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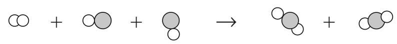
Section 12.3 Limiting Reactants

In your textbook, read about why reactions stop and how to determine the limiting reactant.

Study the diagram showing a chemical reaction and the chemical equation that represents the reaction. Then complete the table. Show your calculations for questions 25–27 in the space below the table.



$$O_2 + 2NO \rightarrow 2NO_2$$

The molar masses of O_2, NO, and NO_2 are 32.00 g/mol, 30.01 g/mol, and 46.01 g/mol, respectively.

Amount of O_2	Amount of NO	Amount of NO_2	Limiting Reactant	Amount and Name of Excess Reactant
1 molecule	2 molecules	2 molecules	none	none
4 molecules	4 molecules	4 molecules	NO	2 molecules O_2
2 molecules	8 molecules	**1. 4 molecules**	**2. O_2**	**3. 4 molecules NO**
1.00 mol	2.00 mol	**4. 2.00 mol**	**5. none**	**6. none**
4.00 mol	4.00 mol	**7. 4.00 mol**	**8. NO**	**9. 2.00 mol O_2**
5.00 mol	7.00 mol	**10. 7.00 mol**	**11. NO**	**12. 1.50 mol O_2**
1.00 mol	4.00 mol	**13. 2.00 mol**	**14. O_2**	**15. 2.00 mol NO**
0.500 mol	0.200 mol	**16. 0.200 mol**	**17. NO**	**18. 0.400 mol O_2**
32.00 g	60.02 g	**19. 92.02 g**	**20. none**	**21. none**
16.00 g	80.00 g	**22. 46.01 g**	**23. O_2**	**24. 50.12 g NO**
10.00 g	20.00 g	**25. 28.76 g**	**26. O_2**	**27. 1.24 g NO**

balanced equation mole ratio = 2 mol NO/1 mol O_2
10.00 ~~g O_2~~ × 1 mol O_2/32.00 ~~g O_2~~ = 0.3125 mol O_2
20.00 ~~g NO~~ × 1 mol NO/30.01 ~~g NO~~ = 0.6664 mol NO
actual mole ratio = 0.6664 mol NO/0.3125 mol O_2 = 2.132 mol NO/1.000 mol O_2
Because the actual mole ratio of NO:O_2 is larger than the balanced equation mole ratio of NO:O_2, there is an excess of NO; O_2 is the limiting reactant.
Mass of NO used = 0.3125 ~~mol O_2~~ × 2 mol NO/1 ~~mol O_2~~ = 0.6250 mol NO
0.6250 ~~mol NO~~ × 30.01 g NO/1 ~~mol NO~~ = 18.76 g NO
Mass of NO_2 produced = 0.6250 ~~mol NO_2~~ × 46.01 g NO_2/1 ~~mol NO_2~~ = 28.76 g NO_2
Excess NO = 20.00 g NO − 18.76 g NO = 1.24 g NO

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Section 12.4 Percent Yield

In your textbook, read about the yields of products.

Study the diagram and the example problem.

$$\textit{percent yield} = \frac{\textit{actual yield}}{\textit{theoretical yield}} \times 100\%$$

actual yield: mass of product from experimental measurement

theoretical yield: mass of product predicted from stoichiometric calculation using
- a. mass of reactant
- b. 4-step mass-to-mass conversion
  1. Write the balanced chemical equation.
  2. Calculate the number of moles of reactant, using molar mass.
  3. Calculate the number of moles of product, using the appropriate mole ratio.
  4. Calculate the mass of product, using the reciprocal of molar mass.

Example Problem: The following chemical equation represents the production of gallium oxide, a substance used in the manufacturing of some semiconductor devices.

$$4Ga(s) + 3O_2(g) \rightarrow 2Ga_2O_3(s)$$

In one experiment, the reaction yielded 7.42 g of the oxide from a 7.00-g sample of gallium. Determine the percent yield of this reaction. The molar masses of Ga and Ga_2O_3 are 69.72 g/mol and 187.44 g/mol, respectively.

Use the information in the diagram and example problem to evaluate each value or expression below. If the value or expression is correct, write *correct*. If it is incorrect, write the correct value or expression.

1. actual yield: unknown **7.42 g Ga_2O_3**
2. mass of reactant: 7.00 g Ga **correct**
3. number of moles of reactant: 7.00 g Ga × $\frac{69.72\text{ g Ga}}{1\text{ mol Ga}}$ **7.00 g Ga × 1 mol Ga/69.72 g Ga**
4. number of moles of product: 0.100 mol Ga × $\frac{2\text{ mol }Ga_2O_3}{1\text{ mol Ga}}$ **0.100 mol Ga × 2 mol Ga_2O_3/4 mol Ga**
5. theoretical yield: 0.0500 mol Ga_2O_3 × $\frac{187.44\text{ g }Ga_2O_3}{1\text{ mol }Ga_2O_3}$ **correct**
6. percent yield: $\frac{9.37\text{ g }Ga_2O_3}{7.42\text{ g }Ga_2O_3}$ × 100 **7.42 g Ga_2O_3/9.37 g Ga_2O_3 × 100**