Combustion Numericals

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DEPT. CLASS DIV ROLL NO. DATE

SUBJECT

Questions	1	2	3	4	5	6	7	8	Total
Marks obtained									

Examiner

1. Calculate the weight of air & volume of air required for combustion of 3 kg of carbon

Sol[n] Combustion reaction

$$C + O_2 \longrightarrow CO_2$$
$$12g \quad 32g$$

Wt of O_2 reqd to burn 12 kg C = 32 kg

Wt of O_2 reqd to burn 3 kg C $= \frac{32}{12} \times 3 = 8$ kg

As air contains 23% O_2 by mass

∴ Wt of air reqd $= 8 \times \frac{100}{23} = 34.783$ kg $= 34783$ g

Vol. of air reqd.:

As 1 mole of any gas at NTP occupies 22.4 lit

∴ vol. occupied by 1 mole air = 28.94 gm = 22.4 lit

∴ Vol. of ~~air~~ occupied by 34783 g of air — ?

$$= \frac{22.4 \times 34783}{28.29}$$
$$= 26.92 \times 10^3 \text{ lit}$$
$$= 26.92 \text{ m}^3 \qquad (\because 1 \text{ lit} = 10^{-3} \text{ m}^3)$$

2. Calculate the mass of air needed for combustion of 5 kg of coal containing C = 80% H 15% O-r4

Basic: Let 1 kg coal contain 0.8 kg C 0.15 kg H & O_2 = 0.05 kg

Wt of ~~air~~ O_2 reqd $= \left[\frac{32}{12} C + 8H + S - O\right]$

$$= \frac{32}{12} \times 0.8 + 8 \times 0.15 - 0.05$$

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% = 26667

= 2.1333 + 1.2 − 0.05

= 3.2833 kg

Wt of O_2 reqd = 3.2833 kg

wt of air reqd = $\frac{100}{23} \times 3.2833$

= 14.275 kg.

wt of air reqd for combustion of 5 kg of coal = 5 × 14.275

= 71.3767 kg

3) A sample of coal was found to have the foll composition by wt
C = 75% H = 5.2% O = 12.1%
N = 3.2% & ash = 4.5%
Calculate
(1) Minimum amt of O_2 & air necessary for complete combustion of 1 kg of coal
(2) wt of air reqd if 40% excess air is supplied

Soln. Basis: 1 kg coal contain
0.75 kg C 0.052 kg H 0.121 kg O

Minimum amt of O_2 reqd for complete combustn of coal = $\frac{32}{12}C + 8H + S - O$

$= \left(\frac{32}{12} \times 0.75\right) + (8 \times 0.052) + 0 - 0.121$

= 2 + 0.416 − 0.121

= 2.295 kg

Min. wt of air reqd = $\frac{100}{23} \times 2.295$

= 9.9782 kg

Actual wt of air supplied = $\frac{140}{100} \times 9.9782$ = 13.9694 kg

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4. A fuel is found to contain C: 90% H: 6% S: 2.5% O: 1% & ash 0.5%. Calculate the amount of air reqd for complete combustion of 1 kg of fuel.
If 25% excess air is used for combusting calculate % composition of dry products in combustion.

Soln: Basis: 1 kg fuel contain
C = 0.9 kg H = 0.06 kg S = 0.025 kg O = 0.01 kg

Wt of air reqd for complete combustion of fuel

$$= \left[\frac{32}{12}C + 8H + S - O\right] \times \frac{100}{23}$$

$$= \left[\left(\frac{32}{12} \times 0.9\right) + (8 \times 0.06) + 0.025 - 0.01\right] \times \frac{100}{23}$$

$$= [2.4 + 0.48 + 0.025 - 0.01] \times \frac{100}{23}$$

$$= 12.5869 \text{ kg}$$

25% excess air is supplied

$$\therefore \text{Excess air} = 12.587 \times \frac{25}{100} = 3.147 \text{ kg}$$

$$\text{Actual air supplied} = \frac{125}{100} \times 12.587 = 15.734$$

OR

$$(12.587 + 3.147)$$

Dry Products in flue gas: Flue gases contains CO_2, SO_2, O_2 from excess air & N_2 from actual air supplied

$$\text{wt of } CO_2 = \frac{44}{12} \times 0.9 = 3.3 \text{ kg}$$

$$SO_2 = \frac{64}{32} \times 0.025 = 0.05 \text{ kg}$$

$$\text{wt of } O_2 = 3.147 \times \frac{23}{100} = 0.724 \text{ kg}$$

$$\text{wt of } N_2 = 15.734 \times \frac{77}{100} = 12.115 \text{ kg}$$

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Total wt of flue gases = 3.3 + 0.05 + 0.724 + 12.115
= 16.189 kg

Percentage of dry flue gas

$\% CO_2 = \frac{\text{wt of } CO_2}{\text{wt of flue gas}} \times 100 = \frac{3.3}{16.189} \times 100 = 20.38\%$

$\% SO_2 = \frac{0.05}{16.189} \times 100 = 0.309\%$

$\% O_2 = \frac{0.724}{16.189} \times 100 = 4.47\%$

$\% N_2 = \frac{12.115}{16.189} \times 100 = 74.835\%$

Problems based on Volume Calculation

1. A gas used in ICE had the foll. comp by vol. : $H_2 = 45\%$ $CH_4 = 36\%$ $CO: 15\%$ $N_2 = 4\%$. Find the volume of air reqd for the combustion of $1 m^3$ of the gas.

