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VCE Chemistry ½
Stoichiometry [2.3]
Homework Solutions

Admin Info & Homework Outline:



Student Name	
Questions You Need Help For	
Compulsory Questions	Pg 2 – Pg 13
Supplementary Questions	Pg 14 – Pg 27

Section A: Compulsory Questions (54 Marks)

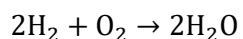
Sub-Section [2.3.1]: Write Balanced Chemical Equations, Including Combustion



Question 1 (1 mark)



Balance the equation where H_2 gas reacts with oxygen gas to form water.

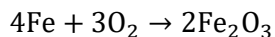


Question 2 (4 marks)



Balance the following equations:

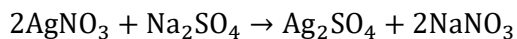
a. $\text{Fe} + \text{O}_2 \rightarrow \text{Fe}_2\text{O}_3$. (1 mark)



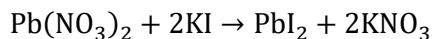
b. $\text{CaCO}_3 \rightarrow \text{CaO} + \text{O}_2$. (1 mark)

Balanced.

c. $\text{AgNO}_3 + \text{Na}_2\text{SO}_4 \rightarrow \text{Ag}_2\text{SO}_4 + \text{NaNO}_3$. (1 mark)



d. $\text{Pb}(\text{NO}_3)_2 + \text{KI} \rightarrow \text{PbI}_2 + \text{KNO}_3$. (1 mark)

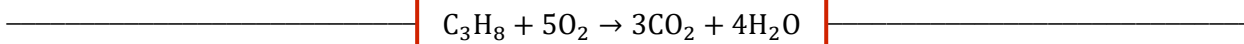


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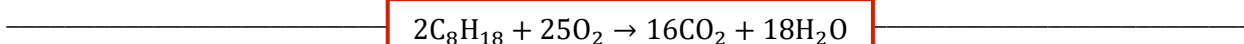

Question 3 (4 marks)

Balance the following combustion equations:

- a. Propane's complete combustion. (2 marks)



- b. Octane's complete combustion. (2 marks)



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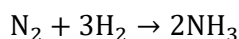


Sub-Section [2.3.2]: Apply Stoichiometry to Find the Amount of Another Substance Used/Produced

Question 4 (2 marks)



Given the equation:



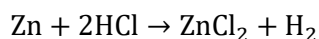
If 4.00 moles of hydrogen gas react, how many moles of ammonia would be produced?

$$4 \times \frac{2}{3} = 2.67 \text{ moles of ammonia}$$

Question 5 (4 marks)



Given the following equation:



- a. If 15.0 g of Zn reacts with excess hydrochloric acid, how many grams of hydrogen gas would be produced? (2 marks)

$$\frac{15}{65.4} = 0.2294 \text{ moles}$$

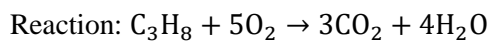
$$0.2294 \times 2 = 0.459 \text{ g}$$

- b. If 2.00 g of H₂ gas was produced, then how much zinc was reacted in the first place, in grams? (2 marks)

$$\frac{2}{2} = 1 \text{ mole}, 1 \times 1 \times 65.4 = 65.4 \text{ grams}$$


Question 6 (4 marks)

Given the combustion of 10.56 g of propane, C_3H_8 , calculate the total mass of gases released, assuming the reaction occurred at $120^\circ C$.



$$n(C_3H_8) = \frac{10.56}{36} = 0.2933 \text{ mol}$$

$$n(CO_2) = 3(0.2933) = 0.88 \text{ mol}$$

$$n(H_2O) = 4(0.2933) = 1.1733... \text{ mol}$$

(gas at $120^\circ C$)

$$m(CO_2) = (0.88)(12.0 + 16.0 \times 2)$$

$$= 38.72 \text{ g}$$

$$m(H_2O) = (1.1733...)(2.0 + 16.0)$$

$$= 21.12 \text{ g}$$

$$\Rightarrow m(\text{gas}) = 38.72 + 21.12$$

$$= 59.839$$

$$\approx 59.8 \text{ g} \quad (3 \text{ sig figs})$$

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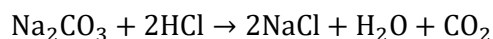


