ANSWER KEY.

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4.5 Stoichiometry

AP Chemistry | ANSWER KEY

Use a periodic table. $R = 0.08206$ L·atm/(mol·K). Show all work with units and correct significant figures.

1. Butane burns according to $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$.

(a) How many moles of O_2 are needed to burn 3.00 mol of C_4H_{10}?

(b) How many moles of H_2O form when 6.50 mol of O_2 reacts?

(a) 3.00 mol C_4H_{10} × (13 mol O_2 / 2 mol C_4H_{10}) = 19.5 mol O_2

(b) 6.50 mol O_2 × (10 mol H_2O / 13 mol O_2) = 5.00 mol H_2O

2. Aluminum reacts with excess oxygen: $4Al + 3O_2 \rightarrow 2Al_2O_3$. What mass of aluminum oxide forms from 5.40 g of aluminum?

5.40 g Al × (1 mol Al / 26.98 g Al) = 0.2001 mol Al
0.2001 mol Al × (2 mol Al_2O_3 / 4 mol Al) = 0.1001 mol Al_2O_3
Al_2O_3 = 2(26.98) + 3(16.00) = 101.96 g/mol
0.1001 mol × 101.96 g/mol = 10.2 g Al_2O_3

3. In a blast furnace, iron is made by the reaction $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$. What mass of carbon monoxide is needed to make 50.0 g of iron?

50.0 g Fe × (1 mol Fe / 55.85 g Fe) = 0.8953 mol Fe
0.8953 mol Fe × (3 mol CO / 2 mol Fe) = 1.343 mol CO
CO = 12.01 + 16.00 = 28.01 g/mol; 1.343 mol × 28.01 g/mol = 37.6 g CO

4. 10.0 g of aluminum reacts with 25.0 g of chlorine gas: $2Al + 3Cl_2 \rightarrow 2AlCl_3$.

(a) Which reactant is limiting? Show how you know.

(b) What mass of $AlCl_3$ forms?

(a) Al: 10.0 g ÷ 26.98 g/mol = 0.3706 mol; ÷ 2 = 0.1853
Cl_2: 25.0 g ÷ 70.90 g/mol = 0.3526 mol; ÷ 3 = 0.1175
The smaller result belongs to Cl_2, so Cl_2 is limiting (even though there are more grams of it).
(b) 0.3526 mol Cl_2 × (2 mol $AlCl_3$ / 3 mol Cl_2) = 0.2351 mol $AlCl_3$
$AlCl_3$ = 26.98 + 3(35.45) = 133.33 g/mol; 0.2351 mol × 133.33 g/mol = 31.3 g $AlCl_3$

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5. What volume, in mL, of 0.150 M NaOH is needed to react completely with 25.0 mL of 0.200 M H_2SO_4?

$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

n H_2SO_4 = M × V = (0.200 mol/L)(0.0250 L) = 0.00500 mol

0.00500 mol H_2SO_4 × (2 mol NaOH / 1 mol H_2SO_4) = 0.0100 mol NaOH

V = n ÷ M = 0.0100 mol ÷ 0.150 mol/L = 0.0667 L = 66.7 mL NaOH

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6. A car air bag inflates when sodium azide decomposes: $2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$. What mass of NaN_3 is needed to fill a 65.0 L air bag with N_2 at 1.00 atm and 298 K?

n N_2 = PV ÷ RT = (1.00 atm)(65.0 L) ÷ [(0.08206 L·atm/(mol·K))(298 K)] = 2.658 mol N_2

2.658 mol N_2 × (2 mol NaN_3 / 3 mol N_2) = 1.772 mol NaN_3

NaN_3 = 22.99 + 3(14.01) = 65.02 g/mol; 1.772 mol × 65.02 g/mol = 115 g NaN_3

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7. A student mixes 1.00 g of H_2 with 1.00 g of O_2 for the reaction $2H_2 + O_2 \rightarrow 2H_2O$. She says, "The masses are equal, so neither reactant is limiting."

(a) Explain the error in her reasoning.

(b) Identify the limiting reactant and show your work.

(a) Coefficients are mole ratios, not gram ratios. Equal masses of substances with different molar masses are different numbers of moles, so compare moles adjusted for the coefficients.

(b) H_2: 1.00 g ÷ 2.016 g/mol = 0.496 mol; ÷ 2 = 0.248. O_2: 1.00 g ÷ 32.00 g/mol = 0.03125 mol; ÷ 1 = 0.0313. O_2 is limiting.

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