Soln.

Basis : $1 m^3$ of gas contains

$H_2 = 0.45 m^3$; $CH_4 = 0.36 m^3$

$CO = 0.15 m^3$ $N_2 = 0.04 m^3$

N_2 does not combust ;

$H_2 + \frac{1}{2} O_2 \longrightarrow H_2O$

1 : 0.5

$\therefore$ Vol. of O_2 reqd for H_2 = $0.45 \times 0.5 = 0.225$

$CH_4 + 2 O_2 \longrightarrow CO_2 + 2H_2O$

1 vol : 2 vol

$\therefore$ Vol of O_2 for CH_4 = $0.36 \times 2 = 0.72$

$CO + \frac{1}{2} O_2 \longrightarrow CO_2$

1 : 0.5

$\therefore$ Vol. of O_2 for CO = $0.15 \times 0.5 = 0.075$

Total Vol of O_2 reqd = $0.225 + 0.72 + 0.075$
$= 1.020 m^3$

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Total O_2 reqd $= 0.4 + 0.05 + 0.15 + 0.4$
$= 1.0\ m^3$

O_2 present in fuel $= 0.020\ m^3$

$\therefore$ Net O_2 reqd $= 1 - 0.020 = 0.98\ m^3$

$\therefore$ Vol. of air reqd for the combustion of $1\ m^3$ of fuel $= 0.98 \times \frac{100}{21} = 4.67\ m^3$

Calculation of dry flue gases

$CO_2 = 0.2 + 0.1 + 0.05 + 0.1 + 0.24 = 0.69\ m^3$

$N_2 = N_2\ (\text{fuel}) + N_2\ (\text{from air})$
$= 0.5 + \left(\frac{79}{100} \times 4.67\right) = 4.19\ m^3$

Total Vol. of dry products $= 0.69 + 4.19$
$= 4.88\ m^3$

$\therefore \%\ CO_2 = \frac{0.69}{4.88} \times 100 = 14.139\%$

$\%\ N_2 = \frac{4.19}{4.88} \times 100 = 85.861\%$

4) A gaseous fuel has the foll composition by volume: $CH_4 = 53\%$, $CO = 26\%$, $CO_2 = 10\%$, $H_2 = 10\%$, $N_2 = 1\%$. If 20% excess air is supplied, calculate volume of air supplied & % composition of dry flue gases.

(1) % to Volume conversion

$CH_4 \rightarrow 53\% \rightarrow 0.53\ m^3$
$CO \rightarrow 26\% \rightarrow 0.26\ m^3$
$CO_2 \rightarrow 10\% \rightarrow 0.10\ m^3$

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$* \ \% \ CO_2 = \frac{\text{Vol of } CO_2}{\text{Vol of fluegas}} = \frac{0.89}{6.74} \times 100 = 13.20\%$

$\% \ O_2 = \frac{0.25}{6.74} \times 100 = 3.71\%$

$H_2 \rightarrow 10\% \rightarrow 0.10 \ m^3$

$N_2 \rightarrow 1\% \rightarrow 0.01 \ m^3$

$\% \ N_2 = \frac{5.6}{6.74} \times 100 = 83.08\%$

Combustion Reactions

① $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

② $CO + \frac{1}{2}O_2 \longrightarrow CO_2$

③ $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$

Total volume of O_2 required for combustion

$= (0.53 \times 2) + (0.26 \times 0.5) + (0.10 \times 0.5)$

$= 1.06 + 0.13 + 0.05$

$= 1.24 \ m^3$

① Amount of air required (without excess air) $= \frac{1.24 \times 100}{21} = 5.90 \ m^3$

② Actual air supplied $= \frac{1.24 \times 120}{21} = 7.08 \ m^3$

③ Excess air $= 7.08 - 5.90 = 1.18 \ m^3$

Flue Gas Composition

① Flue gas contains CO_2, SO_2, O_2 (from excess air) & N_2 (from actual air supplied)

Vol of CO_2 = (CO_2 from CH_4) + (CO_2 from CO) + (CO_2 from fuel)

$= 0.53 + 0.26 + 0.1$

$= 0.89 \ m^3$

Vol. of SO_2 — Nil

Vol. of $O_2 = \frac{21}{100} \times 1.18 = 0.25 \ m^3$

Vol. of N_2 = Vol. of N_2 from fuel + from Actual air supplied

$= 0.01 + \left(\frac{79}{100} \times 7.08\right)$

$= 5.60 \ m^3$

Total Vol of flue Gas $= 0.89 \ (CO_2) + 0.25 \ (O_2) + 5.6 \ (N_2)$

$= 6.74 \ m^3$