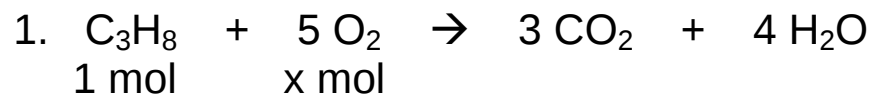
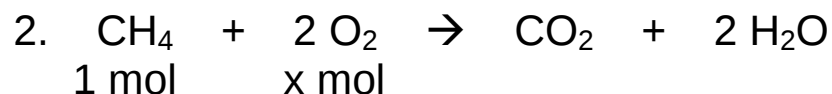


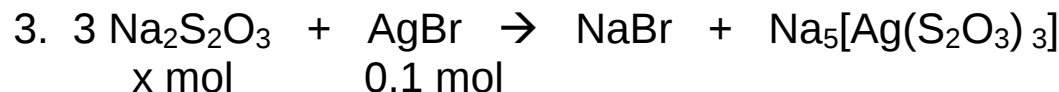
STOICHIOMETRY *Mathematics of the Chemical Equation*



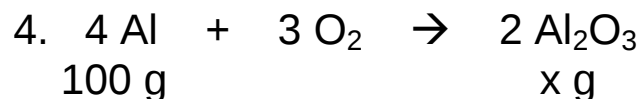
$$x \text{ mol O}_2 = 1 \text{ mol C}_3\text{H}_8 \times \frac{(5 \text{ mol O}_2)}{(1 \text{ mol C}_3\text{H}_8)} = 5 \text{ mol O}_2$$



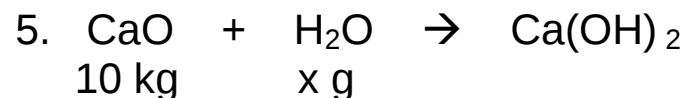
$$x \text{ mol O}_2 = 1 \text{ mol CH}_4 \times \frac{(2 \text{ mol O}_2)}{(1 \text{ mol CH}_4)} = 2 \text{ mol O}_2$$



$$x \text{ mol Na}_2\text{S}_2\text{O}_3 = 0.1 \text{ mol AgBr} \times \frac{(3 \text{ mol Na}_2\text{S}_2\text{O}_3)}{(1 \text{ mol AgBr})} = 0.3 \text{ mol Na}_2\text{S}_2\text{O}_3$$

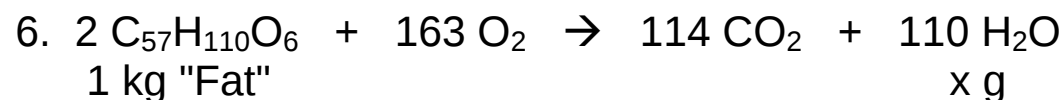


$$x \text{ g Al}_2\text{O}_3 = 100 \text{ g Al} \times \frac{(1 \text{ mol Al})}{(27 \text{ g Al})} \times \frac{(2 \text{ mol Al}_2\text{O}_3)}{(4 \text{ mol Al})} \times \frac{(102 \text{ g Al}_2\text{O}_3)}{(1 \text{ mol Al}_2\text{O}_3)} = 189 \text{ g Al}_2\text{O}_3$$



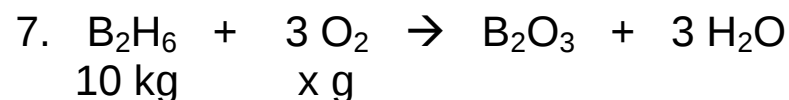
$$\text{x g H}_2\text{O} = 10 \text{ kg CaO} \times \frac{(1000 \text{ g CaO})}{(1 \text{ kg CaO})} \times \frac{(1 \text{ mol CaO})}{(56 \text{ g CaO})} \times \frac{(1 \text{ mol H}_2\text{O})}{(1 \text{ mol CaO})} \times \frac{(18 \text{ g H}_2\text{O})}{(1 \text{ mol H}_2\text{O})} = 3214 \text{ g H}_2\text{O}$$

$$\text{x g Ca(OH)}_2 = 10,000 \text{ g CaO} \times \frac{(1 \text{ mol CaO})}{(56 \text{ g CaO})} \times \frac{(1 \text{ mol Ca(OH)}_2)}{(1 \text{ mol CaO})} \times \frac{(74 \text{ g Ca(OH)}_2)}{(1 \text{ mol Ca(OH)}_2)} = 13214 \text{ g}$$

