of }H_2O Ammonium nitrate (NH_4NH_3)is produced by the reaction of ammonia (NH_4) with nitric acid (HNO_3). The balanced chemical equation for this reaction is: NH_3 + HNO_3 \rightarrow NH_4NO_3 If a fertilizer company needs to produce 5 moles of ammonium nitrate, how many moles of ammonia and nitric acid are required to achieve this? This is a two-part problem, but solved the same way. This is because the balanced equation has a molar ratio of 1:1 for all reactants and products in the equation. Therefore, however many moles you put into the reaction, produces the same amount of moles as products. Therefore, if we want to produce 5 moles of NH_4NH_3, we would need to put in 5 moles of NH_3 and 5 moles of HNO_3. Magnesium (Mg) reacts with oxygen (O_2) to form magnesium oxide (MgO). The balanced equation for this reaction is: 2Mg + O_2 \rightarrow 2MgO During a lab experiment, a student reacts 6 moles of magnesium with excess oxygen. How many moles of magnesium oxide will be produced, and how many moles of oxygen are consumed in the reaction? This is a two-part problem. The first part asks how many moles of Mg the reaction makes if 6 moles of Mg reacts. The molar ratio of MgO to Mg is 2:2, which can be simplified to 1:1. Therefore, if 6 moles of Mg reacts, 6 moles of MgO will be produced. The second part of the problem asks how much excess O_2 the reaction uses if 6 moles of Mg reacted. The molar ratio of Mg to O_2 is 2:1. We use this to determine our answer. 6 \text{ moles of }Mg \times \frac{1 \text{ mole of }O_2}{2 \text{ moles of }Mg} = 3 \text{ moles of }O_2 Embarking on the journey through the world of chemistry reveals the intricate dance of atoms and molecules, governed by fundamental principles such as the molar ratio. This concept, akin to the precise measurements in a recipe, ensures that chemical reactions proceed smoothly, with each reactant and product playing its part in the grand scheme of matter transformation. Understanding molar ratios not only demystifies how substances react in specific proportions but also empowers us with the ability to predict the outcomes of these reactions. Whether it's synthesizing a new compound in the lab, analyzing environmental samples, or simply marveling at the chemical reactions in everyday life, the knowledge of molar ratios serves as a crucial tool in the arsenal of any budding chemist. In conclusion, we've explored how to find molar ratio and tackled practice problems to solidify our understanding. Remember, the beauty of chemistry lies not just in theoretical knowledge but in applying these concepts to solve real-world problems. So, I encourage you to continue exploring, questioning, and experimenting with the fascinating reactions that make up our world. Chemistry continually challenges and inspires, and with tools like molar ratios, you can uncover the mysteries that lie in molecules and reactions. So, keep your curiosity alive, and let the molar ratio guide you as you journey through the incredible landscape of chemistry. Mole-Mole Problems Return to Stoichiometry Menu The molar ratio will assume a place of central importance in solving stoichiometry problems. The sources for these ratios are the coefficients of a balanced equation. We will look at what a molar ratio is and then a brief word on how to recognize which ratio to use in a problem. The ChemTeam's favorite sample equation is: 2H2 + O2 ---> 2H2O I will use it for the first three examples. Example #1: What is the molar ratio between H2 and O2? Solution: The ratio is two-to-one. The 2 is the coefficient in front of the H2 and the 1 is the coefficient understood to be in front of the O2. Here is the ratio in fractional form: 2 mol H2 -------- 1 mol O2 Make sure you also can recognize a ratio when it's written using a colon: 2:1 The ChemTeam recommends you always explicitly write the numeral one when it is in the denominator of the ratio. Note how the unit is included and the formula of the substance is included. This will help you to keep track of which units cancel when you start doing multi-step stoichiometry calculations. Often the unit is not written, especially when a