LESSON MAKER PRO

Which Runs Out?

Use masses and mole ratios to find the limiting reactant.

HIGH SCHOOL · CHE.4.d

CHE.4.d "Qualitatively and quantitatively determine the limiting reactant when given the masses of all reactants."

NAME _____ DATE _____

THE LIMITING REACTANT

Convert each reactant's mass to moles by dividing by its molar mass. Then use the balanced equation to compare how much of each reactant the reaction needs. The limiting reactant runs out first.

WORKED EXAMPLE

For 2 K + I_2 → 2 KI, you have 117 g K and 254 g I_2. Which reactant is limiting? Molar masses: K = 39 g/mol; I_2 = 254 g/mol.

1. K: 117 g / 39 g/mol = 3 mol.
2. I_2: 254 g / 254 g/mol = 1 mol.
3. The equation needs 2 mol K for every 1 mol I_2. There is enough K to use all the I_2.

Answer: I_2 is the limiting reactant.

PRACTICE 6 problems

1 For 2 H_2 + O_2 → 2 H_2O, you have 10 g H_2 and 64 g O_2. Find the limiting reactant. Show a mole comparison. Molar masses: H_2 = 2 g/mol; O_2 = 32 g/mol.

ANSWER _____

2 For N_2 + 3 H_2 → 2 NH_3, you have 28 g N_2 and 8 g H_2. Find the limiting reactant. Show a mole comparison. Molar masses: N_2 = 28 g/mol; H_2 = 2 g/mol.

ANSWER _____

3 For 2 Al + 3 S → Al_2S_3, you have 108 g Al and 96 g S. Find the limiting reactant. Show a mole comparison. Molar masses: Al = 27 g/mol; S = 32 g/mol.

ANSWER _____

4 For Fe + S → FeS, you have 112 g Fe and 128 g S. Find the limiting reactant. Show a mole comparison. Molar masses: Fe = 56 g/mol; S = 32 g/mol.

ANSWER _____

5 For C + O_2 → CO_2, you have 36 g C and 16 g O_2. Find the limiting reactant. Show a mole comparison. Molar masses: C = 12 g/mol; O_2 = 32 g/mol.

ANSWER _____

6 For 2 Na + Br_2 → 2 NaBr, you have 23 g Na and 160 g Br_2. Find the limiting reactant. Show a mole comparison. Molar masses: Na = 23 g/mol; Br_2 = 160 g/mol.

ANSWER _____

APPLY IT Show your work

1 A team tests a hydrogen fuel cell for an e-bike. The overall reaction is $2\ H_2 + O_2 \rightarrow 2\ H_2O$. If it uses 10 g H_2 and 96 g O_2, which reactant is limiting, and what mass of water can form? Molar masses: H_2 = 2 g/mol; O_2 = 32 g/mol; H_2O = 18 g/mol.

WORK SPACE

ANSWER _____

2 A rail crew uses a thermite reaction to weld a track: $2\ Al + Fe_2O_3 \rightarrow Al_2O_3 + 2\ Fe$. If a batch starts with 81 g Al and 160 g Fe_2O_3, which reactant is limiting, and what mass of iron can form? Molar masses: Al = 27 g/mol; Fe_2O_3 = 160 g/mol; Fe = 56 g/mol.

WORK SPACE

ANSWER _____

CHALLENGE One step up

For $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$, you have 168 g Fe and 320 g $CuSO_4$. A student says Fe must be limiting because 168 g is less than 320 g. Explain why that claim is wrong. Identify the limiting reactant, the mass of Fe left over, and the mass of Cu formed. Molar masses: Fe = 56 g/mol; $CuSO_4$ = 160 g/mol; Cu = 64 g/mol.

WORK SPACE AND ANSWER

Which Runs Out?

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	For $2\ H_2 + O_2 \rightarrow 2\ H_2O$, you have 10 g H_2 and 64 g O_2. Find the limiting reactant. Show a mole comparison. Molar masses: H_2 = 2 g/mol; O_2 = 32 g/mol.	**O_2; 5 mol H_2 is available, but 2 mol O_2 needs only 4 mol H_2.**
2	For $N_2 + 3\ H_2 \rightarrow 2\ NH_3$, you have 28 g N_2 and 8 g H_2. Find the limiting reactant. Show a mole comparison. Molar masses: N_2 = 28 g/mol; H_2 = 2 g/mol.	**N_2; 1 mol N_2 needs 3 mol H_2, and 4 mol H_2 is available.**
3	For $2\ Al + 3\ S \rightarrow Al_2S_3$, you have 108 g Al and 96 g S. Find the limiting reactant. Show a mole comparison. Molar masses: Al = 27 g/mol; S = 32 g/mol.	**S; 4 mol Al is available, but 3 mol S needs only 2 mol Al.**
4	For $Fe + S \rightarrow FeS$, you have 112 g Fe and 128 g S. Find the limiting reactant. Show a mole comparison. Molar masses: Fe = 56 g/mol; S = 32 g/mol.	**Fe; 2 mol Fe and 4 mol S are available, and the reaction needs them in a 1:1 ratio.**
5	For $C + O_2 \rightarrow CO_2$, you have 36 g C and 16 g O_2. Find the limiting reactant. Show a mole comparison. Molar masses: C = 12 g/mol; O_2 = 32 g/mol.	**O_2; 3 mol C and 1/2 mol O_2 are available, and the reaction needs them in a 1:1 ratio.**
6	For $2\ Na + Br_2 \rightarrow 2\ NaBr$, you have 23 g Na and 160 g Br_2. Find the limiting reactant. Show a mole comparison. Molar masses: Na = 23 g/mol; Br_2 = 160 g/mol.	**Na; 1 mol Na and 1 mol Br_2 are available, but 1 mol Br_2 needs 2 mol Na.**

PART 2 · APPLY IT

1. **H_2 is limiting; 90 g H_2O can form.** There are 5 mol H_2 and 3 mol O_2. The 5 mol H_2 makes 5 mol H_2O, or 90 g.
2. **Fe_2O_3 is limiting; 112 g Fe can form.** There are 3 mol Al and 1 mol Fe_2O_3. The 1 mol Fe_2O_3 uses 2 mol Al and makes 2 mol Fe, or 112 g.

CHALLENGE

Masses alone cannot show which reactant runs out. There are 3 mol Fe and 2 mol $CuSO_4$, which react in a 1:1 ratio, so $CuSO_4$ is limiting. One mole of Fe, or 56 g, remains; 2 mol Cu, or 128 g, forms.

Accept any correct mole-ratio comparison that identifies the limiting reactant. Product masses assume the reaction goes to completion.