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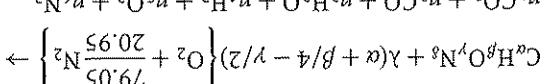
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$n_1 \text{CO}_2 + n_2 \text{CO} + n_3 \text{H}_2\text{O} + n_4 \text{H}_2 + n_5 \text{O}_2 + n_6 \text{N}_2$



generalised combustion equation with air can be written as

products of combustion are limited to CO_2 , CO , H_2O , H_2 , O_2 and N_2 , then the

Consider now the combustion of an arbitrary fuel ($\text{C}_6\text{H}_6\text{O}_y\text{N}_6$) with air. If the

where the excess air ratio (α) is unity for stoichiometric reactions, and greater than

unity for weak mixtures.

Four atomic balances can be written:

$\text{C balance: } \alpha = n_1 + n_2$

$\text{H balance: } \beta = 2n_3 + 2n_4$

$\text{O balance: } \gamma + \alpha(\alpha + \beta/4 - \gamma/2) = 2n_1 + n_2 + n_3 + 2n_5$

$\text{N balance: } \delta + \alpha(\alpha + \beta/4 - \gamma/2) = 2n_1 + n_2 \times \frac{20.95}{79.05} = 2n_6$

$N_{\text{balance}}: \delta + \alpha(\alpha + \beta/4 - \gamma/2) = 2n_1 + n_2 \times \frac{20.95}{79.05} = 2n_6$

With six unknowns and only four simultaneous equations, then two further

equations are needed. A convenient simplification is to assume no oxygen in the

products of rich combustion, and no hydrogen or carbon monoxide in the products

of weak combustion. In other words:

For rich mixtures a further equation is still required, and this is provided by the

water gas equilibrium:

For rich mixtures ($\alpha < 1$): $n_5 = 0$

weak mixtures ($\alpha > 1$): $n_2 = n_4 = 0$

stoichiometric mixtures ($\alpha = 1$): $n_2 = n_4 = n_5 = 0$

Table 3.2 Simplified products of combustion

Species	α	Weak ($\alpha > 1$)	Rich ($\alpha < 1$)
CO_2	1	α	$\alpha - n_2$
H_2O	3	$\beta/2$	n_2
CO	2	0	n_2
H_2	4	0	$\beta/2 - \gamma - \alpha(\alpha + \beta/4 - \gamma/2)2 - 2n_2$
O_2	5	$(\alpha - 1)(\alpha + \beta/4 - \gamma/2)$	0
N_2	6	$\alpha(\alpha + \beta/4 - \gamma/2)$	$\alpha(\alpha + \beta/4 - \gamma/2) 79.05/20.95 + 6/2$

Table 3.2 Simplified products of combustion

written with variable n_2 included; this can now be eliminated by use of the
For the rich products of combustion in table 3.2 the compositions have been
are summarised in table 3.2.

Simultaneous solution of equations (3.9) to (3.15) and (3.17) yields the results that

$$K_p = \frac{n_2 n_4}{n_1 n_3} \quad (3.17)$$

for which the equilibrium constant is K_p :

$$\text{CO}_2 + \text{H}_2 \rightleftharpoons \text{CO} + \text{H}_2\text{O} \quad (3.16)$$

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Species	α	Weak ($\alpha > 1$)	Rich ($\alpha < 1$)
CO_2	1	$\alpha - n_2$	n_2
H_2O	2	α	$\alpha - n_2$
CO	3	0	n_2
H_2	4	$\beta/2$	$\gamma + \alpha(\alpha + \beta/4 - \gamma/2)2 - 2\alpha + n_2$
O_2	5	$(\alpha - 1)(\alpha + \beta/4 - \gamma/2)$	$\beta/2 - \gamma - \alpha(\alpha + \beta/4 - \gamma/2)2 + 2\alpha - n_2$
N_2	6	0	$\alpha(\alpha + \beta/4 - \gamma/2)79.05/20.95 + 8/2$

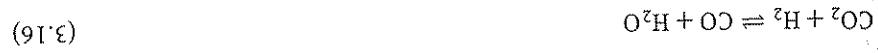
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$$\text{weak mixtures } (\alpha > 1): \quad n_2 = n_4 = 0 \quad (3.14)$$

$$\text{rich mixtures } (\alpha < 1): \quad n_5 = 0 \quad (3.13)$$

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$$N \text{ balance: } 8 + \alpha(\alpha + \beta/4 - \gamma/2)2 \times \frac{20.95}{79.05} = 2n_6 \quad (3.12)$$

$$O \text{ balance: } \gamma + \alpha(\alpha + \beta/4 - \gamma/2)2 = 2n_1 + n_2 + n_3 + 2n_5 \quad (3.11)$$

$$H \text{ balance: } \beta = 2n_3 + 2n_4 \quad (3.10)$$

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$$\text{C}_x \text{H}_y \text{O}_z \text{N}_w + \alpha(\alpha + \beta/4 - \gamma/2) \left[\text{O}_2 + \frac{20.95}{79.05} \text{N}_2 \right] \rightarrow$$

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