Day 10

Key C

Totally Epic AP Chem Review: Limiting and Excess!

Limiting reactant: will be completely used up during the chemical reaction → determines all other amounts

Excess reactant: will NOT be completely used up during the chemical reaction → has some left over at the end

Percent Yield: a method to calculate the effectiveness of a chemical reaction.

- **Actual yield**: what you produce from actually doing the reaction in a lab setting.
- **Theoretical yield:** what "should have been" produced from the chemical reaction. This is calculated with stoichiometry!

$$\text{Percent Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100$$

How do I know if a problem is a limiting reactant problem?

➔ Check if you are given a mass or mole value for **MORE THAN ONE reactant** AND the reaction goes to completion (very large K, acid/base neutralization, etc.). If so, this is a limiting problem.

How to Solve a Limiting Problem: Let's Count the Ways

1. Straight-up: Do math! Twice! Convert from given quantity of reactants to a chosen product: whichever product amount is SMALLER is the product amount actually produced.
2. Shortcuts:
   a. RICE table: use a mol RICE table (same process as a M or atm RICE table)
   b. Find your limiting: convert all givens to moles, then divide each by their stoichiometric coefficient from the balance equation. Whichever reactant gives you the SMALLER final number is your limiting!

Types of Limiting/ Excess Calculations: Be prepared to answer questions for each of the following types.

1. What is the limiting reactant?
2. What is the excess reactant, and how much is left over at the end of the reaction?
3. How much product is produced during this reaction?

Guided Practice

1. Silicon dioxide is usually quite unreactive but reacts readily with hydrogen fluoride according to the following balanced equation:

$$SiO_2(s) + 4\,HF(g) \rightarrow SiF_4(g) + 2\,H_2O(l)$$

If 6.0 mol of HF taking up a volume of 850. mL are exposed to 4.0 mol of SiO_2, how many grams of the excess reactant are left over once the reaction stops?

$SiO_2 + 4HF \rightarrow SiF_4 + 2H_2O$

4.0	6.0
-1.5	-6.0
2.5	∅

$2.5 \text{ mol } SiO_2 \times \frac{60.09 \text{ g}}{1 \text{ mol}} =$ **150 g SiO_2 left over**

10. mmol 7.5 mmol

2. 10.0 mL of 1.0 M KOH was used to neutralize 15.0 mL of 0.50 M HNO_3. What is the pH of the solution formed?

a. 0.60 b. 1.00 (c.) 13.00 d. 13.40

$KOH + HNO_3$

10. 7.5

-7.5 -7.5

2.5 ∅

$[OH^-] = \frac{2.5\ mmol}{25\ mL} = 0.10\ M$

$\Rightarrow pOH = 1$

4. A gaseous mixture at 25°C contained 3.0 mole of CH_4 and 2.0 moles of O_2 and the pressure was measured to be 2.0 atm. The gases then underwent the reaction shown below.

$$CH_4(g) + 2\ O_2(g) \rightarrow 2\ H_2O(l) + CO_2(g)$$

What was the pressure in the container after the reaction had gone to completion and the temperature was allowed to return to 25°C?

a. 0.40 atm (b.) 1.2 atm c. 2.0 atm d. 2.4 atm

$CH_{4(g)} + 2O_{2(g)} \rightarrow 2H_2O_{(\ell)} + CO_{2(g)}$

3.0 2.0 ∅

-1.0 -2.0 +1.0

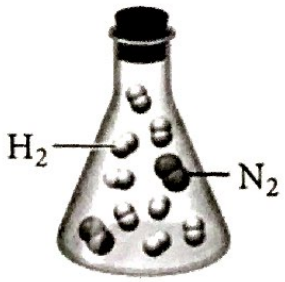
2.0 ∅ 1.0

$\frac{n_1}{P_1} = \frac{n_2}{P_2}$

$\frac{5}{2} = \frac{3}{x}$ $5x = 6$ $x = \frac{6}{5} = 1.2$

5. Nitrogen and hydrogen gas react to form ammonia according to the following reaction:

$$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$$



If a flask contains the mixture of reactants represented in the image to the left,

