

SET 1 COUNTING MOLES
(limiting reagents)

Q1. Interpret the following equation in terms of interacting numbers of moles.



When 1.2 moles of NH_3 reacts with 3.5 moles of NO .

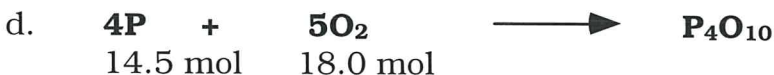
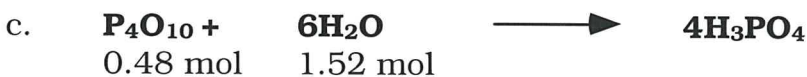
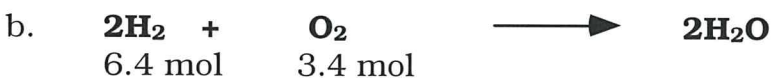
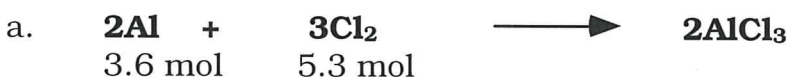
- A. Which reagent is the limiting reagent?
- B. Which reagent is in excess and by how many moles?
- C. How many moles of N_2 are formed?
- D. How many moles of H_2O are formed?

Q2. When 0.2 moles of K reacts with 2.35 moles of O_2 .



- A. Which reagent is the limiting reagent?
- B. Which reagent is in excess and by how many moles?
- C. How many moles of K_2O are formed?

Q3. For each of these balanced equations, identify the limiting reagent for the given combination of reactants.



Q4. For each of the four reactions in Q4, calculate the number of moles of product formed.

Q5. For each of the four reactions in Q4, calculate the number of moles of excess reagent remaining after the reaction has used up the limiting reagent.

Q6. What is the limiting reagent when 0.25 mol of P_4 and 0.25 mol of O_2 react



Q7. What is the limiting reagent when 0.25 mol of Cr and 0.50 mol of H_3PO_4 react according to the following reaction?



EXAMPLE 2

Sulfuric acid forms (H_2SO_4) forms in the chemical reaction



Suppose 6.24 mol SO_2 , 5.47 mol O_2 , and 6.94 mol H_2O are mixed together and the reaction proceeds until one of the reactants is used up.

- Which is the limiting reagent?
- What number of moles of H_2SO_4 is produced?
- What number of moles of the other reactants remain?

Solution

If all the SO_2 reacted, it would give

$$6.24 \text{ mol SO}_2 \times \frac{2 \text{ mol H}_2\text{SO}_4}{2 \text{ mol SO}_2} = 6.24 \text{ mol H}_2\text{SO}_4$$

If all the O_2 reacted, it would give

$$5.47 \text{ mol O}_2 \times \frac{2 \text{ mol H}_2\text{SO}_4}{1 \text{ mol O}_2} = 10.94 \text{ mol H}_2\text{SO}_4$$

If all the H_2O reacted, it would give

$$6.94 \text{ mol H}_2\text{O} \times \frac{2 \text{ mol H}_2\text{SO}_4}{2 \text{ mol H}_2\text{O}} = 6.94 \text{ mol H}_2\text{SO}_4$$

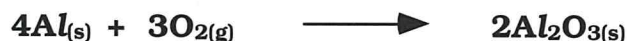
In this case the SO_2 is the limiting reagent, because the computation based on its amount gives the smallest amount of product (6.24 mol H_2SO_4). Oxygen and water are present in excess. After the reaction the amount of each that remains is the original amount minus the amount reacting:

$$\begin{aligned} \text{Moles O}_2 &= 5.47 \text{ mol O}_2 - \left(6.24 \text{ mol SO}_2 \times \frac{1 \text{ mol O}_2}{2 \text{ mol SO}_2} \right) \\ &= 5.47 - 3.12 \text{ mol O}_2 = 2.35 \text{ mol O}_2 \end{aligned}$$

$$\begin{aligned} \text{Moles H}_2\text{O} &= 6.94 \text{ mol H}_2\text{O} - \left(6.24 \text{ mol SO}_2 \times \frac{2 \text{ mol H}_2\text{O}}{2 \text{ mol SO}_2} \right) \\ &= 6.94 - 6.24 \text{ mol H}_2\text{O} = 0.7 \text{ mol H}_2\text{O} \end{aligned}$$