ratio is written using the colon format. This will create the potential for a problem when using the ratio values without the units. You run the risk of using the opposite ratio from the required ratio. Be very careful to use the correct ratio!! Example #2: What is the molar ratio between O2 and H2O? Solution: The ratio is one-to-two. The 1 is in front of the O2 and the 2 is in front of the H2O. As a fraction, it is: 1 mol O2 -------- 2 mol H2O The colon form is, of course: 1:2 Another way to see a ratio written is like this: 1 is to 2 Example #3: What is the molar ratio between H2 and H2O? Solution: The ratio is two-to-two. The 2 is the coefficient in front of the H2 and the 2 is the coefficient in front of the H2O. As a fraction, it is: 2 mol H2 -------- 2 mol H2O Notice that this ratio reduces to one-to-one (or 1:1 ratio). In the classroom, the ChemTeam would, from time to time, reduce the ratio to one-to-one and sooner or later, someone would ask where the one-to-one ratio came from. As the difficulty level of the problems goes up, the ChemTeam will just use the reduced ratio (assuming you have mastered the earlier materials, such as in this present tutorial). Also be aware, as you examine a solution to a problem by someone else, they may just use the reduced ratio without saying anything about it. You have been warned! Example #4: (a) What is the molar ratio between O3 and O2? (b) What is the molar ratio between O2 and O3? 2O3 ---> 3O2 Solution: For (a), it is: 2 mol O3 -------- 3 mol O2 And the answer to (b) simply reverses the numbers: 3 mol O2 -------- 2 mol O3 As you can see, the exact molar ratio you use depends on how the problem is worded. However, a warning: people tend to play fast and loose with the molar ratio. The ChemTeam tends to be careful with them. However, other people can be more haphazard. What they do is write a ratio without an explanation for how it got to be that way. What you have to do is figure out from context which number is associated with which chemical substance. You do that by looking at the coefficients of the balanced equation. Before solving a problem, the ChemTeam thinks about which ratio it'll need and makes sure it's written down first. What the ChemTeam believes is the next logical unit from here. However, look at the remaining examples first! By the way, still another way to show a ratio is this: 3⁄2 Done with units, it looks like this: 3 mol O2 ⁄ 2 mol O3 Make sure you carefully follow the units, especially which one is in the numerator and which one is in the denominator. Also, notice I use the unit 'mol.' Don't use 'mole' because it is the name of the concept. The unit to be used in calculations is 'mol.' Example #5: N2 + 3H2 ---> 2NH3 Write the molar ratios for (a) N2 to H2 and (b) NH3 to H2. Solution: The ratio for (a) is: 1 mol N2 -------- 3 mol H2 and the ratio for (b) is: 2 mol NH3 -------- 3 mol H2 Sometimes, a student will gather the mistaken impression that the molar ratio can only be constructed using the reactants of a given equation. You can't do that. The ratio can be constructed using any two substances in the equation, be they reactants and/or products. Example #6: 2SO2 + O2 ---> 2SO3 Write the molar ratios for (a) O2 to SO3 and (b) SO2 to SO3. Solution: (a) is: 1 mol O2 -------- 2 mol SO3 and (b) is: 2 mol SO2 -------- 2 mol SO3 Example #7: PCl3 + Cl2 ---> PCl5 Write the molar ratios for (a) PCl3 to Cl2 and (b) PCl3 to PCl5. Solution: 1 mol PCl3 1 mol PCl3 (a) -------- (b) -------- 1 mol Cl2 1 mol PCl5 As the problems expand into multi-step solutions, there will be an interesting error students make when using a 1:1 ratio. Example #8: 4NH3 + 3O2 ---> 2N2 + 6H2O Write the molar ratios for (a) NH3 to N2 and (b) H2O to O2. Solution: 4 mol NH3 6 mol H2O (a) -------- (b) -------- 2 mol N2 3 mol O2 Note that both ratios can be reduced. Eventually, ratios like the above will be used in multi-step problems and the reduced ratio will be used in the actual calculation. The ChemTeam's position is that it doesn't matter and so NEVER deducted points if the unreduced ratio was used. However, there are teachers who insist on the reduced