Sub-Section [2.3.3]: Identify the Limiting Reagent When Reactants' Amounts are Known

Question 7 (2 marks)



Consider the reaction:



There are 10.00 g of Na_2CO_3 and 6.00 g of HCl. Determine what the limiting and excess reagents are.

$$\frac{10}{106} + \frac{6}{36.5} = 0.0943 \text{ moles}$$

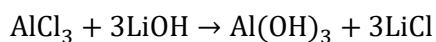
$$\frac{6.00}{36.5} = 0.164 \text{ moles} / 2 = 0.0822 \text{ moles}$$

Hence, HCl is the limiting reagent and Na_2CO_3 is the excess reagent.

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Question 8 (4 marks)

Consider the following reaction:



There are 2.50 *mol* of AlCl_3 , and 5.50 *mol* of LiOH .

- a. What are the limiting and excess reagents? (2 marks)

$$\begin{aligned}\text{AlCl}_3 &= 2.50 \text{ mol} \\ \text{LiOH} &= \frac{5.50}{3} = 1.83 \text{ mol} \\ \text{LiOH is the limiting reagent.}\end{aligned}$$

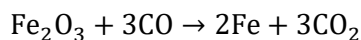
- b. Find the mass of LiCl and Al(OH)_3 formed. (2 marks)

$$\begin{aligned}1.83 \times 3 &= 5.49 \text{ moles} \\ 5.49 \times (7 + 35.5) &= 233.3 \text{ g of LiCl formed.} \\ 1.83 \times (27 + (17 \times 3)) &= 142.7 \text{ g of Al(OH)}_3 \text{ formed.}\end{aligned}$$

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Question 9 (6 marks)

Consider the following reaction:



There are 12.00 g of Fe_2O_3 and 6.00 g of CO.

- a. What are the limiting and excess reagents? (2 marks)

$$\begin{aligned} 12 / (55.8 + 55.8 + 48) &= 0.0752 \text{ moles of } \text{Fe}_2\text{O}_3 \\ \frac{6}{12} + 16 &= 0.214 \rightarrow 0.214 / 3 = 0.0714 \text{ moles of CO} \\ \text{CO is the limiting reagent.} \end{aligned}$$

- b. Find the mass of Fe and CO_2 formed. (2 marks)

$$\begin{aligned} 0.214 \times 2/3 &= 0.143 \text{ moles of Fe} \times 55.8 = 7.96 \text{ g} \\ 0.214 \times 3/3 &= 0.214 \text{ moles of } \text{CO}_2 \times 44 = 9.416 \text{ g} \\ \text{Total} &= 17.38 \text{ g total} \end{aligned}$$

- c. In another experiment, if 12.58 g of CO_2 was formed then how much Fe_2O_3 was reacted initially in grams? (2 marks)

$$\begin{aligned} 12.58 / 44 &= 0.286 \text{ moles of } \text{CO}_2 \text{ formed} \\ 0.286 \times 1/3 &= 0.095 \text{ moles} \times (55.8 \times 2 + 48) = 15.21 \text{ g of } \text{Fe}_2\text{O}_3 \end{aligned}$$

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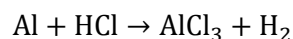


Sub-Section [2.3.4]: Apply Limiting Reagent to Calculate the Mass of Product(s) Formed, & the Amount of Excess Reagent Leftover

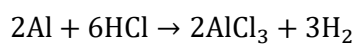
Question 10 (3 marks)



Given the following reaction:



- a. Balance the equation. (1 mark)