- Which is the limiting reagent? **Ans:** SO_2
- What number of moles of H_2SO_4 is produced? **Ans:** 6.24 mol H_2SO_4
- What number of moles of the other reactants remain? **Ans:** 2.35 mol O_2 & 0.7 mol H_2O

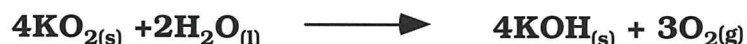
Q8. Consider the reaction



Identify the limiting reagent in each of the following reaction mixtures:

- 1.0 mol Al and 1.0 mol O₂
- 2.0 mol Al and 4.0 mol O₂
- 0.50 mol Al and 0.75 mol O₂

Q9. Potassium superoxide, KO₂, is used in rebreathing gas masks to generate oxygen.



If a reaction vessel contains 0.25 mol KO₂ and 0.15 mol H₂O, what is the limiting reagent (reactant)? How many moles of oxygen can be produced?

Q10. Large quantities of ammonia are burned in the presence of a platinum catalyst to give nitric oxide, as the first step in the preparation of nitric acid.



Suppose a vessel contains 0.120 mol NH₃ and 0.140 mol O₂. What is the limiting reagent (reactant)? How many moles of NO could be obtained?

Q11. Lead(II) nitrate and magnesium sulfate solutions react together to form a precipitate of lead(II) sulfate according to the equation:



Which reactant would be in excess, and by what amount (mol), if solutions containing the following quantities of lead(II) nitrate and magnesium sulfate were added to each other?

- 1.0 mol of lead(II) nitrate and 2.0 mol of magnesium sulfate
- 0.50 mol of lead(II) nitrate and 2.0 mol of magnesium sulfate
- 3.0 mol of lead(II) nitrate and 0.20 mol of magnesium sulfate

Q12. Zinc metal reacts with hydrochloric acid by the following reaction:



If 0.30 mol Zn is added to hydrochloric acid containing 0.52 mol HCl, how many moles of H₂ are produced?

Q13. Aluminium chloride, AlCl₃, is used as a catalyst in various industrial reactions. It is prepared from hydrogen chloride gas and aluminium metal shavings.



How many moles of AlCl₃ can be prepared from a mixture of 0.15 mol Al and 0.35 mol HCl?

Answers: SET 1 Counting Moles (limiting reagents)

1. A. Select one of the products e.g. N_2 . Take each reactant in turn and work out how much N_2 it would produce if it was fully consumed (all reacted).

$$n(N_2) = 5/4 \times n(NH_3) = 5/4 \times 1.2 = 1.5 \text{ moles of } N_2$$

$$n(N_2) = 5/6 \times n(NO) = 5/6 \times 3.5 = 2.92 \text{ moles of } N_2$$

Since NH_3 produces the least amount of N_2 ($1.5 < 2.92$), $\therefore NH_3$ is the limiting reagent. NH_3 as limiting reagent limits the amount of all products formed and the amount of the XS reactant that is consumed.

- B. $n(NO)$ reacting = $6/4 \times n(NH_3) = 6/4 \times 1.2 = 1.8$
 $n(NO)$ in XS = $n(NO)$ initially - $n(NO)$ reacting = $3.5 - 1.8 = 1.7$ moles.
- C. $n(N_2) = 5/4 \times n(NH_3) = 5/4 \times 1.2 = 1.5$ moles of N_2
- D. $n(H_2O) = 6/4 \times n(NH_3) = 6/4 \times 1.2 = 1.8$ moles of H_2O
2. A. Take each reactant in turn and work out how much K_2O it would produce if it was fully consumed (all reacted).

$$n(K_2O) = 2/4 \times n(K) = 2/4 \times 0.2 = 0.1 \text{ moles of } K_2O$$

$$n(K_2O) = 2 \times n(O_2) = 2 \times 2.35 = 4.7 \text{ moles of } K_2O$$

Since K produces the least amount of K_2O ($0.1 < 4.7$), $\therefore K$ is the limiting reagent. K as limiting reagent limits the amount of all products formed and the amount of the XS reactant that is consumed.

- B. $n(O_2)$ reacting = $1/4 \times n(K) = 1/4 \times 0.2 = 0.05$ moles O_2
 $n(O_2)$ in XS = $n(O_2)$ initially - $n(O_2)$ reacting = $2.35 - 0.05 = 2.3$ moles.
- C. $n(K_2O) = 2/4 \times n(K) = 2/4 \times 0.2 = 0.1$ moles of K_2O

3, 4 & 5.

