Name: Key

1. 485 mL of 0.200 M aqueous copper (II) nitrate will react with solid zinc to form solid copper and aqueous zinc nitrate.

a) What is the balanced chemical equation for this reaction?

$Cu(NO_3)_{2\,(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + Zn(NO_3)_{2\,(aq)}$

b) How many moles of copper (II) nitrate are reacting?

$n = M \cdot V \qquad 0.200\,M \times 0.485\,L = 0.0970\ mol\ Cu(NO_3)_2$

c) What mass of zinc will react completely with the copper (II) nitrate solution?

$0.0970\ mol\ Cu(NO_3)_2 \times \frac{1\ mol\ Zn}{1\ mol\ Cu(NO_3)_2} = 0.0970\ mol\ Zn$

$0.0970\ mol\ Zn \times 65.4\ g/mol = 6.34\ g\ Zn$

d) What mass of copper product would you expect?

$0.0970\ mol\ Cu(NO_3)_2 \times \frac{1\ mol\ Cu}{1\ mol\ Cu(NO_3)_2} = 0.0970\ mol\ Cu$

$0.0970\ mol\ Cu \times 63.6\ g/mol = 6.17\ g\ Cu$

2. If 9.25 grams of zinc are reacted with 125 mL of 1.00 M HCl, then zinc chloride and hydrogen gas are formed.

a) Write a balanced chemical equation for this reaction.

$Zn_{(s)} + 2\,HCl_{(aq)} \rightarrow ZnCl_{2\,(aq)} + H_{2\,(g)}$

b) Show which reactant is in excess and which reactant is limiting.

$mol\ Zn = 9.25\,g \times 1\,mol/65.4\,g = 0.141\ mol\ Zn$

$mol\ HCl = 1.00\,M \times 0.125\,L = 0.125\ mol\ HCl$

	Zn	:	HCl
equation	1	:	2
actual	0.141	:	0.125
	i	:	0.250

Zn in XS

HCl Limiting

c) How many litres of hydrogen gas should be formed at STP?

$0.125\ mol\ HCl \left(\frac{1\ mol\ H_2}{2\ mol\ HCl}\right) = 0.0625\ mol$

$0.0625\ mol \times 22.4\,L/mol = 1.40\,L\ H_2$

$Ca_3(PO_4)_{2(s)} + 3\,H_2SO_{4(aq)} \rightarrow 3\,CaSO_{4(s)} + 2\,H_3PO_{4(aq)}$

4.719 g of $Ca_3(PO_4)_2$ and 225.0mL of 0.450 M H_2SO_4 are mixed together; 4.087 g of $CaSO_4$ is produced.

a) Is there a limiting reagent? If so, what is it?

$mol\ Ca_3(PO_4)_2 = 4.719\,g \times 1\,mol/310.3\,g = 0.01521\ mol$

$mol\ H_2SO_4 = 0.450\,M \times 0.2250\,L = 0.1013\ mol$

mol Ratio	$Ca_3(PO_4)_2$	:	H_2SO_4
	1	:	3
	0.01521	:	0.0456
	i	:	0.0557

yes, LR is $Ca_3(PO_4)_2$

b) Determine the percent yield of the reaction.

$mol\ CaSO_4 = 0.01521\ mol\ Ca_3(PO_4)_2 \left(\frac{3\ mol\ CaSO_4}{1\ mol\ Ca_3(PO_4)_2}\right) = 0.04563\ mol\ CaSO_4$

$g\ CaSO_4 = 0.04563\ mol \times 136.2\ g/mol = 6.215\ g$

$\%\ yield = \left(4.087\,g / 6.215\,g\right) \times 100 = 65.8\%\ yield$

Key

4. The oxidation of NH_3 is an important reaction in the preparation of nitric acid. The equation for the first step of that process is

$$4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 6\ H_2O_{(g)} + 4\ NO_{(g)}$$

a) How many litres of oxygen at STP are needed to react with 5.0 kg of NH_3?

$5.0\,kg \times \frac{1000\,g}{1\,kg} \times \frac{1\,mol}{17.0\,g} = 294\ mol\ NH_3$

$294\ mol\ NH_3 \times \frac{5\ mol\ O_2}{4\ mol\ NH_3} = 368\ mol\ O_2$

$368\ mol\ O_2 \times 22.4\,L/mol = \underline{\underline{8.2 \times 10^3\ L\ O_2}}$

b) How many litres of air are required assuming air is 21% oxygen by volume?

$21\% = \frac{8.2 \times 10^3\,L\,O_2}{air} \times 100$

$air = \underline{\underline{3.9 \times 10^4\,L}}$

5. The thermal decomposition of calcium carbonate produces calcium oxide and carbon dioxide gas.

a) Write a balanced chemical equation for this reaction.

$$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$$

b) If a 28.0 g sample of calcium carbonate is heated for 20 minutes the solid weighs 25.0 grams. How many litres of carbon dioxide gas will be produced in 20 minutes at STP?

$28.0\,g - 25\,g = 3.0\,g\ CO_2$ released $\quad 3.0\,g \times \frac{1\,mol}{44.0\,g} = 0.068\ mol$

$0.068\ mol \times 22.4\,L/mol = \underline{\underline{1.5\,L\ CO_2}}$

c) What is the mass of calcium oxide in the 25.0 g solid?

$0.068\ mol\ CO_2 \times \frac{1\ mol\ CaO}{1\ mol\ CO_2} = 0.068\ mol\ CaO$

$0.068\ mol\ CaO \times \frac{56.1\,g}{1\ mol} = \underline{\underline{3.8\,g}}\ CaO$ the rest is unreacted $CaCO_{3(s)}$

d) What is the percentage yield of this reaction?

Yield is $3.0\,g\ CO_2 + 3.8\,g\ CaO = 6.8\,g$ product

$\frac{6.8\,g}{28.0\,g} \times 100 = \underline{\underline{24.0\%}}$