(6) For calculating the quantity of air required for combustion following formulae can be applied :

$$\text{Weight of air needed} = \left\{\frac{32C}{12} + \frac{16H}{2} + \frac{32S}{32} - O\right\} \times 100$$

('O' is oxygen present in fuel)

$$\text{Volume of air required} = (\text{Number of moles of air}) \times 22.4 \text{ litres at N.T.P.}$$

$$= \frac{\text{Weight of air needed in g}}{28.94} \times 22.4 \text{ litres at N.T.P.}$$

(7) The mass of any gas can be converted to its volume at certain temperature and pressure by using the gas equation

$$PV = nRT$$

Where P = Pressure of gas in atmosphere

V = Volume of gas in litres

n = Number of mole of the gas

T = Temperature on the Kelvin scale.

(8) To calculate the volume of gas at given temperature and pressure, following relation is used,

$$\frac{P_0 V_0}{T_0} = \frac{P_1 V_1}{T_1} \quad \text{(from Boyle's and Charles law)}$$

Where P_0, V_0 and T_0 are standard pressure, volume and temperature, P_1 and T_1 are the given pressure and temperature. Thus, V_1 volume at given pressure and temperature can be easily calculated.

6.12 Numericals on Combustion

(A) Calculation of Amount of Air (Weight Basis)

Problem 1

A coal sample contains C = 65%, H = 13%, O = 6%, S = 4%, N = 2%. Calculate the minimum amount of air needed for complete combustion of 1 kg of coal.

(M.U. May 2008)

Solution :

Constituent	% by weight	Weight of each per kg of fuel
C	65	65 / 100 = 0.65
H	13	13 / 100 = 0.13
O	6	6 / 100 = 0.06
N	2	Does not contribute
S	4	4 / 100 = 0.04

$$\text{Amount of air required} = \frac{100}{23}[2.67\,C + 8\,H + S - O]\ \text{kg}$$

$$= \frac{100}{23}[2.67 \times 0.65 + 8 \times 0.13 + 0.04 - 0.06]\ \text{kg}$$

$$= \frac{100}{23}[1.7355 + 1.04 - 0.02]\ \text{kg}$$

$$= \frac{100}{23}[2.7555]\ \text{kg}$$

$$= 11.98\ \text{kg}$$

Ans. : Weight of air needed for combustion of 1 kg of fuel = 11.98 kg.

Problem 2

A coal sample was found to contain the following constituents : C = 81%, O = 8%, S = 1%, H = 5%, N = 1%, ash = 4%. Calculate the minimum amount of air required for complete combustion of 2 kg of coal. **(M.U. May 2010)**

Solution :

Constituent	% by weight	Weight of each per kg of fuel
C	81	81 / 100 = 0.81
O	8	8 / 100 = 0.08
S	1	1 / 100 = 0.01
H	5	5 / 100 = 0.05
N	1	Does not contribute

$$\text{Amount of air required} = \frac{100}{23}[2.67C + 8H + S - O]\ \text{kg}$$

$$= \frac{100}{23}[2.67 \times 0.81 + 8 \times 0.05 + 0.01 - 0.08]\ \text{kg}$$

$$= \frac{100}{23}[2.163 + 0.4 + 0.01 - 0.08]\ \text{kg}$$

$$= \frac{100}{23}[2.493]\ \text{kg}$$

$$= 10.839\ \text{kg}$$

$\therefore$ Amount of air required for 2 kg of coal

$$= 2 \times 10.839$$

$$= 21.68\ \text{kg}$$

Ans. : Amount of air needed for 2 kg of coal = 21.68 kg

Problem 3

Calculate weight of air needed for complete combustion of 1 kg of coal containing C = 72%, H = 10%, O = 9%, N = 3% and remaining being ash. **(M.U. Dec. 2011)**

Solution :

Constituent	% by weight	Weight of each per kg of fuel
C	72	72 / 100 = 0.72
H	10	10 / 100 = 0.01
O	9	9 / 100 = 0.09

$$\text{Amount of air required} = \frac{100}{23}[2.67C + 8H + S - O]\ \text{kg}$$

$$= \frac{100}{23}[2.67 \times 0.72 + 8 \times 0.1 - 0.09]\ \text{kg}$$

$$= \frac{100}{23}[1.9224 + 0.8 - 0.09]\ \text{kg}$$

$$= \frac{100}{23}[2.6324]\ \text{kg}$$

$$= 11.45\ \text{kg}$$

Ans. : Weight of air required for combustion of 1 kg of coal = 11.45 kg.

Problem 4

A coal sample was found to contain the following constituents :

C = 81%, H = 6%, S = 1%, N = 2%, Ash = 4% and rest is oxygen.

Calculate the minimum weight of air required at STP for complete combustion of 1 kg of the coal sample.

(M.U. Dec. 2019)

Solution :

Constituent	% by weight	Weight of each per kg of fuel
C	81	81 / 100 = 0.81
H	6	6 / 100 = 0.06
S	1	1 / 100 = 0.01
N	2	Does not contribute
O	6	6 / 100 = 0.06
Ash	4	Does not contribute

$$\text{Amount of air required} = \frac{100}{23}[2.67\,C + 8\,H + S - O]\ \text{kg}$$

$$= \frac{100}{23}[2.67 \times 0.81 + 8 \times 0.06 + 0.01 - 0.06]\ \text{kg}$$

$$= \frac{100}{23}[2.1627 + 0.48 - 0.05]\ \text{kg}$$

$$= \frac{100}{23}[2.5927]\ \text{kg}$$

$$= 11.273\ \text{kg}$$

Ans. : Weight of air required for combustion of 1 kg of coal = 11.273 kg.