(1.)

$$3\,NH_4NO_3 + Na_3PO_4 \rightarrow (NH_4)_3PO_4 + 3\,NaNO_3$$

30.0g	50.0g		
80.06g/mol	163.94g/mol	149.12g/mol	85.00 g/mol

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let NH_4NO_3 be limiting

$$m_{Na_3PO_4} \text{ req'd} = m_{NH_4NO_3} \times \frac{1}{M_{NH_4NO_3}} \times \text{mol ratio} \times M_{Na_3PO_4}$$

$$= 30.0g\ NH_4NO_3 \times \frac{1mol\ NH_4NO_3}{80.06g} \times \frac{1mol\ Na_3PO_4}{3mol\ NH_4NO_3} \times \frac{163.94g\ Na_3PO_4}{1\ mol\ Na_3PO_4}$$

$$= 20.48g\ Na_3PO_4$$

$m_{req'd} < m_{have}$. $\therefore$ NH_4NO_3 is limiting

20.48g 50.0g Na_3PO_4 is excess

$$m_{Na_3PO_4} \text{ remaining} = m_{have} - m_{req'd}$$
$$= 50.0g - 20.5g$$
$$= 29.5g$$

$$m_{(NH_4)_3PO_4} = m_{NH_4NO_3} \times \frac{1}{M_{NH_4NO_3}} \times \text{mol ratio} \times M_{(NH_4)_3PO_4}$$

$$= 30.0g \times \frac{1mol\ NH_4NO_3}{80.06g} \times \frac{1mol\ (NH_4)_3PO_4}{3mol\ NH_4NO_3} \times \frac{149.12\ g\ (NH_4)_3PO_4}{1mol\ (NH_4)_3PO_4}$$

$$= 18.6\ g\ (NH_4)_3PO_4$$

$$m_{NaNO_3} = m_{NH_4NO_3} \times \frac{1}{M_{NH_4NO_3}} \times \text{mol ratio} \times M_{NaNO_3}$$

$$= 30.0g \times \frac{1mol\ NH_4NO_3}{80.06g} \times \frac{3mol\ NaNO_3}{3mol\ NH_4NO_3} \times \frac{85.00g}{1mol\ NaNO_3}$$

$$= 31.9g\ NaNO_3$$

2. $3CaCO_3 + 2FePO_4 \rightarrow Ca_3(PO_4)_2 + Fe_2(CO_3)_3$

100 g	45.0 g	x	x
100.08 g/mol	150.82 g/mol	310.18 g/mol	291.73 g/mol

Let $CaCO_3$ be limiting

$$m_{FePO_4} \text{ req'd} = m_{CaCO_3} \times \frac{1}{M_{CaCO_3}} \times \text{mol ratio} \times M_{CaCO_3}$$

$$= 100g \times \frac{1 \text{ mol } CaCO_3}{100.08g} \times \frac{2 \text{ mol } FePO_4}{3 \text{ mol } CaCO_3} \times \frac{150.82g}{1 \text{ mol } FePO_4}$$

$$= 100.5g$$

$\therefore$ $m_{req'd} > m_{have}$ $\therefore$ $FePO_4$ limiting

$$m_{Ca_3(PO_4)_2} = m_{FePO_4} \times \frac{1}{M_{FePO_4}} \times \text{mol ratio} \times M_{Ca_3(PO_4)_2}$$

$$= 45.0g \times \frac{1 \text{ mol } FePO_4}{150.82g\ FePO_4} \times \frac{1 \text{ mol } Ca_3PO_4}{2 \text{ mol } FePO_4} \times \frac{310.18g\ Ca_3(PO_4)_2}{1 \text{ mol } Ca_3(PO_4)_2}$$

$m_{Ca_3(PO_4)_2} = 46.27g\ Ca_3(PO_4)_2$

$$m_{Fe_2(CO_3)_2} = m_{FePO_4} \times \frac{1}{M} \times \text{mol ratio} \times M_{Fe_2(CO_3)_3}$$

$$= 45.0g\ FePO_4 \times \frac{1 \text{ mol } FePO_4}{150.82g\ FePO_4} \times \frac{1 \text{ mol } Fe_2(CO_3)_3}{2 \text{ mol } FePO_4} \times \frac{291.73g\ Fe_2(CO_3)_3}{1 \text{ mol } Fe_2(CO_3)_3}$$

