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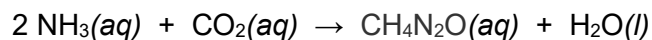
Limiting Reactant Stoichiometry and Percent Yield

Unit 4: Chemical Reactions (Notes 3)

AP Chemistry Standards: 4.5 Stoichiometry (limiting reactants and percent yield)

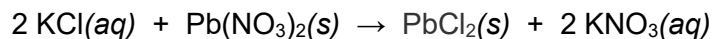
Video notes:

Urea ($\text{CH}_4\text{N}_2\text{O}$) is a common fertilizer (also, it's in your pee) made by reacting ammonia (NH_3) with CO_2 .



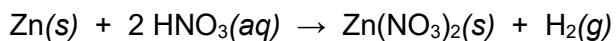
A chemist combines 592.7 g of ammonia (molar mass = 17.03 g/mol) with 994.3 g of carbon dioxide (m.m. = 44.01 g/mol) and produces 898.4 g of urea (m.m. = 60.06 g/mol). Determine the limiting reactant, theoretical yield of urea, and percent yield for the reaction.

In the lab, you pour 55.0 mL of 0.200 M KCl in a beaker. To this, you drop 1.52 g of solid lead(II) nitrate crystals (m.m. = 331.3 g/mol), which are completely soluble in the water. Lead(II) chloride (m.m. = 278.1 g/mol) precipitate forms in the beaker. You filter out the new precipitate using filter paper and a funnel, then weigh it on a balance, which reads "1.135 grams." Determine the limiting reactant, theoretical yield of lead(II) chloride, and percent yield for the reaction.



Practice Problems:

1. You react 20.5 g of Zn with 100.0 mL of 6.00 M nitric acid¹, then evaporate the remaining water. You measure the mass of zinc nitrate to be 53.2 g. *Determine the theoretical yield, actual yield, and the percent yield of that reaction.*

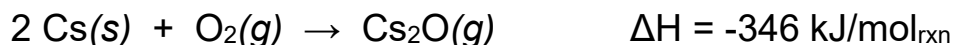


¹ We actually have 6 M nitric acid in the lab. It'll burn your skin. Most of the time, we use acid around 0.1 M or 1.0 M, which isn't all that dangerous. But when you get up to 6 M (or the 13.8 M HCl that literally fumes when you open the lid), we have to take some extra precautions, like working exclusively in the fume hood.

2. You won't find any solid rubidium or cesium in our lab at school. That's because these two heavy alkali metals are very reactive with air (see [this video](#) for the reaction). In fact, they have to be stored in sealed containers of non-reactive noble gases like argon to prevent that reaction with oxygen.

So here's my limiting reactant question: If we stored a **50.0 g of cesium** in a small lab bottle filled with regular air, would all of the cesium react? Let's assume that 20% of the air in the bottle is oxygen, and the small bottle's volume is 200 mL, meaning there is **40.0 mL of oxygen** in the bottle. To make our calculations quicker, let's assume STP for this problem.

Determine the limiting reactant and the amount of energy (in kJ) released while in the container.

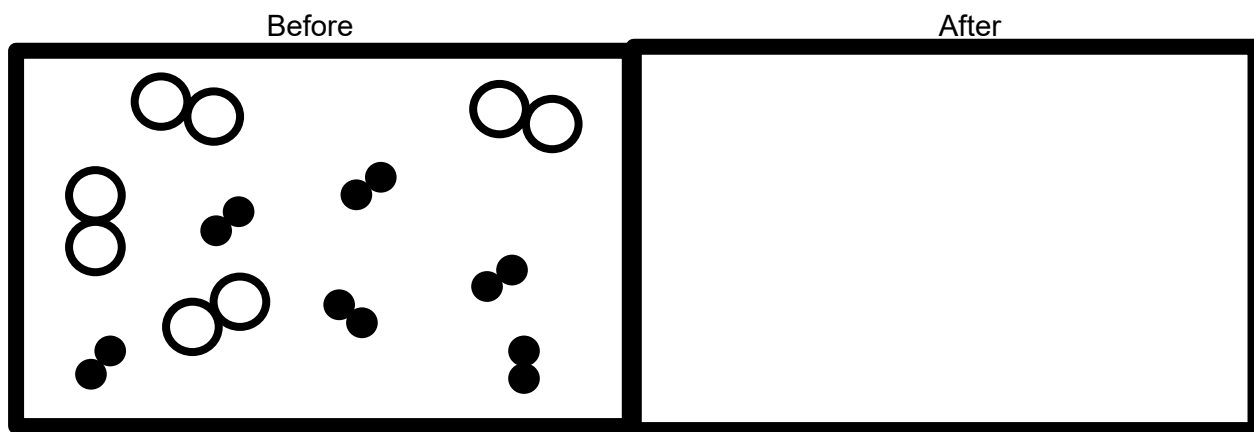
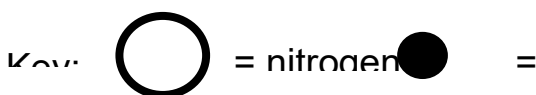
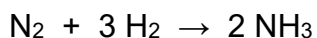


3. If you've ever seen old statues like [this one](#), where the statue has been eroded away, it's likely due to the effects of acid rain on limestone (CaCO_3). The reaction that's occurring is shown below.



If you placed a 9.00 kg (about 20 lb) statue in an excess of hydrochloric acid, how many liters of carbon dioxide would be produced? The lab's temperature is 23 °C (*convert to K!*) and the pressure of 1.0 atm when you do this.

4. Ammonia is synthesized from nitrogen and hydrogen by the reaction shown below. Draw the products and leftover reactants in the rigid container after the reaction proceeds to completion.



The limiting reactant is _____.

After the reaction is complete, there are _____(number) _____(reactant) molecules left over.