1) In a certain experiment, 0.424 mol sample of Zn is allowed to react with 158 mL of 7.60 M HNO_3 according to the following reaction:

$$Zn_{(s)} + HNO_{3(aq)} \rightarrow Zn(NO_3)_{2(aq)} + H_2O_{(l)} + NO_{2(g)}$$

a) What is the limiting reactant?

b) How many grams of NO_2 is formed?

c) How many grams of the excess reactant remain after the limiting reactant is completely consumed?

Given,

Zn	HNO_3
n = 0.424	V = 158 ml
	C = 7.60 M

$$1\,Zn + 4\,HNO_3 \rightarrow 1\,Zn(NO_3)_2 + 2H_2O + 2NO_2$$

① limiting reactant ⇝ finding (n) of reactants.

$n = \frac{m}{M_r}$

$n = C \times V$ (M, L)

$n_{Zn} = 0.424$

$n_{HNO_3} = C \times V = 7.60 \times \frac{158}{1000} = 1.2324$ mol.

$n_{Zn(NO_3)_2}$ → Zn → $n = 0.424$

$n_{Zn(NO_3)_2}$ → HNO_3 →

HNO_3	$Zn(NO_3)_2$
4	1
1.2324	? $\frac{1.2324}{4} = 0.3081$

HNO3 is the limiting reacting

Zn is in excess.

⇝ another way for determining limiting reactant.

required $\frac{n_{Zn}}{n_{HNO_3}} = \frac{1}{4} = 0.25$

actual $\frac{n_{Zn}}{n_{HNO_3}} = \frac{0.424}{1.2324} = 0.344$

Zn excess

HNO3 limiting

(b) $m_{NO_2} = ?$

* find (n) of NO_2 by using molar ratio → HNO_3

HNO_3	→	NO_2
4		2
1.2324		?

$$n_{NO_2} = \frac{2 \times 1.2324}{4} = 0.6162 \text{ mol.}$$

$$m_{NO_2} = n \times M_r = 0.6162 \times (14.007 + 2 \times 15.999)$$
$$= 28.348 \simeq 28.3 \text{ g}$$

(c) → * find (n) of Zn reacted from {HNO_3}

Zn reacted	HNO_3
1	4
?	1.2324

$$n_{Zn\ reacted} = \frac{1.2324}{4} = 0.3081 \text{ mol.}$$

$$n_{Zn\ unreacted} = n_{original} - n_{reacted} = 0.424 - 0.3081$$
$$= 0.1159$$

$$m_{Zn\ unreacted} = n \times M_r$$
$$= 0.1159 \times 65.39 = 7.578 \simeq 7.58 \text{ g}$$

$$\% \text{ yield} = \frac{\text{actual yield (given)}}{\text{theoritical yield (calculated)}} \times 100$$

2) Aluminum oxide, Al_2O_3, can be prepared by the reaction between solid aluminium, Al, and solid chromium(III) oxide, Cr_2O_3. The other product of the reaction is liquid chromium, Cr. In an experiment, a reaction mixture containing 45.7 g Al and 45.7 g Cr_2O_3 yields 17.5 g Al_2O_3. Calculate the percentage yield of the experiment.

$$2Al + Cr_2O_3 \rightarrow Al_2O_3 + 2Cr$$

45.7 g   45.7 g   17.5 g

* determining limiting reactant

$$n_{Al} = \frac{m}{Mr} = \frac{45.7}{26.982} = 1.6937$$

$$n_{Cr_2O_3} = \frac{45.7}{151.989} = 0.300679$$

$n_{Al_2O_3}$ (from Al): Al : Al_2O_3 = 2 : 1; 1.6937 : ?

$$n = \frac{1.6937}{2} = 0.8468$$

$n_{Al_2O_3}$ (from Cr_2O_3): Cr_2O_3 : Al_2O_3 = 1 : 1; 0.300679 : 0.300679

Cr_2O_3 is limiting

& will be used

$$m_{Al_2O_3} = n \times Mr = 0.300679 \times 101.961$$
$$= 30.657 \text{ g} \rightarrow \text{theoritical}$$

$$\% \text{ yield} = \frac{m_{actual}}{m_{theori}} \times 100 = \frac{17.5}{30.657} = 57.08\%$$