$m_{Fe_2(CO_3)_3} = 43.52g\ Fe_2(CO_3)_2$

$$m_{CaCO_3} \text{ req'd} = m_{FePO_4} \times \frac{1}{M_{FePO_4}} \times \text{mol ratio} \times M_{CaCO_3}$$

$$= 45.0g \times \frac{1 \text{ mol } FePO_4}{150.82g\ FePO_4} \times \frac{3 \text{ mol } CaCO_3}{2 \text{ mol } FePO_4} \times \frac{100.08g}{1 \text{ mol } CaCO_3}$$

m_{CaCO_3} req'd $= 44.79g\ CaCO_3$

$$m_{remain} = m_{have} - m_{req'd}$$

$$= 100g - 44.79g$$

$$= 55.21$$

$\therefore$ 55.21g $CaCO_3$ remain

3. $CuCl_2 + 2\,NaNO_3 \longrightarrow Cu(NO_3)_2 + 2\,NaCl$

$CuCl_2$: 15.0g, 134.45g/mol

$NaNO_3$: 20.0g, 85.00g/mol

$NaCl$: AY = 11.3g, 58.44g/mol

let $NaNO_3$ be limiting

$$m_{CuCl_2}\text{ req'd} = m_{NaNO_3} \times \frac{1}{M_{NaNO_3}} \times \text{mol ratio} \times M_{CuCl_2}$$

$$= 20g\ NaNO_3 \times \frac{1mol\ NaNO_3}{85.00g} \times \frac{1mol\ CuCl_2}{2mol\ NaNO_3} \times \frac{134.45g\ CuCl_2}{1mol\ CuCl_2}$$

$$= 15.82g\ CuCl_2$$

m_{CuCl_2} req'd > m_{CuCl_2} have ∴ $CuCl_2$ is limiting

$$m_{NaCl} = m_{CuCl_2} \times \frac{1}{M_{CuCl_2}} \times \text{mol ratio} \times M_{NaCl}$$

$$= 15.0g \times \frac{1mol\ CuCl_2}{134.45g} \times \frac{2mol\ NaCl}{1mol\ CuCl_2} \times \frac{58.44g\ NaCl}{1mol\ NaCl}$$

$$= 13.04g\ NaCl$$

$$\%\text{ yield} = \frac{AY}{TY} \times 100\%$$

$$= \left(\frac{11.3g}{13.04g}\right) \times 100\%$$

$$= 86.66$$

$$= 86.7\%$$

$$m_{NaNO_3}\text{ req'd} = m_{CuCl_2} \times \frac{1}{M_{CuCl_2}} \times \text{mol ratio} \times M_{NaNO_3}$$

$$= 15.0g \times \frac{1mol\ CuCl_2}{134.45g\ CuCl_2} \times \frac{2\ mol\ NaNO_3}{1mol\ CuCl_2} \times \frac{85.00g\ NaNO_3}{1mol\ NaNO_3}$$

$$= 18.97g$$

$$m_{remain} = m_{have} - m_{req'd}$$

$$= 20.0g - 18.9g$$

$$= 1.1g$$

∴ 1.1g $NaNO_3$ remain

4. $2\,FePO_4 + 3Na_2SO_4 \longrightarrow Fe_2(SO_4)_3 + 2\,Na_3PO_4$

25.0g (FePO₄) — excess (Na₂SO₄) — x g, AY = 18.5g ($Fe_2(SO_4)_3$)

150.82g/mol — 399.88g/mol

$$m_{Fe_2(PO_4)_3} = m_{FePO_4} \times \frac{1}{M_{FePO_4}} \times \text{mol ratio} \times M_{Fe_2(SO_4)_3}$$

$$= 25.0g \times \frac{1\,mol\,FePO_4}{150.82g\,FePO_4} \times \frac{1\,mol\,Fe_2(SO_4)_3}{2\,mol\,FePO_4} \times \frac{399.88g\,Fe_2(SO_4)_3}{1\,mol\,Fe_2(SO_4)_2}$$

