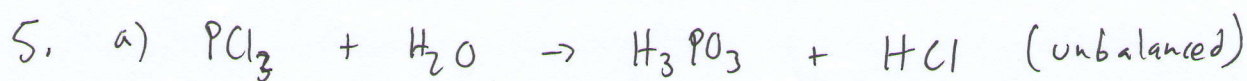
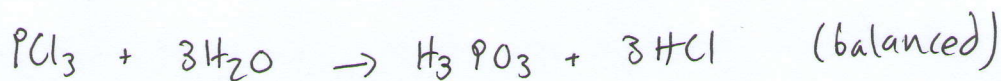


# Chapter 9

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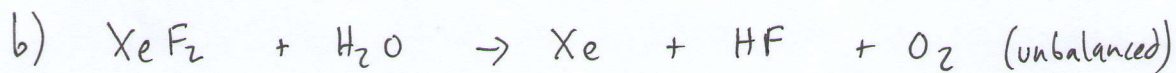


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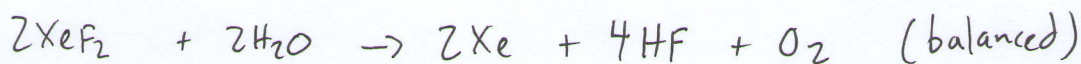


We can read this equation two ways:

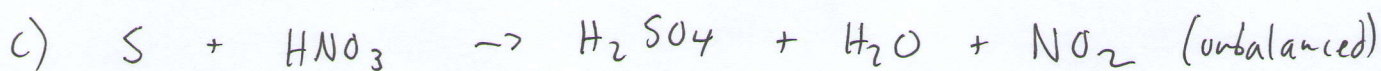
- 1) One molecule of  $\text{PCl}_3$  reacts with <sup>three</sup> ~~1~~ molecules of  $\text{H}_2\text{O}$  to yield one molecule of  $\text{H}_3\text{PO}_3$  and three molecules of  $\text{HCl}$ .
- 2) One mole of  $\text{PCl}_3$  reacts with three moles of  $\text{H}_2\text{O}$  to yield one mole of  $\text{H}_3\text{PO}_3$  and three moles of  $\text{HCl}$ .



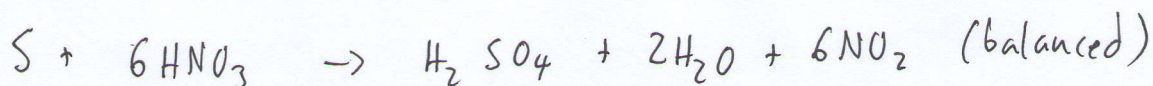
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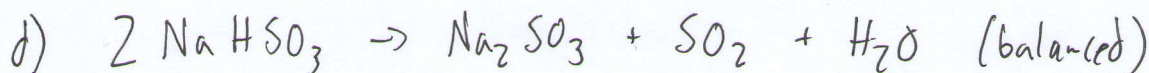
Two molecules (moles) of  $\text{XeF}_2$  reacts with ~~two~~ two molecules (moles) of  $\text{H}_2\text{O}$  to yield two molecules (moles) of  $\text{Xe}$  ~~two~~, four molecules (moles) of  $\text{HF}$ , and one molecule (mole) of  $\text{O}_2$ .



⇓



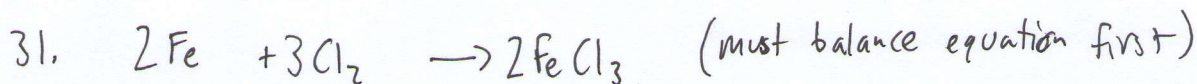
Follow examples from (a) & (b).



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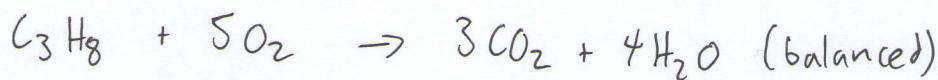
17. Molar mass serves as the conversion factor between the mass of a sample and how many moles the sample contains.