	Limiting Reagent	Product	XS
a.	Cl_2	3.53	0.0667
b.	H_2	6.4	0.2
c.	H_2O	1.01	0.227
d.	O_2	3.6	0.1

6. O_2
7. Cr
8. a. Al b. Al c. Al
9. KO_2 is limiting; 0.19 moles of O_2
10. O_2 is limiting; 0.112 moles of NO
11. A. $MgSO_4$, 1.0 mol
 B. $MgSO_4$, 1.5 mol
 C. $Pb(NO_3)_2$, 2.8 mol
12. 0.26 mol.
13. HCl is limiting; 0.117 moles of $AlCl_3$

SET 2 COUNTING MOLES
(limiting reagents)

Q1. Acetylene, C₂H₂, will burn in the presence of oxygen.



How many grams of water can be produced by the reaction of 2.40 mol of C₂H₂ with 7.4 mol of O₂?

Q2. What is the limiting reagent when 1.00 g of Si and 1.00 g of N combine according to the following reaction?



Q3. What is the limiting reagent when 10.0 g of propane, C₃H₈, is burned with 25 g of oxygen?



Q4. What mass of H₂ is formed when 2.430 g of Mg reacts with a solution containing 9.125 g of HCl?



Q5. A. What mass of P₂I₄ is produced by reacting 2.00 g of P₄O₆ with 2.00 g of I₂ according to



B. Which reactant is in excess and by how many grams?

C. What mass of P₄O₁₀ forms?

Q6. When a mixture of silver metal and sulphur is heated, silver sulphide is formed:



A. What mass of Ag₂S is produced from a mixture of 2.0 g Ag and 2.0 g S₈?

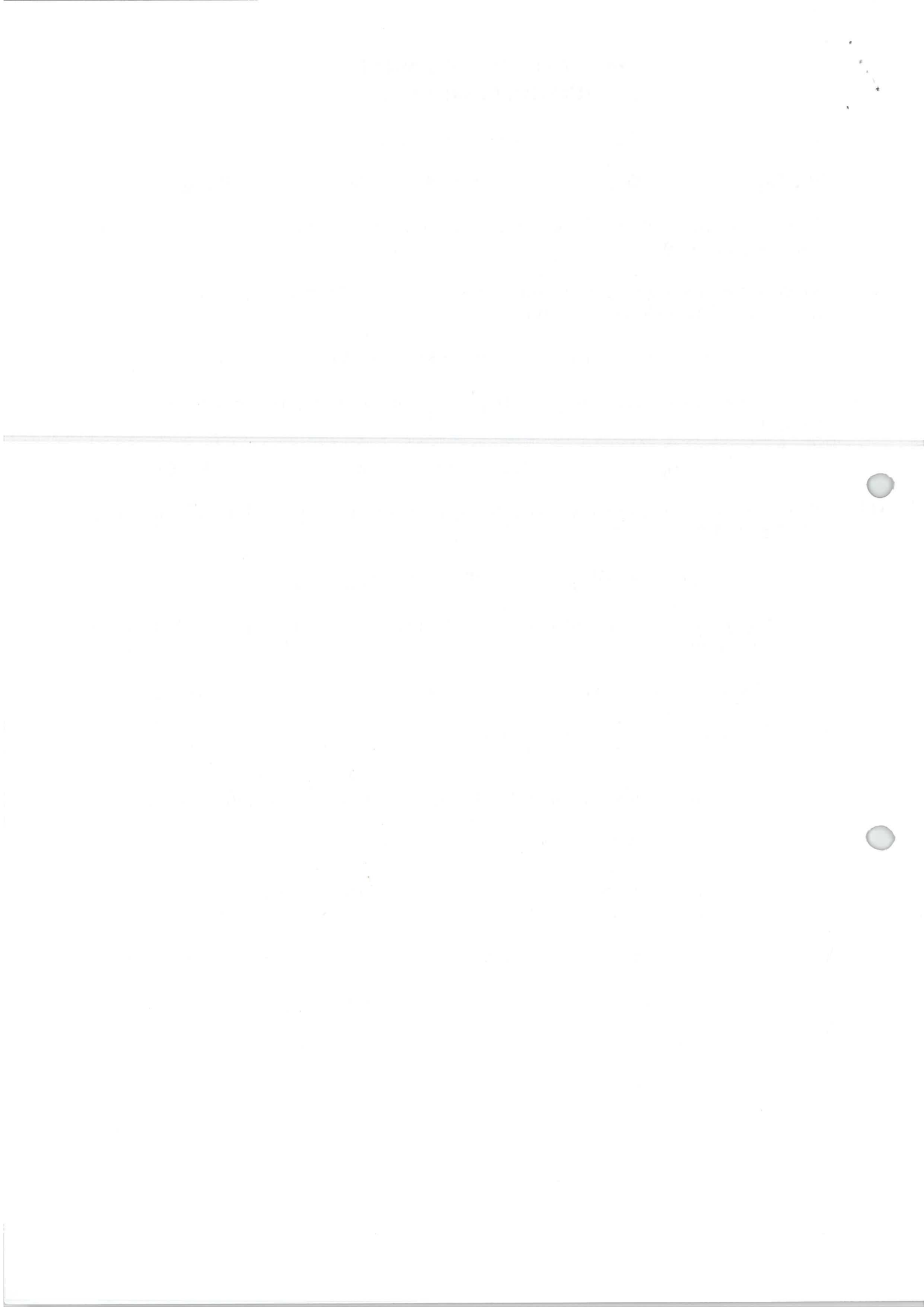
B. What mass of which reactant is left unreacted?