a. Which reactant is limiting? $N_{2(g)}$

b. Which reactant is in excess? $H_{2(g)}$

c. How much of the excess reactant will remain once the reaction stops? 2 molec. H_2

d. How much NH_3 was produced in this reaction? 4 molec. NH_3

$N_2 + 3H_2 \rightarrow 2NH_3$

2 8 ∅

-2 -6 +4

∅ 2 4

7. The reaction of silver metal and dilute nitric acid proceeds according to the equation below. If 0.10 mol of powdered silver is added to ~~0.060 moles of HNO_3 in a 425 mL solution~~, how many grams of the excess reactant remain?

100. mL of 0.40M HNO_3

$$3\ Ag(s) + 4\ HNO_3(aq) \rightarrow 4\ AgNO_3(aq) + NO(g) + 2\ H_2O(l)$$

b. 0.95 g b. 1.6 g (c.) ~~4.8 g~~ 7.6 g d. ~~5.9 g~~

$3Ag + 4HNO_3 \rightarrow$

0.10 0.04

−0.03 −0.04

0.07 ∅

$0.07\ mol\ Ag \times \frac{107.87\ g}{1\ mol} \approx 0.07 \times 100 = 7\ g$

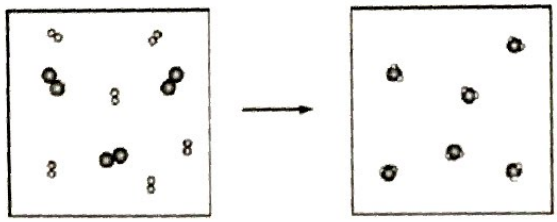
8. The percentage yield for the reaction $PCl_3 + Cl_2 \rightarrow PCl_5$ is 83.2%. What mass is PCl_5 is expected from the reaction of 73.7 g of PCl_3 with excess chlorine?

$$73.7\ g\ PCl_3 \times \frac{1\ mol\ PCl_3}{137.32\ g\ PCl_3} \times \frac{1\ mol\ PCl_5}{1\ mol\ PCl_3} \times \frac{208.22\ g\ PCl_5}{1\ mol\ PCl_5} = 112\ g\ PCl_5$$

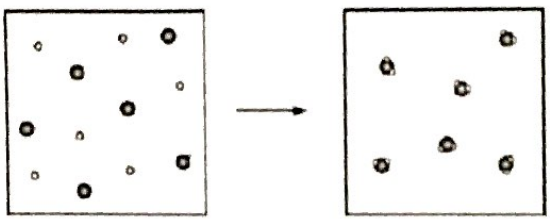
$$\text{actual yield} = 112\ g \times \frac{83.2}{100} = \boxed{93.0\ g\ PCl_5 \text{ expected}}$$

9. Which of the following particulate diagrams best shows the formation of water vapor from hydrogen gas and oxygen gas in a rigid container at 125°C?

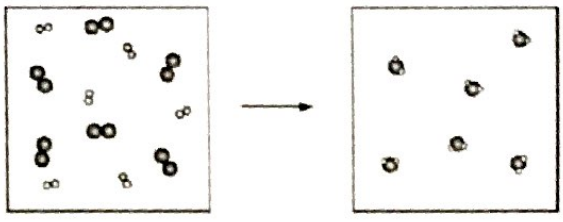
(A)



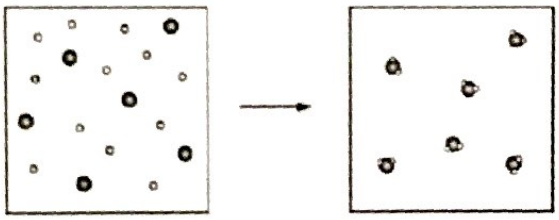
B



C



D



$2H_2 + 1O_2 \rightarrow 1H_2O$