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② That equation says that 1 mol of C reacts with one mole of O_2. Thus, 12g of C will react with 32g of O_2. This is not the same ratio as 1g C : 1g O_2.

④ ⓐ $3MnO_2 + 4Al \rightarrow 3Mn + 2Al_2O_3$

3 mol MnO_2 reacts with 4 mol Al to produce 3 mol Mn and 2 mol Al_2O_3

\- or -

3 formula units of MnO_2 react with 4 atoms of Al to produce 3 atoms of Mn and 2 formula units of Al_2O_3

ⓒ $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

3 mol NO_2 reacts w/ 1 mol H_2O to produce 2 mol HNO_3 and 1 mol NO.

\- or -

3 molecules of NO_2 react w/ 1 molecule of H_2O to produce 2 molecules of HNO_3 and 1 molecule of NO

⑦ $2Ag + H_2S \rightarrow Ag_2S + H_2$

For every 2 mol of Ag that reacts, 1 mol of Ag_2S and 1 mol of H_2 could be produced (assuming that sufficient H_2S is available).

$$\frac{2\,\text{mol Ag}}{1\,\text{mol } Ag_2S} \text{ or } \frac{1\,\text{mol } Ag_2S}{2\,\text{mol Ag}} \;//\; \frac{2\,\text{mol Ag}}{1\,\text{mol } H_2} \text{ or } \frac{1\,\text{mol } H_2}{2\,\text{mol Ag}}$$

⑧ ⓐ $2FeO + C \rightarrow 2Fe + CO_2$

$$0.125 \text{ mol FeO} \times \frac{2\text{ mol Fe}}{2\text{ mol FeO}} = \underline{0.125} \text{ mol Fe}$$

$$0.125 \text{ mol FeO} \times \frac{1\text{ mol } CO_2}{2\text{ mol FeO}} = \underline{.0625} \text{ mol } CO_2$$

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⑧ ⓒ Skip this; it can not be balanced as written.

⑨ ⓐ $0.50\text{ mol } NH_3 \times \frac{1\text{ mol } NH_4Cl}{1\text{ mol } NH_3} = 0.50\text{ mol } NH_4Cl$

$0.50\text{ mol } NH_3 \times \frac{1\text{ mol } NH_4Cl}{1\text{ mol } NH_3} \times \frac{53.5\ NH_4Cl}{1\text{ mol } NH_4Cl} = \underline{27}\text{ g } NH_4Cl$

ⓒ $0.50\text{ mol } PCl_3 \times \frac{1\text{ mol } H_3PO_3}{1\text{ mol } PCl_3} = 0.50\text{ mol } H_3PO_3$

$0.5\text{ mol } PCl_3 \times \frac{1\text{ mol } H_3PO_3}{1\text{ mol } PCl_3} \times \frac{82\text{ g } H_3PO_3}{1\text{ mol } H_3PO_3} = \underline{41}\text{ g } H_3PO_3$

$0.5\text{ mol } PCl_3 \times \frac{3\text{ mol } HCl}{1\text{ mol } PCl_3} = \underline{1.5}\text{ mol } HCl$

$0.5\text{ mol } PCl_3 \times \frac{3\text{ mol } HCl}{1\text{ mol } PCl_3} \times \frac{36.5\text{ g } HCl}{1\text{ mol } HCl} = \underline{55}\text{ g } HCl$

⑩ ⓐ $4KO_2 + 2H_2O \rightarrow \overset{\text{1st product}}{3O_2} + \overset{\text{2nd product}}{4KOH}$

$0.625\text{ mol } KOH \times \frac{3\text{ mol } O_2}{4\text{ mol } KOH} = \underline{0.469}\text{ mol } O_2$

ⓒ $2CH_3CH_2OH + O_2 \rightarrow \underset{\text{1st product}}{2CH_3CHO} + \underset{\text{2nd product}}{2H_2O}$

$0.625\text{ mol } H_2O \times \frac{2\text{ mol } CH_3CHO}{2\text{ mol } H_2O} = \underline{0.625\text{ mol } CH_3CHO}$

⑫ ~~I have no idea.~~ The balanced chemical reaction described the mole ratios that exist between the reactants & products,

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⑬ ⓐ $$2.01 \times 10^{-2}\text{ g Ag} \times \frac{1\text{ mol Ag}}{108\text{ g Ag}} = \underline{1.86 \times 10^{-4}}\text{ mol Ag}$$

ⓒ $$61.7\ \mu\text{g U} \times \frac{1\text{ g}}{10^{6}\ \mu\text{g}} \times \frac{1\text{ mol}}{238} = \underline{2.59 \times 10^{-7}}\text{ mol U}$$

ⓔ $$272\text{ g Fe(NO}_3)_3 \times \frac{1\text{ mol}}{241.85\text{ g}} = \underline{1.12}\text{ mol Fe(NO}_3)_3$$