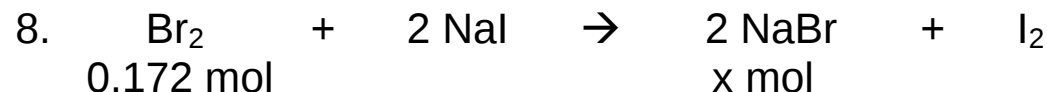


$$\text{x g H}_2\text{O} = 1 \text{ kg "Fat"} \times \frac{(1000 \text{ g "Fat"})}{(1 \text{ kg "Fat"})} \times \frac{(1 \text{ mol "Fat"})}{(890 \text{ g "Fat"})} \times \frac{(110 \text{ mol H}_2\text{O})}{(2 \text{ mol "Fat"})} \times \frac{(18 \text{ g H}_2\text{O})}{(1 \text{ mol H}_2\text{O})}$$

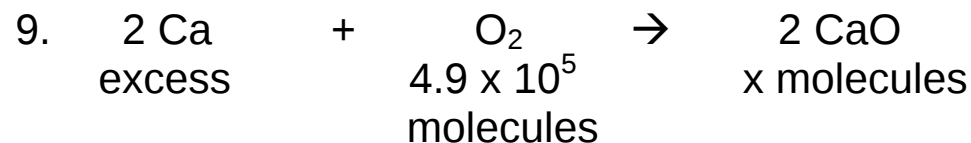
$$= 1,112 \text{ g H}_2\text{O}$$



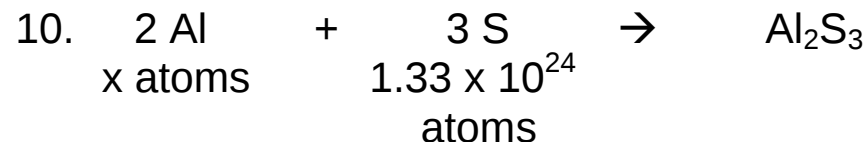
$$\text{x g O}_2 = 10,000 \text{ g B}_2\text{H}_6 \times \frac{(1 \text{ mol B}_2\text{H}_6)}{(27.6 \text{ g B}_2\text{H}_6)} \times \frac{(3 \text{ mol O}_2)}{(1 \text{ mol B}_2\text{H}_6)} \times \frac{(32 \text{ g O}_2)}{(1 \text{ mol O}_2)} = 34,783 \text{ g O}_2$$



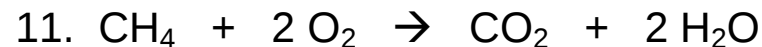
$$\text{x mol NaBr} = 0.172 \text{ mol Br}_2 \times \frac{(2 \text{ mol NaBr})}{(1 \text{ mol Br}_2)} = 0.344 \text{ mol NaBr}$$



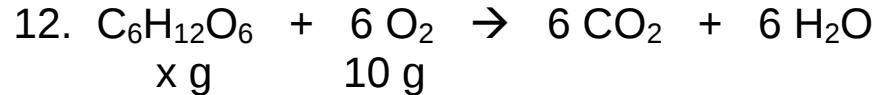
$$\begin{aligned} \text{X molecules CaO} &= 4.9 \times 10^5 \text{ molecules O}_2 \times \frac{(1 \text{ mol O}_2)}{(6.02 \times 10^{23} \text{ molecules O}_2)} \times \frac{(2 \text{ mol CaO})}{(1 \text{ mol O}_2)} \times \frac{(6.02 \times 10^{23} \text{ molecules})}{(1 \text{ mol CaO})} \\ &= 9.8 \times 10^5 \text{ molecules CaO} \end{aligned}$$