3) The reaction of NH_3 and O_2 forms NO and water. The NO can be used to convert P_4 to P_4O_6, forming N_2 in the process. The P_4O_6 can be treated with water to form H_3PO_3. How many grams of H_3PO_3 can be produced from 85.0 grams of a sample containing 49.2% NH_3.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

$$6NO + P_4 \rightarrow P_4O_6 + 3N_2$$

$$P_4O_6 + 6H_2O \rightarrow 4H_3PO_3$$

49.2% NH_3

Sample = 85.0 g

$$m_{NH_3} = \frac{49.2}{100} \times 85.0 = 41.82\ g$$

$$n_{NH_3} = \frac{m}{Mr} = \frac{41.82}{17.031} = 2.4555\ mol$$

1st Rxn → n_{NO} = 2.4555 mol.

2nd Rxn →

NO	P_4O_6
6	1
2.4555	?

$$n_{P_4O_6} = \frac{2.4555}{6} = 0.409$$

3rd →

P_4O_6	H_3PO_3
1	4
0.409	?

$$n_{H_3PO_3} = 4 \times 0.409 = 1.636$$

$$m_{H_3PO_3} = n \times Mr$$

$$= 1.636 \times 81.995 = 134.14\ g$$

4) The purity of phosphorus sample was tested by the redox reaction between NaOH, and phosphorus in water according to the below reaction. If 45.92 g of NaOH yielded 5.760 g PH_3, what is the percent impurity of phosphorus by mass?

$$4\,P_{(s)} + 3\,NaOH_{(aq)} + 3\,H_2O_{(l)} \rightarrow 3\,NaH_2PO_{2(aq)} + PH_{3(g)}$$

$n_{NaOH} = \frac{m}{M_r} = \frac{45.92}{39.997} = 1.148$ mol

P	NaOH
4	3
?	1.148

$n_P = \frac{1.148 \times 4}{3} = 1.531$ mol

sample $m_P = n \times M_r = 1.531 \times 30.974 = 47.414\,g$

pure $m_P \rightarrow PH_3$

$n_P = n_{PH_3}$

$n_{PH_3} = \frac{5.760}{33.998} = 0.1694$

$m_{P\,pure} = 0.1694 \times 30.974 = 5.2477\,g$

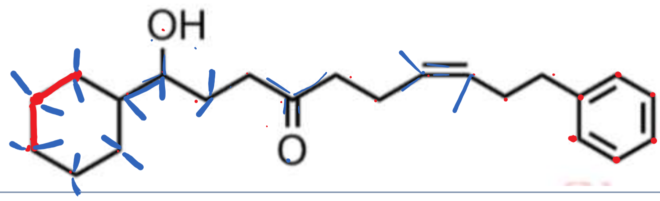
impure $m_P = m_{Sample} - m_{pure}$

$\%\ Impurity = \frac{47.414 - 5.2477}{47.414} \times 100 = 88.932\ \%$

Substance + O_2 → CO_2 + H_2O

5) Write the balanced combustion reaction of 72.0 g of the molecule drawn below. How many grams of oxygen are consumed? How many grams of CO_2 are produced?

$C_{22}H_{32}O_2$



C, H, O
22 2

$$C_{22}H_{32}O_2 + 29O_2 \rightarrow 22CO_2 + 16H_2O$$

72.0 g → n → n → g

$$n = \frac{72.0}{328.496} = 0.219$$

n of O_2

$C_{22}H_{32}O_2$	O_2
1	29
0.219	?

$$n_{O_2} = \frac{29 \times 0.219}{1} = 6.356$$

$$m_{O_2} = n \times M_r = 6.356 \times 2 \times 15.999 = 203.38\ g$$

n of CO_2

$$n_{CO_2} = 22 \times 0.219 = 4.818$$

$$m_{CO_2} = 4.818 \times (12.011 + 2 \times 15.999) = 212.03\ g$$