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$$15.5 \times 10^{-3} \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} \times \frac{2 \text{ mol FeCl}_3}{2 \text{ mol Fe}} \times \frac{162.21 \text{ g FeCl}_3}{1 \text{ mol FeCl}_3} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \boxed{45.02 \text{ mg FeCl}_3}$$

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$$10 \text{ g C}_3\text{H}_8 \times \frac{1 \text{ mol C}_3\text{H}_8}{44.0962 \text{ g C}_3\text{H}_8} \times \frac{3 \text{ mol CO}_2}{1 \text{ mol C}_3\text{H}_8} \times \frac{44.011 \text{ g CO}_2}{1 \text{ mol CO}_2} = \boxed{29.9420 \text{ g CO}_2 \text{ produced}}$$

$$10 \text{ g O}_2 \times \frac{1 \text{ mol O}_2}{32 \text{ g O}_2} \times \frac{3 \text{ mol CO}_2}{5 \text{ mol O}_2} \times \frac{44.011 \text{ g CO}_2}{1 \text{ mol CO}_2} = \boxed{8.2521 \text{ g CO}_2 \text{ produced}}$$

$$8.2521 \text{ g CO}_2 < 29.9420 \text{ g CO}_2 \Rightarrow \boxed{\text{O}_2 \text{ is the limiting reagent}}$$

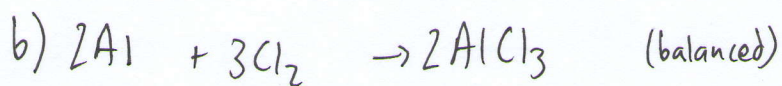
$$10 \text{ g O}_2 \times \frac{1 \text{ mol O}_2}{32 \text{ g O}_2} \times \frac{4 \text{ mol H}_2\text{O}}{5 \text{ mol O}_2} \times \frac{18.0158 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 4.5040 \text{ g H}_2\text{O} \text{ produced}$$

$$10 \text{ g O}_2 \times \frac{1 \text{ mol O}_2}{32 \text{ g O}_2} \times \frac{1 \text{ mol C}_3\text{H}_8}{5 \text{ mol O}_2} \times \frac{44.0962 \text{ g C}_3\text{H}_8}{1 \text{ mol C}_3\text{H}_8} = 2.7560 \text{ g C}_3\text{H}_8 \text{ used}$$

$$10 \text{ g} - 2.7560 \text{ g} = 7.2440 \text{ g C}_3\text{H}_8 \text{ remaining}$$

At the end of the reaction, we have

8.251 g CO <sub>2</sub>
4.5040 g H <sub>2</sub> O
<del>2.7560 g</del> 7.2440 g C <sub>3</sub> H <sub>8</sub>



$$10 \text{ g Al} \times \frac{1 \text{ mol Al}}{26.98 \text{ g Al}} \times \frac{2 \text{ mol AlCl}_3}{2 \text{ mol Al}} \times \frac{133.339 \text{ g AlCl}_3}{1 \text{ mol AlCl}_3} = 49.4214 \text{ g AlCl}_3 \text{ produced}$$

$$10 \text{ g Cl}_2 \times \frac{1 \text{ mol Cl}_2}{70.906 \text{ g Cl}_2} \times \frac{2 \text{ mol AlCl}_3}{3 \text{ mol Cl}_2} \times \frac{133.339 \text{ g AlCl}_3}{1 \text{ mol AlCl}_3} = 12.5367 \text{ g AlCl}_3 \text{ produced}$$

$$12.5367 \text{ g} < 49.4214 \text{ g} \Rightarrow \boxed{\text{Cl}_2 \text{ is the limiting reagent}}$$

$$10 \text{ g Cl}_2 \times \frac{1 \text{ mol Cl}_2}{70.906 \text{ g Cl}_2} \times \frac{2 \text{ mol Al}}{3 \text{ mol Cl}_2} \times \frac{26.98 \text{ g Al}}{1 \text{ mol Al}} = 2.5367 \text{ g Al consumed}$$

$$10 \text{ g Al initially} - 2.5367 \text{ g Al consumed} = 7.4633 \text{ g Al remaining}$$