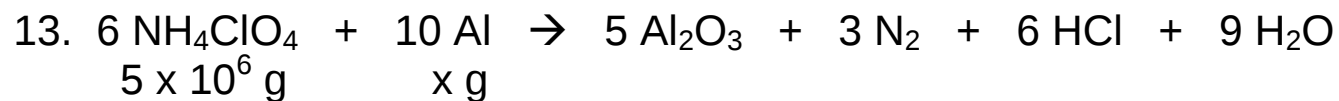
$$\begin{aligned} \text{x atoms Al} &= 1.33 \times 10^{24} \text{ atoms S} \times \frac{(1 \text{ mol S})}{(6.02 \times 10^{23} \text{ atoms S})} \times \frac{(2 \text{ mol Al})}{(3 \text{ mol S})} \times \frac{(6.02 \times 10^{23} \text{ atoms Al})}{(1 \text{ mol Al})} \\ &= 8.9 \times 10^{23} \text{ atoms Al} \end{aligned}$$



$$\text{x g CH}_4 = 1 \text{ g O}_2 \times \frac{(1 \text{ mol O}_2)}{(32 \text{ g O}_2)} \times \frac{(1 \text{ mol CH}_4)}{(2 \text{ mol O}_2)} \times \frac{(16 \text{ g CH}_4)}{(1 \text{ mol CH}_4)} = 0.25 \text{ g CH}_4$$



$$x \text{ g C}_6\text{H}_{12}\text{O}_6 = 10 \text{ g O}_2 \times \frac{(1 \text{ mol O}_2)}{(32 \text{ g O}_2)} \times \frac{(1 \text{ mol C}_6\text{H}_{12}\text{O}_6)}{(6 \text{ mol O}_2)} \times \frac{(180 \text{ g C}_6\text{H}_{12}\text{O}_6)}{(1 \text{ mol C}_6\text{H}_{12}\text{O}_6)} = 9.375 \text{ g C}_6\text{H}_{12}\text{O}_6$$



$$x \text{ g Al} = 5 \times 10^6 \text{ g NH}_4\text{ClO}_4 \times \frac{(1 \text{ mol NH}_4\text{ClO}_4)}{(117.5 \text{ g NH}_4\text{ClO}_4)} \times \frac{(10 \text{ mol Al})}{(6 \text{ mol NH}_4\text{ClO}_4)} \times \frac{(27 \text{ g Al})}{{(1 \text{ mol Al})}} = 1,914,894 \text{ g Al}$$



$$\begin{array}{cc} 5 \text{ g} & 5 \text{ g} \\ / 170 \text{ g/mol} & / 74.6 \text{ g/mol} \end{array}$$

"Have" 0.0294 mol 0.067 mol

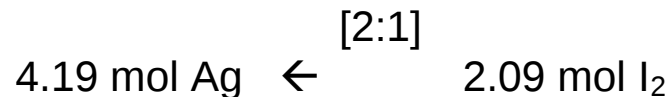
"Need" 0.067 mol 0.0294 mol

Silver Nitrate is LIMITING REACTANT; KCl is in excess.



$$\frac{2.5 \times 10^{24} \text{ atoms}}{6.02 \times 10^{23} \text{ atoms/mol}} \times \frac{1 \text{ mol Ag}}{107.87 \text{ g/mol}} \times \frac{2 \text{ mol AgI}}{2 \text{ mol Ag}} \times \frac{253.81 \text{ g/mol}}{1 \text{ mol AgI}} = 2.5 \times 10^{24} \text{ atoms Ag}$$

$$\text{x atoms Ag} = 531.8 \text{ g I}_2 \times \frac{1 \text{ mol I}_2}{253.81 \text{ g I}_2} \times \frac{2 \text{ mol Ag}}{1 \text{ mol I}_2} \times \frac{6.02 \times 10^{23} \text{ atoms Ag}}{1 \text{ mol Ag}} = 2.5 \times 10^{24} \text{ atoms Ag}$$



$$\text{x atoms Ag} = 531.8 \text{ g I}_2 \times \frac{1 \text{ mol I}_2}{253.81 \text{ g I}_2} \times \frac{2 \text{ mol Ag}}{1 \text{ mol I}_2} \times \frac{6.02 \times 10^{23} \text{ atoms Ag}}{1 \text{ mol Ag}} = 2.5 \times 10^{24} \text{ atoms Ag}$$