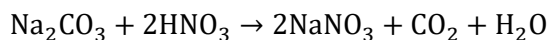
- b. A sample of 4.00 moles of Al and 10.00 moles of HCl reacts. What is the amount of HCl left? (2 marks)

$$\begin{aligned} 4 / 2 &= 2.00 \text{ moles} \\ 10 / 6 &= 1.67 \text{ moles} \\ \text{HCl is limiting, and so 0 will be leftover.} \end{aligned}$$

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Question 11 (4 marks)

Consider the reaction:



- a. Which is the excess and limiting reagent, given that there are 45 grams of Na_2CO_3 and 30 grams of HNO_3 ? (2 marks)

$45 / 106 = 0.4245$ moles of Na_2CO_3
 $30 / 63 = 0.4762$ moles of $\text{HNO}_3 / 2 = 0.2381$
 So therefore, HNO_3 is limiting.

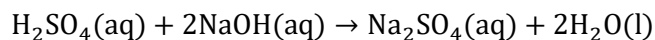
- b. What is the amount of excess reagent left over in grams? (2 marks)

$0.4762 / 2 = 0.2381$ moles of Na_2CO_3 reacts
 Leftover = $0.4245 - 0.2381 = 0.1864$ moles
 $0.1864 \times (23 \times 2) + 12 + 48 = 19.76 \text{ g}$

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Question 12 (6 marks)

Given the following reaction:



- a. If there are 3.20 g of sulphuric acid, H_2SO_4 , and 3.28 g of NaOH, find the limiting reagent. (3 marks)

$$\text{Moles of sulphuric acid} = \frac{3.2}{98.1} = 0.0326 \text{ moles}$$

$$\text{Moles of NaOH} = \frac{3.28}{40} = 0.082 \text{ moles}$$

NaOH = 0.041 moles and sulphuric acid 0.0326 moles
Sulphuric acid is the limiting reagent.

- b. What mass of the excess reagent will be left over? (2 marks)

$$\text{Amount of NaOH reacting} = 0.0326 \times 2 = 0.0652 \text{ moles}$$

$$\text{Leftover} = 0.082 - 0.0163 = 0.0168 \text{ moles}$$

$$0.0168 \times (23 + 17) = 0.672 \text{ g}$$

- c. What is the percentage of the excess reagent that was used in this reaction? (1 mark)

$$\frac{3.28\text{g} - 0.672\text{g}}{3.28\text{g}} \times 100 = 80\%$$

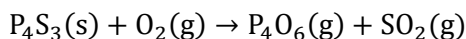
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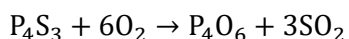
Sub-Section: The 'Final Boss'


Question 13 (10 marks)

Given the following reaction:



- a. Balance the above reaction. (1 mark)



- b. If 3.00 g of P_4S_3 is reacted, then how much SO_2 gas would be produced? (2 marks)

$$\begin{aligned} 3 / (31 \times 4 + 32.1 \times 3) &= 0.0136 \text{ moles} \\ 0.0136 \times 3 &= 0.0408 \text{ moles} \\ 0.0408 \times (32.1 + 32) &= 2.62 \text{ g} \end{aligned}$$

- c. If there is 10.37 g of P_4S_3 and 9.62 g of oxygen gas, which is the limiting and excess reagent? (3 marks)

$$\begin{aligned} &0.0471 \text{ moles of } \text{P}_4\text{S}_3 \\ &0.301 \text{ moles of } \text{O}_2 \\ &0.301/6 = 0.050 \text{ moles for } \text{O}_2 \text{ and } \text{P}_4\text{S}_3 \text{ stay same.} \\ &\text{P}_4\text{S}_3 \text{ is the limiting reagent.} \end{aligned}$$

- d. Find the mass of P_4O_6 produced. (2 marks)

$$0.0471 \times (31 \times 4 + (16 \times 6)) = 10.362 \text{ g of } \text{P}_4\text{O}_6$$

e. How much of the excess reagent, in *mol*, is left at the end of the reaction? (2 marks)

$$\begin{aligned}\text{Moles used up} &= 0.0471 \times 6 = 0.2826 \text{ moles} \\ \text{Leftover} &= 0.301 - 0.2826 = 0.0184 \text{ moles left over}\end{aligned}$$

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Section B: Supplementary Questions (81 Marks)

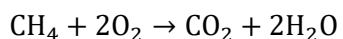
Sub-Section [2.3.1]: Write Balanced Chemical Equations, Including Combustion



Question 14 (1 mark)



Balance the equation where CH_4 reacts with oxygen gas to form carbon dioxide and water.