Q7. Mercury and bromine will react with each other to produce mercury(II) bromide:



A. What mass of HgBr₂ can be produced from the reaction of 10.0 g Hg and 9.00 g Br₂?

B. What mass of which reagent is left unreacted?



Answers: SET 2 Counting Moles (limiting reagents)

1. 43.2 g
2. Si
3. O₂
4. 0.200 g
5. A. 2.24 g
B. P₄O₆ by 0.917 g
C. 0.839 g
6. A. 2.4 g B. 1.7 g S₈ unreacted.
7. A.

$$n(\text{Hgl}) = \frac{10}{200.6} = 0.0498 \text{ mol}$$

$$n(\text{Br}_2) = \frac{9}{159.8} = 0.0563 \text{ mol}$$

limiting reagent Hg

$$n(\text{HgBr}_2) \quad 0.0498 = \frac{m}{360.4} \quad m = 17.9 \text{ g}$$

$$R_1 \quad \text{Br}_2 \quad 0.0563 - 0.0498 = 0.0065 \text{ mol}$$

$$n(\text{Br}_2)_{\text{unreacted}} = 0.0065 = \frac{m}{159.8}$$

$$m = 1.04 \text{ g}$$

6) Ag

$$\frac{2}{107.9} = 0.0185 \text{ mol}$$

$$\frac{2}{256} = 0.00781 \text{ mol}$$

$$n(\text{Ag}) \frac{1}{16} = n(\text{S}) = 0.001156 \text{ mol}$$

∴ Ag limiting reagent

a) $n(\text{Ag}) \times \frac{8}{16} = n(\text{Ag}_2\text{S})$

$$0.0185 \times \frac{1}{2} = n(\text{Ag}_2\text{S}) = 0.00925 \text{ mol}$$

$$\frac{2.3 \text{ g}}{246} = \frac{m}{246}$$

$$b) \text{ Excess } n(s) - n(s)_{\text{used}}$$

$$0.00781 - 0.001156$$

$$n(s)_{\text{excess}} = 0.006654 \text{ mol}$$

$$= \frac{m}{256} = 1.70 \text{ g}$$

5) a)

P_{406}

I_2

$\frac{2}{219.88}$

$$= 0.00909 \text{ mol}$$

$\frac{2}{253.8}$

$$= 0.00788 \text{ mol}$$

219.88

253.8

$$n(P_{406}) \cdot \frac{8}{5} = n(I_2) = 0.014544$$

$\therefore I_2$ limiting reagent

b)

$$\text{So } n(I_2) = 0.00788 \times \frac{5}{8} = 0.004925 \text{ mol}$$

$$\text{Excess } (P_{406}) - n(I_2)_{\text{used}}$$

$$0.00909 - 0.004925$$

$$= 0.004165 \text{ mol}$$

$\frac{m}{M_r}$

$\frac{m}{219.88}$

$$= 0.916 \text{ g}$$