16. % Yield = $\frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100 \%$

$$\% \text{ Yield} = \frac{480 \text{ tons}}{550 \text{ tons}} \times 100 \% = 87.3 \% \text{ Yield}$$

17. 1 mol N₂ = 22.4 L @ STP

$$\text{x L N}_2 = 16.3 \text{ mol N}_2 \times \frac{22.4 \text{ L N}_2}{1 \text{ mol N}_2} = 365 \text{ L N}_2$$

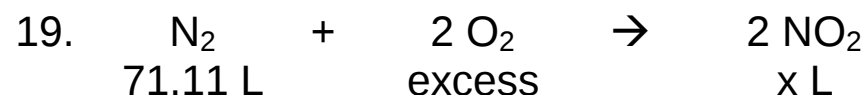
$$18. 1 \text{ mol F}_2 = 22.4 \text{ L @ STP}$$

$$1 \text{ cc} = 1 \text{ cm}^3 = 1 \text{ mL}$$

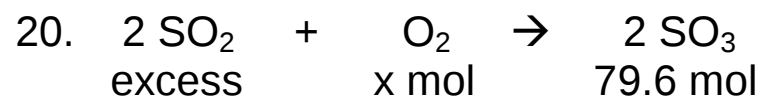
$$\& 1 \text{ dm}^3 = 1 \text{ L}$$

$$\begin{aligned} 10 \text{ cm} &= 1 \text{ dm} \\ (10 \text{ cm})^3 &= (1 \text{ dm})^3 \\ 1000 \text{ cm}^3 &= 1 \text{ dm}^3 \end{aligned}$$

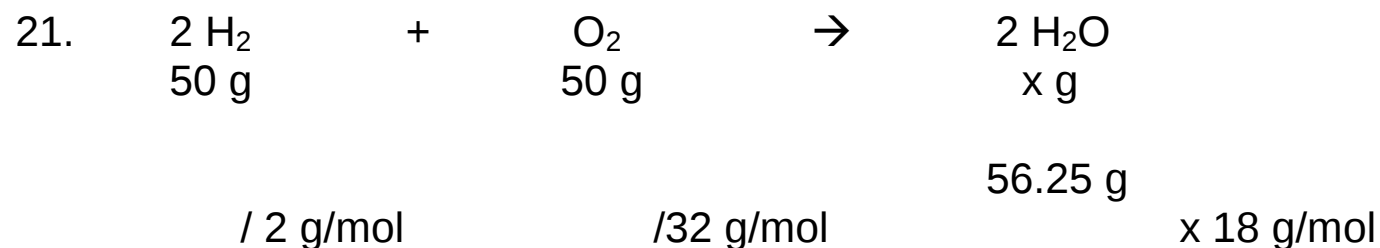
$$x \text{ mol F}_2 = 0.269 \text{ L F}_2 \times \frac{(1 \text{ mol F}_2)}{(22.4 \text{ L F}_2)} = 0.012 \text{ mol F}_2$$



$$x \text{ L NO}_2 = 71.11 \text{ L NO}_2 \times \frac{(1 \text{ mol N}_2)}{(22.4 \text{ L N}_2)} \times \frac{(2 \text{ mol NO}_2)}{(1 \text{ mol N}_2)} \times \frac{(22.4 \text{ L NO}_2)}{(1 \text{ mol NO}_2)} = 142.22 \text{ L NO}_2$$



$$x \text{ mol O}_2 = 79.6 \text{ mol SO}_3 \times \frac{(1 \text{ mol O}_2)}{(2 \text{ mol SO}_3)} = 39.8 \text{ mol O}_2$$

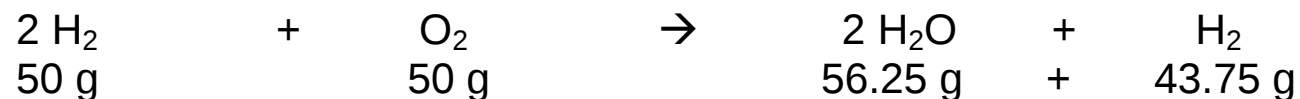


"Have" 25 mol H₂ 1.56 mol O₂ 3.125 mol H₂O [1:2]