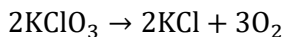


Question 15 (4 marks)

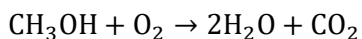


Balance the following equations:

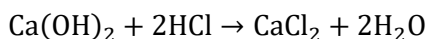
a. $\text{KClO}_3 \rightarrow \text{KCl} + \text{O}_2$. (1 mark)



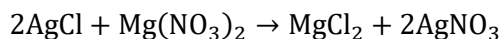
b. $\text{CH}_3\text{OH} + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{CO}_2$. (1 mark)



c. $\text{Ca}(\text{OH})_2 + \text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O}$. (1 mark)



d. $\text{AgCl} + \text{Mg}(\text{NO}_3)_2 \rightarrow \text{MgCl}_2 + \text{AgNO}_3$. (1 mark)

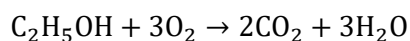


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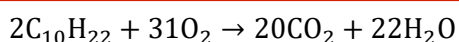
Question 16 (4 marks)


Balance the following combustion equations:

- a. Ethanol's complete combustion. (2 marks)

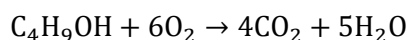


- b. Decane's complete combustion. (2 marks)

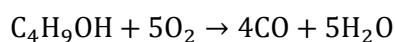

Question 17 (7 marks)


Consider the combustion equation of butanol.

- a. Write the balanced equation, assuming that CO_2 and H_2O is produced. (2 marks)



- b. Now, consider when CO and H_2O is produced. (1 mark)



- c. Why is it suggested that we balance carbon last in a chemical equation generally? (2 marks)

We balance carbon last because other elements can exist in isolation whereas carbon is more likely to exist with something else and so it is harder to balance since it affects multiple species, so we leave it until the end to make it easier.

- d. A student argues that we can have more matter at the end of a reaction as we are inputting energy into the reaction system as a combustion reaction usually results in our fuel disappearing over time. Evaluate this statement. (2 marks)

This is not true due to the law of conservation of mass stating that the matter that is at the start of the reaction should be present at the end of the reaction, and that matter cannot be created or destroyed, just transformed. In this case the fuel would have just transformed into energy and gas that is released into the environment and so that's why we see it as changing, but if we captured everything it would be the same amount of matter.

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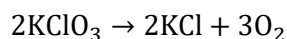


Sub-Section [2.3.2]: Apply Stoichiometry to Find the Amount of Another Substance Used/Produced

Question 18 (2 marks)



Given the equation:



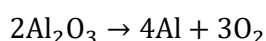
If 5.50 moles of KClO_3 reacts, then how much oxygen gas would be produced, in moles?

$$5.50 \times 3/2 = 8.25 \text{ moles of oxygen gas}$$

Question 19 (4 marks)



Given the following equation:



a. If 7.00 g of Al_2O_3 decomposes, how many grams of O_2 gas would be produced? (2 marks)

$$7 / (27 \times 2 + 16 \times 3) = 0.0686 \text{ moles}$$

$$0.0686 \times 3/2 = 0.1029 \text{ moles of oxygen gas} \times 32 = 3.29 \text{ g of O}_2 \text{ gas}$$