⑭ ⓐ $$2.21 \times 10^{-4}\text{ mol CaCO}_3 \times \frac{100.1\text{ g}}{1\text{ mol}} = \underline{0.0100}\text{ g CaCO}_3$$

ⓒ $$0.00975\text{ mol O}_2 \times \frac{32\text{ g}}{1\text{ mol}} = \underline{0.312}\text{ g O}_2$$

ⓔ $$0.835\text{ mol FeS} \times \frac{87.91\text{ g}}{1\text{ mol}} = \underline{73.4}\text{ g FeS}$$

⑮ ⓐ $Mg + CuCl_2 \rightarrow MgCl_2 + Cu$ already balanced

$$25.0\text{ g Mg} \times \frac{1\text{ mol Mg}}{24.3\text{ g Mg}} \times \frac{1\text{ mol CuCl}_2}{1\text{ mol Mg}} = \underline{1.03}\text{ mol Mg}$$

ⓒ $NaHSO_3 + NaOH \rightarrow Na_2SO_3 + H_2O$ already balanced

$$25.0\text{ g NaHSO}_3 \times \frac{1\text{ mol NaHSO}_3}{104.1\text{ g NaHSO}_3} \times \frac{1\text{ mol NaOH}}{1\text{ mol NaHSO}_3} = \underline{0.240}\text{ mol NaOH}$$

⑱ $2H_2 + O_2 \rightarrow 2H_2O$

$$0.0275\text{ mol H}_2 \times \frac{1\text{ mol O}_2}{2\text{ mol H}_2} \times \frac{32\text{ g O}_2}{1\text{ mol O}_2} = \underline{0.440}\text{ g O}_2$$

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⑳ $2Fe + 3Cl_2 \rightarrow 2FeCl_3$

$$15.5\,mg\,Fe \times \frac{1\,g\,Fe}{1000\,mg\,Fe} \times \frac{1\,mol\,Fe}{55.85\,g\,Fe} \times \frac{2\,mol\,FeCl_3}{2\,mol\,Fe} \times \frac{162.2\,g\,FeCl_3}{1\,mol\,FeCl_3} \times \frac{10^3\,mg\,FeCl_3}{1\,g\,FeCl_3}$$

$= 45.0\,mg\,FeCl$

㉒ $$1.25\,g\,Cu \times \frac{1\,mol\,Cu}{63.55\,g\,Cu} \times \frac{1\,mol\,S}{1\,mol\,Cu} \times \frac{32.06\,g\,S}{1\,mol\,S} = \underline{0.631}\,g\,S$$

$Cu + S \rightarrow CuS$

㉔ $$1.25\,g\,Mg \times \frac{1\,mol\,Mg}{24.31\,g\,Mg} \times \frac{2\,mol\,MgO}{2\,mol\,Mg} \times \frac{40.31\,g\,MgO}{1\,mol\,MgO} = \underline{2.07}\,g\,MgO$$

㉕ $Cl_2 + 2KI \rightarrow I_2 + 2KCl$

$$4.50 \times 10^3\,g\,Cl_2 \times \frac{1\,mol\,Cl_2}{70.9\,g\,Cl_2} \times \frac{1\,mol\,I_2}{1\,mol\,Cl_2} \times \frac{253.8\,g\,I_2}{1\,mol\,I_2} = \underline{1.61 \times 10^4}\,g\,I_2$$

㉘ $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

$$1.00\,g\,CH_4 \times \frac{1\,mol\,CH_4}{16\,g\,CH_4} \times \frac{2\,mol\,H_2O}{1\,mol\,CH_4} \times \frac{18\,g\,H_2O}{1\,mol\,H_2O} = \underline{2.25}\,g\,H_2O$$

$$2.25\,g\,H_2O \times \frac{1\,mol\,H_2O}{18\,g\,H_2O} \times \frac{4\,mol\,NH_3}{6\,mol\,H_2O} \times \frac{17\,g\,NH_3}{1\,mol\,NH_3} = \underline{1.42}\,g\,NH_3$$

~~$2NH_3 + \frac{5}{2}O_2 \rightarrow 2NO + 3H_2O$~~ $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

㉙ The reactant which gets entirely consumed in a chemical reaction. The reaction stops because all reactants are necessary for a reaction to proceed.

㉝ Excess; some of it remains at completion of reaction. No; it gets entirely used up. No, because the excess portion does not react.

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(34) (a) $15.0\,g\ Al \times \frac{1\ mol}{27.0\,g} = \underline{0.556}\ mol\ Al$ $\quad 2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$

$15.0\,g\ HCl \times \frac{1\ mol}{36.5\,g} = \underline{0.411}\ mol\ HCl$

$\underset{available}{0.556\ mol\ Al} \times \frac{6\ mol\ HCl}{2\ mol\ Al} = \underline{1.668}$ mol HCl needed to use up all Aluminum.