$= 33.14$

$m = 33.1\ g\ Fe_2(SO_4)_3$

$$\%\text{ yield} = \left(\frac{AY}{TY}\right) \times 100\%$$

$$= \frac{18.5g}{33.1g} \times 100\%$$

$\%\text{ yield} = 55.9\ \%$

d. $2FePO_4 + 3Na_2SO_4 \longrightarrow Fe_2(SO_4)_3 + 2Na_3PO_4$

15.0g (Na₂SO₄)
142.04g/mol

AY =
TY =
%yield = 65.0%
163.94g/mol.

$$m_{Na_3PO_4} = m_{Na_2SO_4} \times \frac{1}{M_{Na_2SO_4}} \times \text{mol ratio} \times M_{Na_3PO_4}$$

$$= 15.0g \times \frac{1\,mol\,Na_2SO_4}{142.04g} \times \frac{2\,mol\,Na_3PO_4}{3\,mol\,Na_2SO_4} \times \frac{163.94g}{1\,mol}$$

TY $m_{Na_3PO_4} = 11.5g$

$$\%\text{ yield} = \frac{AY}{TY} \times 100\%$$

$$AY = \frac{\%\text{ yield}}{100\%} \times TY$$

$$= \frac{65\%}{100\%} \times 11.5g$$

$AY = 7.50g$

5. $2C_2H_6 + 7O_2 \rightarrow 4CO_{2(g)} + 6H_2O$

16.4 L @STP   0.980 mol   L @STP.

$n_{C_2H_6} = V \times \frac{1}{V_{molar}}$

$= 16.4\,L \times \frac{1\,mol\,C_2H_6}{22.4\,L}$

$= 0.7321\,mol\,C_2H_6$

n_{O_2} req'd $= n_{C_2H_6} \times$ mol ratio

$= 0.7321\,mol\,C_2H_6 \times \frac{7\,mol\,O_2}{2\,mol\,C_2H_6}$

$= 2.56\,mol\,O_2$

n_{O_2} have $< n_{O_2}$ req'd

∴ O_2 is limiting

$V_{CO_2} = n_{O_2} \times$ mol ratio $\times V_{molar}$

$= 0.980\,mol\,O_2 \times \frac{4\,mol\,CO_2}{7\,mol\,O_2} \times \frac{22.4\,L\,CO_2}{1\,mol\,CO_2}$

(a) $V_{CO_2} = 12.5\,L\,CO_2$

$N_O = V_{CO_2} \times \frac{1}{V_{molar}} \times$ mol ratio $\times N_A$

$= 12.5\,L\,CO_2 \times \frac{1\,mol\,CO_2}{22.4\,L} \times \frac{2\,mol\,O}{1\,mol\,CO_2} \times \frac{6.022 \times 10^{23}\,O\,atom}{1\,mol\,O}$

(b) $N_O = 6.72 \times 10^{23}$ O atoms

n_{CO_2} req'd $= n_{O_2} \times$ mol ratio

$= 0.980\,mol\,O_2 \times \frac{2\,mol\,C_2H_6}{7\,mol\,O_2}$

$= 0.28\,mol\,CO_2$

n_{CO_2} remain $= n_{CO_2}$ have $- n_{CO_2}$ req'd

$= 0.7321\,mol\,CO_2 - 0.28\,mol\,CO_2$

(c) $= 0.452\,mol\,C_2H_6$

(d) $m_{C_2H_6} = n \times M$

$= 0.452\ mol \times \frac{30.08\ g}{mol}$

$= 13.6 g\ C_2H_6$

(e) $N_C = n \times mol\ ratio \times N_A$

$= 0.452\ mol\ C_2H_6 \times \frac{2\ mol\ C}{1\ mol\ C_2H_6} \times \frac{6.022 \times 10^{23}\ C\ atom}{1\ mol\ C}$

$= 5.45 \times 10^{23}\ C\ atom$

$N_H = n \times mol\ ratio \times N_A$

$= 0.452\ mol\ C_2H_6 \times \frac{6\ mol\ H}{1\ mol\ C_2H_6} \times \frac{6.022 \times 10^{23}\ H\ atom}{1\ mol\ H}$

$= 1.63 \times 10^{24}\ H\ atom$