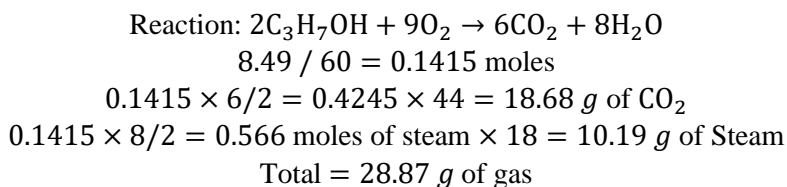
b. If 3.00 g of oxygen gas was produced, how much Al_2O_3 would've been needed, in grams? (2 marks)

$$3 / 32 = 0.09375 \times 2/3 = 0.0625 \text{ moles of Al}_2\text{O}_3$$

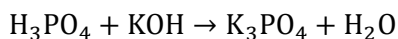
$$0.0625 \times (27 \times 2) + (16 \times 3) = 6.375 \text{ g}$$

Question 20 (4 marks)

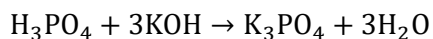

Given the combustion of 8.49 g of propanol, C_3H_7OH , calculate the total mass of gases released, assuming the reaction occurred at 120°C.


Question 21 (9 marks)

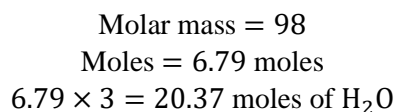

Consider the following chemical equation:



- a. Balance the above equation as it is currently unbalanced. (1 mark)



- b. If 665.42 g of phosphoric acid (H_3PO_4) reacted, how many moles of water were produced? (2 marks)



c. Consider if 8.15 *mol* of K_3PO_4 was produced.

i. How many moles of phosphoric acid were used up? (2 marks)

$$8.15 \times 1 = 8.15 \text{ moles}$$

ii. How much water was also produced? (2 marks)

$$8.15 \times 3 = 24.45 \text{ moles}$$

iii. What is the mass of KOH required to get this amount of K_3PO_4 ? (2 marks)

$$8.15 \times 3 = 24.45 \text{ moles of KOH, } 24.45 \times (39.1 + 17) = 1371.65 \text{ g}$$

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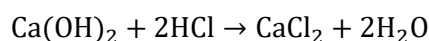


Sub-Section [2.3.3]: Identify the Limiting Reagent When Reactants' Amounts are Known

Question 22 (2 marks)



Consider the reaction:



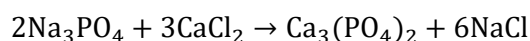
There are 13.00 g of Ca(OH)_2 and 5.00 g of HCl, determine what the limiting and excess reagents are.

0.175 moles of Ca(OH)_2
 0.137 moles of HCl / 2 = 0.0685 moles
 HCl is the limiting reagent.

Question 23 (4 marks)



9.55 g of Na_3PO_4 and 7.31 g of CaCl_2 are mixed and allowed to react according to this equation:



a. Which reactant is the limiting reagent? Which reactant is in excess? (2 marks)

Moles of $\text{Na}_3\text{PO}_4 = 9.55/164 = 0.0582$ moles
 Moles of $\text{CaCl}_2 = 7.31 / 111.1 = 0.0658$ moles
 $\text{Na}_3\text{PO}_4 = 0.0582 / 2 = 0.0291$ moles
 $\text{CaCl}_2 = 0.0658/3 = 0.0219$ moles
 CaCl_2 is the limiting reagent and Na_3PO_4 excess reagent.

b. What is the mass of $\text{Ca}_3(\text{PO}_4)_2$ that is formed? (2 marks)

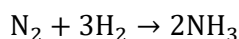
$$0.0658 \times 1/3 = 0.02193 \text{ moles}$$

$$0.02193 \times (40.1 \times 3) + (31 + 64) \times 2 = 6.90 \text{ g}$$

Question 24 (6 marks)



Consider the following reaction:



There are 14.00 g of N_2 and 4.00 g of H_2 .

a. What are the limiting and excess reagents? (2 marks)

$$14 / 28 = 0.500 \text{ moles of } \text{N}_2$$

$$4 / 2 = 2.00 \text{ moles of } \text{H}_2 \rightarrow 2/3 = 0.667 \text{ moles of } \text{H}_2 \text{ in } 1:1 \text{ ratio}$$