There is not enough HCl (there is only 0.411 mol HCl).

HCl is limiting reactant.

$0.411\ mol\ HCl \times \frac{2\ mol\ AlCl_3}{6\ mol\ HCl} \times \frac{133.35\,g\ AlCl_3}{1\ mol\ AlCl_3} = \boxed{\underline{18.3}\,g\ AlCl_3}$

$0.411\ mol\ HCl \times \frac{3\ mol\ H_2}{6\ mol\ HCl} \times \frac{2.02\,g\ H_2}{1\ mol\ H_2} = \boxed{\underline{0.415}\,g\ H_2}$

(c) $Pb(NO_3)_2 + 2HCl \rightarrow PbCl_2 + 2HNO_3$

$15.0\,g\ Pb(NO_3)_2 \times \frac{1\ mol}{331.2\,g} = \underline{0.0453}\ mol\ Pb(NO_3)_2$

$15.0\,g\ HCl \times \frac{1\ mol}{36.5\,g} = \underline{0.411}\ mol\ HCl$

$\underset{available}{0.0453\ mol\ Pb(NO_3)_2} \times \frac{2\ mol\ HCl}{1\ mol\ Pb(NO_3)_2} = \underline{0.0906}$ mol HCl needed to use up all of the available $Pb(NO_3)_2$. There is way too much HCl available.

$Pb(NO_3)_2$ is the limiting reactant

$0.0453\ mol\ Pb(NO_3)_2 \times \frac{1\ mol\ PbCl_2}{1\ mol\ Pb(NO_3)_2} \times \frac{278.1\,g\ PbCl_2}{1\ mol\ PbCl_2} = \underline{12.6}\,g\ PbCl_2$

$0.0453\ mol\ Pb(NO_3)_2 \times \frac{2\ mol\ HNO_3}{1\ mol\ Pb(NO_3)_2} \times \frac{63\,g\ HNO_3}{1\ mol\ HNO_3} = \underline{5.71}\,g\ HNO_3$

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(35) ⓐ $2\,NH_3 + 2Na \longrightarrow 2\,NaNH_2 + H_2$

$$50.0g\ NH_3 \times \frac{1\ mol\ NH_3}{17\ g\ NH_3} = \underline{2.94}\ mol\ NH_3$$

$$50.0g\ Na \times \frac{1\ mol\ Na}{23.0\ g\ Na} = \underline{2.17}\ mol\ Na$$

$$\underset{available}{2.94\ mol\ NH_3} \times \frac{2\ mol\ Na}{2\ mol\ NH_3} = \underline{2.94}\ mol\ Na$$

needed to use up all of the NH_3 available. → Na is the L.R., because there is too little Na available

$$2.17\ mol\ Na \times \frac{2\ mol\ NaNH_2}{2\ mol\ Na} \times \frac{39.0\ g\ NaNH_2}{1\ mol\ NaNH_2} = \underline{84.6}\ g\ NaNH_2$$

ⓒ $SO_2 + 2NaOH \longrightarrow Na_2SO_3 + H_2O$

$$50.0g\ SO_2 \times \frac{1\ mol}{64.1\ g} = \underline{0.780}\ mol\ SO_2$$

$$50.0g\ NaOH \times \frac{1\ mol}{40.0\ g} = \underline{1.25}\ mol\ NaOH$$

$$\underset{Available}{0.780g\ SO_2} \times \frac{2\ mol\ NaOH}{1\ mol\ SO_2} = \underline{1.56}\ mol\ NaOH$$

needed to use all available SO_2. There is not enough NaOH, NaOH is L.R.

NaOH is L.R.

$$1.25\ mol\ NaOH \times \frac{1\ mol\ Na_2SO_3}{2\ mol\ NaOH} \times \frac{126.1\ g\ Na_2SO_3}{1\ mol\ Na_2SO_3} = \underline{78.8}\ g\ Na_2SO_3$$

(36) $CO + 2H_2 \longrightarrow CH_3OH$

ⓐ

$$10.0mg\ CO \times \frac{1\ g\ CO}{1000\ mg\ CO} \times \frac{1\ mol\ CO}{28\ g\ CO} = \underline{3.57 \times 10^{-4}}\ mol\ CO$$

$$10.0mg\ H_2 \times \frac{1\ g\ H_2}{1000\ mg\ H_2} \times \frac{1\ mol\ H_2}{2.02\ g\ H_2} = \underline{4.95 \times 10^{-3}}\ mol\ H_2$$

$$\underset{available}{3.57 \times 10^{-4}\ mol\ CO} \times \frac{2\ mol\ H_2}{1\ mol\ CO} = \underline{7.14 \times 10^{-4}}\ mol\ H_2\ needed$$

There is a lot more H_2 than this, so H_2 is excess reactant.