"Need" 3.125 mol H₂ 12.5 mol O₂

Oxygen is the LIMITING REACTANT; hydrogen is in excess.

$$x \text{ g H}_2\text{O} = 50 \text{ g O}_2 \times \frac{(1 \text{ mol O}_2)}{(32 \text{ g O}_2)} \times \frac{(2 \text{ mol H}_2\text{O})}{(1 \text{ mol O}_2)} \times \frac{(18 \text{ g H}_2\text{O})}{(1 \text{ mol H}_2\text{O})} = 56.25 \text{ g H}_2\text{O}$$



$$6.25 \text{ g} + 43.75 \text{ g} + 50 \text{ g} = 56.25 \text{ g} + 43.75 \text{ g}$$

$$100 \text{ g Reactant} = 100 \text{ g Product}$$

Law of Conservation of Mass is observed!



100 g x Joules

$$\text{x Joules heat} = 100 \text{ g C} \times \frac{(1 \text{ mol C})}{(12 \text{ g C})} \times \frac{(113 \text{ kJ})}{(1 \text{ mol C})} \times \frac{(1000 \text{ J})}{(1 \text{ kJ})} = 942,000 \text{ Joules}$$



7.1×10^{23} atoms

/ 63.5 g/mol

/ 170 g/mol

x 6.02×10^{23} atoms

[2:2]

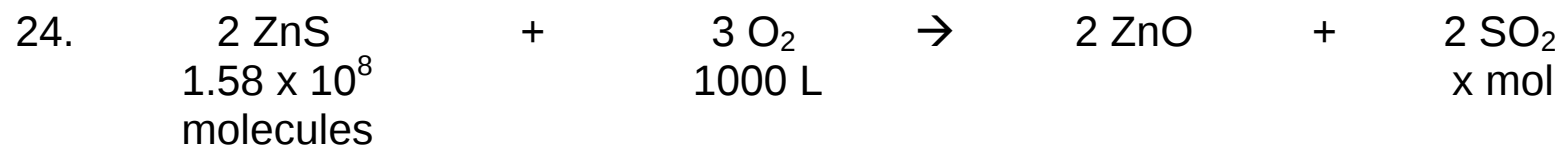
"Have" 1.57 mol Cu 1.18 mol AgNO₃ 1.18 mol Ag

"Need" 0.59 mol Cu 3.14 mol AgNO₃

Silver nitrate is LIMITING Reactant; copper is in excess.

$$\text{X atoms Ag} = 200 \text{ g AgNO}_3 \times \frac{(1 \text{ mol AgNO}_3)}{(170 \text{ g AgNO}_3)} \times \frac{(2 \text{ mol Ag})}{(2 \text{ mol AgNO}_3)} \times \frac{(6.02 \times 10^{23} \text{ atoms Ag})}{(1 \text{ mol Ag})}$$

$$= 7.1 \times 10^{23} \text{ atoms Ag}$$



$$\frac{1.58 \times 10^8 \text{ molecules}}{6.02 \times 10^{23} \text{ molecules/mol}} \quad \frac{1000 \text{ L}}{22.4 \text{ L/mol}}$$

"Have" $2.49 \times 10^{-16} \text{ mol ZnS}$ 44.6 mol O_2 _____ mol

"Need" [2:2]

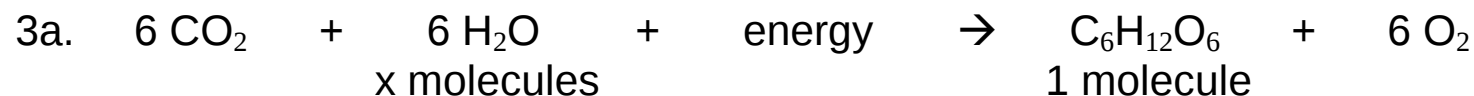
Zinc sulfide is LIMITING Reactant; oxygen is in excess.

