Stoichiometry of Gases Practice Problems:

name: SOLUTIONS

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1) Assume that 8.5 L of iodine gas (I_2) are produced at STP according to the following balanced equation:

$$2KI_{(aq)} + Cl_{2\,(g)} \rightarrow 2KCl_{(aq)} + I_{2\,(g)}$$

a. How many moles of I_2 are produced?
b. How many moles of KI were used?
c. How many grams of KI were used?

a) at STP

1 mole = 22.4 L

x = 8.5 L

x = 0.38 moles I_2

or

$PV = nRT$

$n = \frac{PV}{RT}$

$n = \frac{(101.3)(8.5)}{8.31\,(273)}$

n = 0.38 moles I_2

b) 2 moles — 1 mole

x — 0.38 moles

x = 0.76 moles KI

c) $n = \frac{m}{M}$

$0.76 = \frac{m}{166\ g/mol}$

m = 126.2 g

2) Jacques Charles used a balloon containing approximately 31,150 L of H_2 for his initial hot air balloon flight in 1783. The hydrogen gas was produced by the reaction of metallic iron with dilute hydrochloric acid according to the following balanced chemical equation:

$$Fe_{(s)} + 2HCl_{(aq)} \rightarrow H_{2\,(g)} + FeCl_{2\,(aq)}$$

How much iron (in kilograms) was needed to produce this volume of H_2 if the temperature was 30°C and the atmospheric pressure was 745 mmHg?

① $PV = nRT$

$n = \frac{PV}{RT}$

$n = \frac{99.3\,(31150)}{(8.31)(303)}$

n = 1228.46 moles

② 1 mole — 1 mole

x — 1228.46 moles

x = 1228.46 moles Fe

③ $n = \frac{m}{M}$ $\quad 1228.46 = \frac{m}{55.8}$

m = 68.6 kg

3) Sodium azide (NaN_3) decomposes to form sodium metal and nitrogen gas according to the following balanced chemical equation:

$$2NaN_{3\,(s)} \rightarrow 2Na_{(s)} + 3N_{2\,(g)}$$

This reaction is used to inflate the air bags that cushion passengers during automobile collisions. The reaction is initiated in air bags by an electrical impulse and results in the rapid escape of gas. If 5.0 g sample of NaN_3 decomposes, what volume of gas would be produced at 22°C and 762 mmHg?

① 2 mole: $m = n \cdot M$, $m = 2(65)$, $m = 130\,g$ — 3 mole: $m = n \cdot M$, $m = 3(28)$, $m = 84\,g$

$5\,g$ — x

$x = 3.23\,g$

② $PV = \frac{m}{M}RT$ $\quad V = \frac{(3.23)(8.31)(295)}{28\,(101.56)}$ $\quad \boxed{V = 2.78\,L}$

4) If 45.0 L of natural gas, which is essentially methane (CH_4), undergoes complete combustion at 730 mm of Hg and 20°C, how many grams of CO_2 is formed? 97.3 kPa

$$CH_{4\,(g)} + 2O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2H_2O_{(g)}$$

① $PV = \frac{mRT}{M}$

$\frac{PVM}{RT} = m$

$\frac{97.3(45)(16)}{8.31\,(293)} = m$

$m = 28.8\,g$

② 1 mole: $m = n \cdot M$, $m = 1(16)$, $m = 16\,g$ — 1 mole: $m = nM$, $m = 1(44)$, $m = 44\,g$

$28.8\,g$ — m

$\boxed{m = 79.2\,g\ CO_2}$

5) A 2.75 g sample of zinc metal is added to a solution of dilute hydrochloric acid. It dissolves to produce H_2 gas according to the equation:

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + ZnCl_{2(aq)}$$

The resulting H_2 gas is collected at 30°C and an atmospheric pressure of 760 mmHg. What volume does it occupy? 101.3 kPa

① 1 mole
$m = n \cdot M$
$m = 1(65.4)$
$m = 65.4g$

1 mole
$m = n \cdot M$
$m = 1(2)$
$m = 2g$

$2.75g$ — x

$x = 0.0841g$

② $PV = \frac{mRT}{M}$

$V = \frac{mRT}{MP}$

$V = \frac{(0.0841)(8.31)(303)}{2(101.3)}$

$V = 1.045\,L$

6) Hydrogen gas (and NaOH) is produced when sodium metal is added to water. What mass of Na is needed to produce 20.0 L of H_2 at STP?

$$2Na_{(s)} + 2H_2O_{(l)} \rightarrow H_{2(g)} + 2NaOH_{(aq)}$$

① $PV = \frac{mRT}{M}$

$\frac{PVM}{RT} = m$

$\frac{(101.3)(20)(2)}{8.31(273)} = m$

$m = 1.79g$

②

2 moles
$m = n \cdot M$
$m = 2(23)$
$m = 46g$

1 mole
$m = n \cdot M$
$m = 1(2)$
$m = 2g$

x — $1.78g$

$x = 41g$ of Na

7) Ammonium sulfate, an important fertilizer, can be prepared by the reaction of ammonia with sulfuric acid according to the following balanced equation:

$$2\ NH_{3\,(g)} + H_2SO_{4\,(aq)} \rightarrow (NH_4)_2SO_{4\,(aq)}$$

Calculate the volume of NH_3 (in liters) needed at 20°C and 25.0 atm to react with 150 kg of H_2SO_4.

150000g

① 2 moles NH_3 : 1 mole H_2SO_4

$m = n \cdot M$ | $m = n \cdot M$

$m = 2(17)$ | $m = 1(98)$

$m = 34g$ | $m = 98g$

x : 150000g

$x = 52040\ g$

② $PV = \frac{mRT}{M}$

$V = \frac{mRT}{MP}$

$V = \frac{52040(8.31)(293)}{(17)(2532.5)}$

$V = 2943\ L$

aqueous solid

8) Solid iron reacts with sulfuric acid (H_2SO_4) to produce iron (II) sulfate and hydrogen gas. If 650 mL of hydrogen gas are collected at STP, how many grams of iron (II) sulfate are also produced?

② $Fe_{(s)} + H_2SO_{4\,(aq)} \rightarrow FeSO_{4\,(s)} + H_{2\,(g)}$

1 mole | 1 mole

$m = n \cdot M$ | $m = n \cdot M$

$m = 1(151.8)$ | $m = 1(2)$

$m = 151.8g$ | $m = 2g$

x : 0.058g

$x = 4.4\ g$

① $PV = \frac{mRT}{M}$

$\frac{PVM}{RT} = m$

$\frac{(101.3)(0.650)(2)}{8.31(273)} = m$

$m = 0.058\ g$

Answer Key: *1) a. 0.38 mol I_2 b. 0.76 mol KI c. 126.2 g KI 2) 68.6 kg 3) 2.78 L 4) 1.8 mole 79.2g 5) 1.05 L 6) 41.1 g 7) 2945 L 8) 4.4 g*