CO is L.R.

$$3.57 \times 10^{-4}\ mol\ CO \times \frac{1\ mol\ CH_3OH}{1\ mol\ CO} \times \frac{32\ g\ CH_3OH}{1\ mol\ CH_3OH} = 0.0114\ g\ CH_3OH$$

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(36) (c) $Ca(OH)_2 + 2HBr \rightarrow CaBr_2 + 2H_2O$

$10.0\,\text{mg}\,Ca(OH)_2 \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol}}{74.1\ \text{g}} = \underline{1.35\times10^{-4}}\ \text{mol}\ Ca(OH)_2$

$10.0\,\text{mg} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol}}{80.9\ \text{g}} = \underline{1.24\times10^{-4}}\ \text{mol HBr}$

$1.35\times10^{-4}\ \text{mol}\ Ca(OH)_2\ \text{available} \times \frac{2\ \text{mol HBr}}{1\ \text{mol}\ Ca(OH)_2} = \underline{2.70\times10^{-4}}\ \text{mol HBr needed}$

There is not enough HBr.
HBr is L.R.

$1.24\times10^{-4}\ \text{mol HBr} \times \frac{1\ \text{mol}\ CaBr_2}{2\ \text{mol HBr}} \times \frac{199.9\ \text{g}\ CaBr_2}{1\ \text{mol}\ CaBr_2} = \underline{0.0124}\ \text{g}\ CaBr_2$

$1.24\times10^{-4}\ \text{mol HBr} \times \frac{2\ \text{mol}\ H_2O}{2\ \text{mol HBr}} \times \frac{18\text{g}\ H_2O}{1\ \text{mol}\ H_2O} = \underline{2.23\times10^{-3}}\ \text{g}\ H_2O$

(38) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

$1.25\text{g Fe} \times \frac{1\ \text{mol}}{55.85\ \text{g}} = \underline{0.0224}\ \text{mol Fe}$

$0.0224\ \text{mol Fe} \times \frac{3\ \text{mol}\ O_2}{4\ \text{mol Fe}} = \underline{0.0168}\ \text{mol}\ O_2$ needed to use all Fe

There is 0.0204 mol O_2 available, which is too much (more than needed).

$0.0224\ \text{mol Fe} \times \frac{2\ \text{mol}\ Fe_2O_3}{4\ \text{mol Fe}} \times \frac{159.7\ \text{g}\ Fe_2O_3}{1\ \text{mol}\ Fe_2O_3} = \underline{1.79}\ \text{g}\ Fe_2O_3$

(41) Perhaps not all reactant molecules can actually come into contact with one another.

(44) $2LiOH + CO_2 \rightarrow Li_2CO_3 + H_2O$

$\rightarrow 155\text{g LiOH} \times \frac{1\ \text{mol LiOH}}{23.9\ \text{g LiOH}} \times \frac{1\ \text{mol}\ CO_2}{2\ \text{mol LiOH}} \times \frac{44\ \text{g}\ CO_2}{1\ \text{mol}\ CO_2} = \underline{142}\ \text{g}\ CO_2$

$\rightarrow (102/142) \times 100 = 71.6\%$ of capacity

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㊻

$$\begin{array}{ccccccccc} CaCO_3 & + & 2HCl & \longrightarrow & CaCl_2 & + & CO_2 & + & H_2O \\ 155g & & 250.\,g & & 142g & & & & \\ & & & & \uparrow & & & & \\ & & & & \text{actual yield} & & & & \end{array}$$

$$155g\ CaCO_3 \times \frac{1\ mol\ CaCO_3}{100.1\ g\ CaCO_3} = \underline{1.55}\ mol\ CaCO_3$$

$$250.\ g\ HCl \times \frac{1\ mol\ HCl}{36.5g\ HCl} = \underline{6.85}\ mol\ HCl$$

$$\underset{\text{available}}{1.55\ mol\ CaCO_3} \times \frac{2\ mol\ HCl}{1\ mol\ CaCO_3} = \underline{3.10}\ mol\ HCl\ \text{needed to consume all available}\ CaCO_3.$$

There is too much HCl.

$CaCO_3$ is L.R.

$$1.55\ mol\ CaCO_3 \times \frac{1\ mol\ CaCl_2}{1\ mol\ CaCO_3} \times \frac{111\ g\ CaCl_2}{1\ mol\ CaCl_2} = \underline{172.0}\ g\ CaCl_2\ \text{should have been produced}$$

$$\frac{142g = \text{actual yield}}{172g = \text{theoretical yield}} \times 100 = \boxed{82.5\ \%\ \text{yield}}$$