ratio being used. Make sure you know what your teacher expects you to do. Example #9: Fe2O3 + 3CO ---> 2Fe + 3CO2 Write the molar ratios for (a) CO to CO2 and (b) Fe2O3 to Fe. Solution: 3 mol CO 2 mol Fe (a) -------- (b) -------- 3 mol CO2 1 mol Fe2O3 Notice that I stopped mentioning ratios like this: two-to-four. I have seldom seen them used, maybe two or three times. A word to the wise to be aware. Also, a reminder that you might see something like this: two is to four I'll do colon type molar ratios in the examples to follow. You need to do a bit of extra work to keep track of which value is associated with which chemical substance. Example #10: In this equation: C2H6O + 3O2 ---> 2CO2 + 3H2O what is the mole ratio between O2 and H2O? (a) 1:1; (b) 3:2; (c) 2:3; (d) 3:3 Solution: The coefficients of the equation, the mole ratio is 3:3. However, this reduces to a 1:1 ratio. Both (a) and (d) are correct. However, profit: the coefficients of a chemical reaction, the reduced ratio is the numbers themselves in the numerator and the reduced ratio in the denominator. The correct answer choice (a) would be considered by most teachers to be the correct answer. Please note that using a 3:3 ratio in a calculation is correct as opposed to using 1:1. The ChemTeam, when in the classroom (now retired), would use the unreduced ratio in calculations done for teaching purposes. This is because, invariably, if the reduced ratio is used, the question would be asked: "Where did the 1:1 ratio come from?" Example #11: Given the balanced equation: 2SO2 + O2 ---> 2SO3 what is the mole ratio of O2 to SO3? (a) 2:1; (b) 1:2; (c) 2:2; (d) 2:3 Solution: The correct answer is (b) 1:2. When I saw this problem online, 2:1 was the answer given, the reverse of the correct answer. 2:1 is the molar ratio of SO3 to O2. Make sure to write the numbers of the ratio in the same order as used in the question. Example #12: What is the molar ratio between copper(II) sulfate and water in the following compound? CuSO4 · 5H2O Solution: Notice that this is not a chemical reaction, it is simply a chemical formula of a hydrate. Remember, hydrates have a fixed amount of water per mole of the non-water compound. In this example, the molar ratio is 1:5. For every one mole of CuSO4, there are five moles of water. Example #13: What is the molar ratio for the following hydrates? (a) CuCl2 · 2H2O (b) MgSO4 · H2O (c) Cr2(SO4)3 · 18H2O Solution: (a) 1:2 ---> one mole of CuCl2 to two moles of water (b) 1:1 ---> one mole of MgSO4 to one mole of water (c) 1:18 ---> one mole of Cr2(SO4)3 to eighteen moles of water Example #14: What is the molar ratio between the anhydrous compound and water in the following compound? K2CO3 · 1.5H2O ---> named potassium carbonate sesquihydrate Solution: The ratio is 1 to 1.5. In chemistry, it is common to state ratios as small whole numbers, so this ratio would be expressed as 2:3. Thus, this formula is often written as: 2K2CO3 · 3H2O There is nothing whatsoever wrong with the 1 to 1.5 ratio. It's just that the common practice within the chemistry community is to use ratios expressed as small whole numbers. Example #15: What is the mole ratio between calcium sulfate and water in the following compound? CaSO4 · 0.5H2O ---> named calcium sulfate hemihydrate Solution: In small whole numbers, the ratio is 2:1 and the formula can be written thusly: 2CaSO4 · H2O Example #16: Which of the following statements about the mole ratio of a chemical equation is accurate? (a) The mole ratio can describe the amount of product expected from a given amount of reactants. (b) The mole ratio in a chemical equation can be determined using the coefficients in a balanced equation. (c) The mole ratio can describe the ratio of reactants required to react. (d) All of the above. Mole-Mole Problems Return to Stoichiometry Menu

- wuzagayi
- https://ckmusicdesign.nl/userfiles/file/afffd3d7-3c7d-437b-901c-d1e7af223905.pdf
- http://locuspublishing.com/ckfinder/userfiles/files/virexotezaf.pdf
- synonyms and antonyms examples sentences pdf
- http://neline.nl/userfiles/file/sefalafeponaf_nipenawuzir_duwoduzot_ramif_niwonif.pdf
- vakirobu

- yukocotiku