Therefore, N_2 is the limiting reagent.

b. Find the mass of NH_3 formed. (2 marks)

$$0.5 \times 2 = 1.00 \text{ mol } \text{NH}_3$$

$$1 \times 17 = 17 \text{ g of } \text{NH}_3$$

c. In another experiment, if 25.5 g of NH_3 was formed, how much H_2 was used initially in grams? (2 marks)

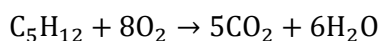
$$25.5 / 17 = 1.50 \text{ moles of } \text{NH}_3$$

$$1.50 \times 3/2 = 2.25 \text{ moles of } \text{H}_2 \times 2 = 4.50 \text{ g of } \text{H}_2$$


Question 25 (9 marks)

Consider the combustion reaction of pentane at 200°C.

- a. Write the fully balanced reaction. (1 mark)



- b. Consider in an experiment we had 44.00 g of pentane and 160.00 g of oxygen gas.

- i. What are the limiting and excess reagents? (2 marks)

$$\begin{aligned} 44 / 72 &= 0.61 \text{ moles} \\ 160 / 32 &= 5 \text{ moles} / 8 = 0.625 \text{ moles} \end{aligned}$$

Pentane is the limiting reagent and oxygen gas is the excess.

- ii. What is the mass of gases formed? (2 marks)

$$\begin{aligned} 0.61 \times 5 &= 3.05 \text{ moles of CO}_2 \times 44 = 134.2 \text{ g} \\ 0.61 \times 6 &= 3.66 \text{ moles of water vapour} \times 18 = 65.88 \text{ g} \\ \text{Total} &= 200.08 \text{ g of gas} \end{aligned}$$

- iii. Is this the same as the total mass of gases left over at the end of the reaction? (2 marks)

No, since there will be an amount of leftover gas at the end of the reaction from the excess reagents so it will be a bit more.

- c. In another experiment, if 88.00 g of CO₂ was formed, how much O₂ was used initially in grams? (2 marks)

$$88 / 44 = 2 \text{ moles}$$

$$2 \times 8/5 = 3.20 \text{ moles} \times 32 = 102.4 \text{ g of oxygen gas}$$

Space for Personal Notes

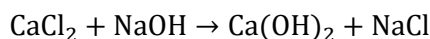


Sub-Section [2.3.4]: Apply Limiting Reagent to Calculate the Mass of Product(s) Formed, & the Amount of Excess Reagent Leftover

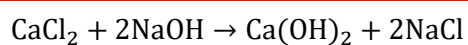
Question 26 (3 marks)



Given the following reaction:



- a. Balance the equation. (1 mark)



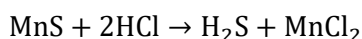
- b. A sample of 5.00 moles of CaCl_2 and 5.00 moles of NaOH reacts. What is the amount of CaCl_2 that would be left over? (2 marks)

$$5.00 - 2.50 = 2.50 \text{ moles left over.}$$

Question 27 (6 marks)



An experiment is conducted according to the following equation:



If a sample contained 50.00 g of MnS and 26.00 g of HCl , determine the excess and limiting reagent. (2 marks)

- a. Which is the excess and limiting reagent? (2 marks)

$$\begin{aligned} 50 / 87 &= 0.575 \\ 26 / 36.5 &= 0.712 / 2 = 0.356 \\ \text{HCl is limiting} \end{aligned}$$

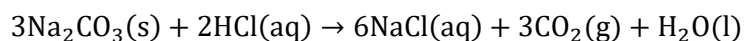
b. What is the amount left of the reactants? (2 marks)

$$\begin{aligned}\text{Amount of MnS that reacts} &= 0.712 \times \frac{1}{2} = 0.356 \\ 0.575 - 0.356 &= 0.219 \text{ moles of MnS left over}\end{aligned}$$

