EXERCISE 3.7

MODULE 3 TOPIC 4, p. 145
Gr 10 Physical Sciences 3-in-1

QUESTION 1

Determine the:

1.1 mass of 5 mol nitrogen gas

1.2 volume of 2,5 mol NH_3 at STP

1.3 mass of 112 cm^3 H_2S gas at STP

1.4 concentration of 3 mol of $NaC\ell$ dissolved in 250 cm^3 water

1.5 concentration of 500 g of $Fe_2(SO_4)_3$ dissolved in 2 dm^3 water

1.6 mass of calcium chloride dissolved in water to give a 100 $m\ell$ solution with a concentration of 0,2 $mol \cdot dm^{-3}$

QUESTION 2

During a reaction, 58,5 g potassium reacts with enough hydrochloric acid to form potassium chloride and hydrogen gas.

2.1 Write a balanced equation for the reaction.

2.2 Calculate the number of moles of potassium that has reacted.

2.3 Calculate the mass of the hydrogen gas produced.

2.4 Calculate the volume of hydrogen gas produced at STP.

QUESTION 3

3.1 Two gases, hydrogen (H_2) and nitrogen (N_2), react to form ammonia gas (NH_3).

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

3.1.1 How many moles of ammonia will be produced from 1 mole of hydrogen gas?

3.1.2 Initially 10 cm^3 nitrogen and 24 cm^3 hydrogen are mixed in a container. The temperature and pressure remain constant. Calculate the volume of gas that will remain in the container after the reaction is completed.

3.2 In another experiment, 80 g of hydrogen gas reacts with nitrogen gas to form ammonia. Calculate the:

3.2.1 number of moles of hydrogen gas that reacted

3.2.2 volume of the nitrogen gas used at STP

EXERCISE ANSWERS

QUESTION 1

1.1.1 $m = nM$
$= 5 \times 28$
$= 140\ g$

$M(N_2) = 2 \times 14 = 28\ g \cdot mol^{-1}$

1.1.2 $V = nV_m$
$= 2{,}5 \times 22{,}4$
$= 56\ dm^3$

$V_m = 22{,}4\ dm^3$ at STP

1.1.3 $n = \frac{V}{V_m}$
$= \frac{0{,}112}{22{,}4}$
$= 0{,}005$
$m = nM$
$= 0{,}005 \times 34$
$= 0{,}17\ g$

$V(H_2S) = 112\ cm^3 = 0{,}112\ dm^3$
$V_m = 22{,}4\ dm^3$ at STP
$M(H_2S) = (2 \times 1) + 32 = 34\ g \cdot mol^{-1}$

1.1.4 $c = \frac{n}{V}$
$= \frac{3}{0{,}25}$
$= 12\ mol \cdot dm^{-3}$

$n(NaC\ell) = 3$
$V = 250\ cm^3 = 0{,}25\ dm^3$

1.1.5 $n = \frac{m}{M}$
$= \frac{500}{400}$
$= 1{,}25\ mol$

$m(Fe_2(SO_4)_3) = 500\ g$
$M(Fe_2(SO_4)_3) = (2 \times 56) + 3[32 + (4 \times 16)]$
$= 400 g \cdot mol^{-1}$
$V = 2\ dm^3$

$c = \frac{n}{V}$
$= \frac{1{,}25}{2}$
$= 0{,}625\ mol \cdot dm^{-3}$

OR

$c = \frac{n}{V} = \frac{m}{MV}$
$= \frac{500}{400 \times 2}$
$= 0{,}625\ mol \cdot dm^{-3}$

1.1.6 $c = \frac{n}{V}$
$n = cV$
$= 0{,}2 \times 0{,}1$
$= 0{,}02\ mol$
$m = nM$
$= 0{,}02 \times 111$
$= 2{,}22\ g$ **OR**

$c = \frac{m}{MV}$
$m = cMV$
$= 0{,}2 \times 111 \times 0{,}1$
$= 2{,}22\ g$

$c(CaC\ell_2) = 0{,}2\ mol \cdot dm^{-3}$
$V = 100\ m\ell$
$= 100\ cm^3 = 0{,}1\ dm^3$
$M(CaC\ell_2) = 40 + (2 \times 35{,}5)$
$= 111\ g \cdot mol^{-1}$

QUESTION 2

2.1 $2K(s) + 2HC\ell(aq) \rightarrow 2KC\ell(aq) + H_2(g)$
58,5 g x

2.2 $n(K) = \frac{m}{M}$
$= \frac{58{,}5}{39}$
$= 1{,}5\ mol$

2.3 $n(K : H_2)$ **OR** 2 mol K forms 1 mol H_2

mole ratio from equation: 2 : 1 1,5 mol K forms 0,75 mol H_2

moles given/asked: 1,5 : x

solve for x: $\therefore \frac{1,5}{2} = \frac{x}{1}$

$x = 0,75$ mol

$m(H_2) = nM$

$= 0,75 \times 2$

$= 1,5$ g

$M(H_2) = 2\ g \cdot mol^{-1}$

2.4 $V(H_2) = nV_m$

$= 0,75 \times 22,4$

$= 16,8$ dm3

$V_m = 22,4\ dm^3$ at STP

QUESTION 3

3.1.1 $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

$n(H_2 : NH_3)$

mole ratio from equation: 3 : 2

moles given/asked: 1 : x

solve for x: $\therefore \frac{1}{3} = \frac{x}{2}$

$x = \frac{2}{3}$

$\therefore \frac{2}{3}$ mol NH_3 will be produced

3.1.2 $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

n ratio	1	3	2
V(initial)	10 cm^3	24 cm^3	
V(react)	–8 cm^3	–24 cm^3	+16 cm^3
V(final)	2 cm^3	0 cm^3	16 cm^3

Total volume = 18 cm^3

REMEMBER

At the same temperature and pressure, the molar ratio and volume ratio of a gas is the same.

3.2.1 $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

x 80 g

$n(H_2) = \frac{m}{M}$

$= \frac{80}{2}$

$= 40$ mol

$m(H_2) = 80$ g

3.2.2 $n(H_2 : N_2)$

mole ratio from equation: 3 : 1

moles given/asked: 40 : x

solve for x: $\therefore \frac{40}{3} = \frac{x}{1}$

$x = 13,33$ mol

$n(N_2) = \frac{V}{V_m}$

$\therefore 13,33 = \frac{V}{22,4}$

$\therefore V(N_2) = 13,33 \times 22,4$

$= 298,67\ dm^3\ N_2$

NOTE

Remember to always convert the given quantity of a specific substance to mol ❶ → then use the molar ratio between the substances to find the number of moles of the substance inquired about ❷ → then convert the number of moles to the specific quantity of this substance. ❸