$$\text{X mol SO}_2 = 1.5 \times 10^8 \text{ molecules ZnS} \times \frac{(1 \text{ mol ZnS})}{(6.02 \times 10^{23} \text{ molecules ZnS})} \times \frac{(2 \text{ mol SO}_2)}{(2 \text{ mol ZnS})}$$

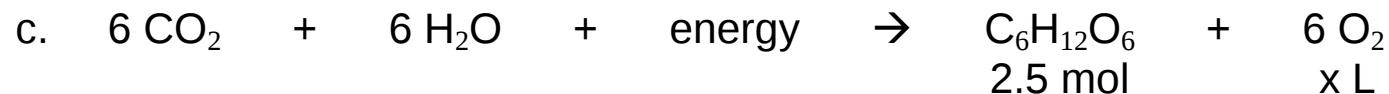
$$= 2.5 \times 10^{-16} \text{ mol SO}_2$$

$$\times 0.75 \quad (75 \% \text{ Yield})$$

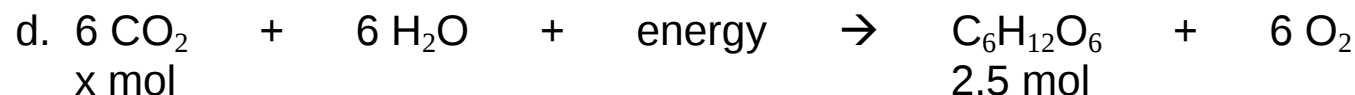
$$1.9 \times 10^{-16} \text{ mol SO}_2$$



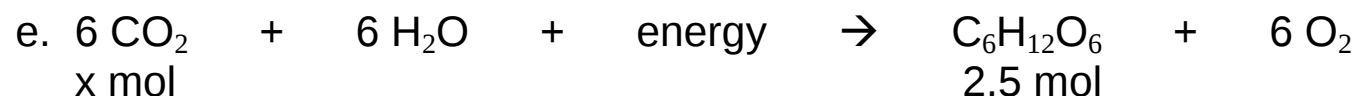
b. 6 molecules H₂O



$$\text{x L O}_2 = 2.5 \text{ mol } \cancel{\text{C}_6\text{H}_{12}\text{O}_6} \times \frac{(6 \text{ mol } \cancel{\text{O}_2})}{(1 \text{ mol } \cancel{\text{C}_6\text{H}_{12}\text{O}_6})} \times \frac{(22.4 \text{ L O}_2)}{(1 \text{ mol } \cancel{\text{O}_2})} = 336 \text{ L O}_2$$

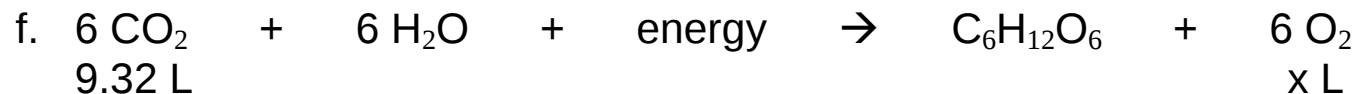


$$\text{x mol CO}_2 = 2.5 \text{ mol } \cancel{\text{C}_6\text{H}_{12}\text{O}_6} \times \frac{(6 \text{ mol CO}_2)}{(1 \text{ mol } \cancel{\text{C}_6\text{H}_{12}\text{O}_6})} = 15 \text{ mol CO}_2$$

