Answer on Question #40495, Chemistry, Other

Task:

Cryolite, $Na_3AlF_6(s)$ an ore used in the production of aluminium, can be synthesided using aluminium oxide.

$Al_2O_3(s)+NaOH(l)+HF(g)=Na_3AlF_6+H_2O(g)$

1) Balance the equation
2) If 15.2 kilograms of $Al_2O_3(s)$, 57.4 kilograms of NaOH(l) and 57.4 kilograms of HF gas react completely, how many kilograms of criolite will be produced?
3) Which reactants will be in excess?
4) What is the total mass of the excess reactants left over after the reaction is complete?

Answer:

$Al_2O_3(s)+6NaOH(l)+12HF(g)=2Na_3AlF_6+9H_2O(g)$

$$v=\frac{m}{M}$$

where m-mass, grams;

M-molar mass, gram/mol.

$M(Al_2O_3)=101.96\,g/mol$ $M(NaOH)=39.996\,g/mol$ $M(HF)=20.007\,g/mol$

$M(Na_3AlF_6)=209.95\,g/mol$

$$v(Al_2O_3)=\frac{15200}{101.96}=149.08 \text{ moles}$$

$$v(NaOH)=\frac{57400}{39.996}=1435.1 \text{ moles}$$

$$v(HF)=\frac{57400}{20.007}=2869.0 \text{ moles}$$

Let's calculate the amount of Na_3AlF_6, that can be produced from the

indicated amount of each reactant:

$$v(Na_3AlF_6)=2\cdot v(Al_2O_3)=2\cdot 149.08=298.16 \text{ moles}$$

$$v(Na_3AlF_6)=\frac{v(NaOH)}{6}\cdot 2=\frac{1435.1}{6}\cdot 2=478.37 \text{ moles}$$

$$v(Na_3AlF_6)=\frac{v(HF)}{12}\cdot 2=\frac{2869.0}{12}\cdot 2=478.17 \text{ moles}$$

As we can see from the previous calculations, the amount of Al_2O_3 is the determining factor.

All other reactants (NaOH, HF) will be in excess.

That is why, the maximum mass of Na_3AlF_6 that can be produced is equal to:

$$m(Na_3AlF_6)=v(Na_3AlF_6)\cdot M(Na_3AlF_6)$$

$$m(Na_3AlF_6)=298.16\cdot 209.95=62599\,g=62.599\,kg$$

NaOH and HF will be in excess. Let's calculete this excess:

$$m(NaOH)_{ex} = \frac{478.37 - 298.16}{2} \cdot 6 \cdot 39.996 = 21623\,g = 21.623\,kg$$

$$m(HF)_{ex} = \frac{478.17 - 298.16}{2} \cdot 12 \cdot 20.007 = 21609\,g = 21.609\,kg$$

The total mass of the excess reactants leftover after the reaction is complete will be:

$$m(NaOH)_{ex} + m(HF)_{ex} = 21.623\,kg + 21.609\,kg = 43.232\ kg$$