Question 28 (7 marks)



Given the following reaction:



a. Given that there was 9.40 g of sodium carbonate and 8.90 g of hydrogen chloride, find the limiting and excess reagents. (3 marks)

$$\begin{aligned}9.40 / 23 + 23 + 12 + 48 &= 0.0886 \\ 8.90 / 1 + 35.5 &= 0.243 \text{ moles of HCl} \\ 0.0886 / 3 &= 0.02867 \text{ moles} \\ 0.243 / 2 &= 0.122 \text{ moles}\end{aligned}$$

Therefore, the sodium carbonate is limiting, and hydrogen chloride is excess.

b. Find the mass of NaCl and CO₂ that will be produced. (2 marks)

$$\begin{aligned}0.0886 \times 2 &= 0.1732 \text{ moles of NaCl} \rightarrow 0.1732 \times (23 + 35.5) = 10.13 \text{ g} \\ 0.0886 \times 3/3 &= 0.0886 \text{ moles of carbon dioxide} \rightarrow 0.0886 \times (12 + 32) = 3.81 \text{ g of CO}_2\end{aligned}$$

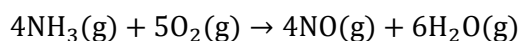
- c. What is the mass of the excess reagent left over? (2 marks)

Moles reacted = $0.0886 \times \frac{2}{3} = 0.05773$ moles reacted
 Left over = $0.243 - 0.05773 = 0.1853$ moles left
 $0.1853 \times 36.5 = 6.76 \text{ g}$ of HCl left over.

Question 29 (9 marks)



Given the following reaction:



- a. Given that there was 5.03 g of NH_3 and 3.45 g of O_2 , find the limiting and excess reagents. (2 marks)

$5.03 / 17 = 0.296$ moles of NH_3
 $3.45 / 32 = 0.107$ moles of O_2
 $0.296 / 4 = 0.074$ moles
 $0.107 / 5 = 0.0214$ moles
 So, oxygen is the limiting reagent.

- b. After the reaction is completed, some of the excess reagent remains.

- i. Find the amount of excess reagent that is left over. (2 marks)

Moles reacted = $0.107 \times \frac{4}{5} = 0.0856$ moles reacted
 Left over = $0.296 - 0.0856 = 0.210$ moles left

- ii. Find the mass of the excess reagent that is left over. (1 mark)

$0.210 \times 17 = 3.58 \text{ g}$ left over

iii. Find the mass of gases produced. (2 marks)

$$\begin{aligned}
 0.107 \times 4/5 &= 0.0856 \text{ moles} \\
 0.0856 \times 30 &= 2.568 \text{ g of NO} \\
 0.107 \times 6/5 &= 0.1284 \text{ moles} \times 18 = 2.311 \text{ g of H}_2\text{O} \\
 \text{Total} &= 4.879 \text{ g of gas}
 \end{aligned}$$

c. What is the amount, in grams, of the current limiting reagent we need to add to turn the reaction into one where the reactants fully react? (2 marks)

For full reaction: effective moles of NH₃ and O₂ need to be the same

$$\begin{aligned}
 \Delta \text{eff. moles} &= n_{\text{eff.}}(\text{NH}_3) - n_{\text{eff.}}(\text{O}_2) \\
 &= 0.074 - 0.0214 \\
 &= 0.0526 \\
 \therefore n_{\text{eff}}(\text{O}_2) &\text{ needs to be increased by } 0.0526 \\
 \therefore n(\text{O}_2 \text{ increase}) &= 0.0526 \times 5 \\
 &= 0.263 \text{ mol} \quad \begin{array}{l} \uparrow \\ \text{coeff. of} \\ \text{O}_2 \text{ in eq.} \end{array} \\
 m(\text{O}_2 \text{ needed}) &= 0.263 \times 32.0 \text{ g/mol} \\
 &= 8.42 \text{ g needs to be added}
 \end{aligned}$$

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