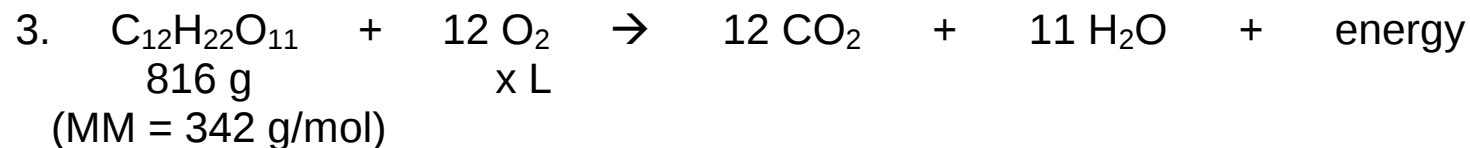


$$\text{x mol CO}_2 = 2.5 \text{ mol } \cancel{\text{C}_6\text{H}_{12}\text{O}_6} \times \frac{(6.02 \times 10^{23} \text{ molecules } \cancel{\text{C}_6\text{H}_{12}\text{O}_6})}{(1 \text{ mol } \cancel{\text{C}_6\text{H}_{12}\text{O}_6})} \times \frac{(6 \text{ atoms C})}{(1 \text{ molecule } \cancel{\text{C}_6\text{H}_{12}\text{O}_6})}$$

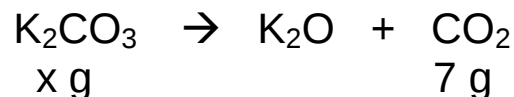
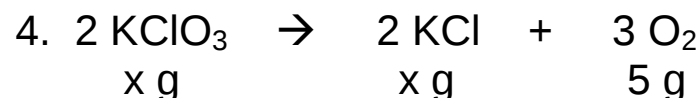
$$= 9.03 \times 10^{24} \text{ atoms C}$$



$$\text{x L O}_2 = 9.32 \text{ L } \cancel{\text{CO}_2} \times \frac{(1 \text{ mol } \cancel{\text{CO}_2})}{(22.4 \text{ L } \cancel{\text{CO}_2})} \times \frac{(6 \text{ mol O}_2)}{(6 \text{ mol } \cancel{\text{CO}_2})} \times \frac{(22.4 \text{ L O}_2)}{(1 \text{ mol } \cancel{\text{O}_2})} = 9.32 \text{ L O}_2$$



$$\text{x L O}_2 = 816 \text{ g C}_{12}\text{H}_{22}\text{O}_{11} \times \frac{(1 \text{ mol C}_{12}\text{H}_{22}\text{O}_{11})}{(342 \text{ g C}_{12}\text{H}_{22}\text{O}_{11})} \times \frac{(12 \text{ mol O}_2)}{(1 \text{ mol C}_{12}\text{H}_{22}\text{O}_{11})} \times \frac{(22.4 \text{ L O}_2)}{(1 \text{ mol O}_2)} = 641 \text{ L O}_2$$



$$\text{x g KClO}_3 = 5 \text{ g O}_2 \times \frac{(1 \text{ mol O}_2)}{(32 \text{ g O}_2)} \times \frac{(2 \text{ mol KClO}_3)}{(3 \text{ mol O}_2)} \times \frac{(122.6 \text{ g KClO}_3)}{(1 \text{ mol KClO}_3)} = 12.77 \text{ g KClO}_3$$

$$\text{x g KCl} = 5 \text{ g O}_2 \times \frac{(1 \text{ mol O}_2)}{(32 \text{ g O}_2)} \times \frac{(2 \text{ mol KCl})}{(3 \text{ mol O}_2)} \times \frac{(74.6 \text{ g KCl})}{(1 \text{ mol KCl})} = 7.77 \text{ g KCl "Produced"}$$

$$\text{x g K}_2\text{CO}_3 = 7 \text{ g CO}_2 \times \frac{(1 \text{ mol CO}_2)}{(44 \text{ g CO}_2)} \times \frac{(1 \text{ mol K}_2\text{CO}_3)}{(1 \text{ mol CO}_2)} \times \frac{(138.2 \text{ g K}_2\text{CO}_3)}{(1 \text{ mol K}_2\text{CO}_3)} = 21.99 \text{ g K}_2\text{CO}_3$$

$$\begin{array}{l} \text{Original Mixture: } 12.77 \text{ g KClO}_3 + 21.99 \text{ g K}_2\text{CO}_3 + \underline{\text{x g KCl}} = 50 \text{ g} \\ \text{x} = 15.24 \text{ g KCl} \end{array}$$

$$12.77 \text{ g KClO}_3 + 21.99 \text{ g K}_2\text{CO}_3 + \underline{15.24 \text{ g KCl}} = 50 \text{ g}$$