At the end of the reaction, we have  $\boxed{12.5367 \text{ g AlCl}_3 \text{ produced}}$   
~~2.5367 g Al consumed~~  
 $7.4633 \text{ g Al remaining}$ .

c)  $\boxed{\text{limiting reagent} = \text{NaOH}}$

At the end of the reaction, we have  $\boxed{2.2521 \text{ g H}_2\text{O} \text{ produced}}$   
 $\boxed{13.2496 \text{ g Na}_2\text{CO}_3 \text{ produced}}$   
 $4.4983 \text{ g CO}_2 \text{ remaining}$

d)  $\boxed{\text{limiting reagent} = \text{NaHCO}_3}$

At the end of the reaction, we have  $\boxed{6.9577 \text{ g NaCl} \text{ produced}}$   
 $\boxed{2.1448 \text{ g H}_2\text{O} \text{ produced}}$   
 $\boxed{5.2395 \text{ g CO}_2 \text{ produced}}$   
 $5.6593 \text{ g HCl} \text{ remaining}$

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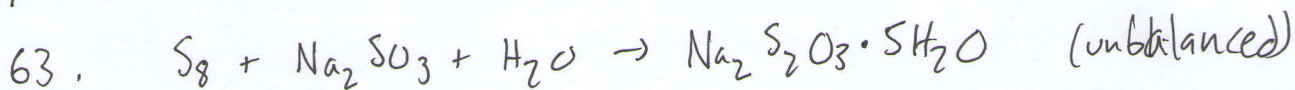


$$50 \text{ kg PbO} \times \frac{1000 \text{ g PbO}}{1 \text{ kg PbO}} \times \frac{1 \text{ mol PbO}}{223.2 \text{ g PbO}} \times \frac{1 \text{ mol Pb}}{1 \text{ mol PbO}} \times \frac{207.2 \text{ g Pb}}{1 \text{ mol Pb}} = 46.4158 \text{ kg Pb}$$

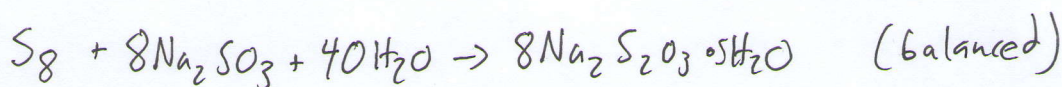
$$50 \text{ kg C} \times \frac{1000 \text{ g C}}{1 \text{ kg C}} \times \frac{1 \text{ mol C}}{12.011 \text{ g C}} \times \frac{1 \text{ mol Pb}}{1 \text{ mol C}} \times \frac{207.2 \text{ g Pb}}{1 \text{ mol Pb}} = 86.2543 \text{ kg Pb}$$

Expected yield of lead = 46.4158 kg

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↓



$$3.25 \text{ g S}_8 \times \frac{1 \text{ mol S}_8}{256.48 \text{ g S}_8} \times \frac{8 \text{ mol Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}}{1 \text{ mol S}_8} \times \frac{248.179 \text{ g Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}}{1 \text{ mol Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}} = 25.159 \text{ g Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$$

$$13.1 \text{ g Na}_2\text{SO}_3 \times \frac{1 \text{ mol Na}_2\text{SO}_3}{126.04 \text{ g Na}_2\text{SO}_3} \times \frac{8 \text{ mol Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}}{8 \text{ mol Na}_2\text{SO}_3} \times \frac{248.179 \text{ g Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}}{1 \text{ mol Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}} = 25.795 \text{ g Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$$

Theoretical yield of  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} = 25.159 \text{ g}$

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} = \frac{5.26 \text{ g}}{25.159 \text{ g}} = 0.20907 = 20.91\% \text{ yield}$$