

6. Problem on Biological Oxygen Demand

A 2 % solution of sewage sample is kept in incubation for 5 days at 20 Celsius. If dissolved oxygen of day 1 and day 5 are 8.5 mg/lit and 5.5 mg/lit respectively. Calculate BOD

Soln:

Formula:

$$\begin{aligned}\text{BOD} &= (\text{DO}_1 - \text{DO}_5) \times \text{dilution factor} \\ &= (8.5 - 5.5) \times V_f/V_i \\ &= 3 \times 100/2 \\ &= 150 \text{ mg /lit}\end{aligned}$$

ENERGY

$$1 \text{ K cal} = 2.2 \text{ C.H.U} = 3.968 \text{ B.T.U}$$

1. Problem on Dulong-Petit's formula:

Calculate the GCV and NCV of coal sample containing C= 74 % , H= 10%, S = 6%, O= 5% and ash=5%.

Soln:

$$\begin{aligned}\text{GCV} &= 1/100 [8080 \times \%C + 34500 (\text{H}-\text{O}/8) + 2240 \times \text{S}] \\ &= 1/100 [8080 \times 74 + 34500 (10-5/8) + 2240 \times 6] \\ &= 9347.97 \text{ Kcal /Kg}\end{aligned}$$

$$\begin{aligned}\text{NCV} &= \text{GCV} - 9/100 \times \% \text{H} \times 587 \\ &= 9347.97 - 0.09 \times 10 \times 587 \\ &= 8819.67 \text{ Kcal/Kg}\end{aligned}$$

2. _Proximate analysis

i) 1.5 gram of coal was subjected for proximate analysis. The weight of coal after heating at 100 ° C for 60 minutes was found to be 1.28 g. This was further heated in muffle furnace at 925 ° C for 7 minutes, the weight after heating was found 1.08 g. Finally, the coal is heated further at 750 ° C for 30 minutes the weight of residue was found as 0.35 g. Calculate % Moisture, % volatile matter, % ash and % fixed carbon.

Soln: Weight of coal taken for analysis = $W_1 = 1.5$ g
 Weight of coal after heating 100°C for 60 minutes = $W_2 = 1.28$ g
 Weight of coal after heating in furnace at 925°C for 7 minute= $W_3= 1.08$ g
 Weight of coal after heating in furnace at 750°C for 30 min= $W_4= 0.35$ g

Formula:

$$\begin{aligned}\% \text{ Moisture} &= \frac{W_1 - W_2}{W_1} \times 100 \\ &= \frac{1.5 - 1.28}{1.5} \times 100 \\ &= 14.66\end{aligned}$$

$$\begin{aligned}\% \text{ V.M} &= \frac{W_2 - W_3}{W_1} \times 100 \\ &= \frac{1.28 - 1.08}{1.5} \times 100 \\ &= 13.33\%\end{aligned}$$

$$\begin{aligned}\% \text{ Ash} &= \frac{W_4}{W_1} \times 100 \\ &= \frac{0.35}{1.5} \times 100 \\ &= 23.33\%\end{aligned}$$

3. Problem on Ultimate analysis

i)Determination of % Carbon and % Hydrogen:

1.8 gram of coal was analyzed for % C and % H in combustion tube experiment. The vapour released during combustion was absorbed in dry CaCl_2 tube and KOH bulb. The increase in mass of CaCl_2 tube and KOH bulb was found to be 0.35 g and 0.68 g respectively. Calculate % C and % H.

Soln:

Mass of coal = 1.8 g

Increase in mass of CaCl_2 tube = 0.35 g

Increase in mass of KOH bulb = 0.68 g

$$\begin{aligned}\% \text{ Carbon} &= \frac{\text{increase in mass of KOH bulb}}{\text{Mass of coal}} \times \frac{12}{44} \times 100 \\ &= \frac{0.35 \times 12 \times 100}{1.8 \times 44} \\ &= 5.3\end{aligned}$$

$$\begin{aligned}
 \% \text{ Hydrogen} &= \frac{\text{increase in mass of CaCl}_2 \text{ tube}}{\text{Mass of coal}} \times \frac{2}{18} \times 100 \\
 &= \frac{0.68 \times 2 \times 100}{1.8 \times 18} \\
 &= 4.19 \%
 \end{aligned}$$

ii) Kjeldahl Method for determination of Nitrogen:

1.35 gram of coal was heated in Kjeldahl flask for nitrogen determination. The liberated ammonia was dissolved in 45 ml of 0.25 N H₂SO₄ solution. The excess acid required 18 ml of 0.25 N KOH solution for neutralization. while the 50 ml of distilled water required 48 ml of 0.25 N KOH for neutralization. Calculate % Nitrogen in coal.

$$\begin{aligned}
 \% \text{ Nitrogen} &= \frac{(V_{\text{blank}} - V_{\text{Sample}}) \times N_{\text{KOH}} \times 1.4}{\text{Mass of coal}} \\
 &= \frac{(48 - 18) \times 0.25 \times 1.4}{1.35} \\
 &= 7.77 \%
 \end{aligned}$$

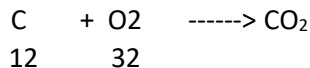
iii) Problem on Sulphur content:

1.1 gram of coal in bomb calorimeter experiment gave of BaSO₄ residue which on heating in furnace and cooling in desiccator gave 0.69 g of residue. Calculate % S in coal sample.

Soln:

$$\begin{aligned}
 \% \text{ Sulphur} &= \frac{\text{mass of BaSO}_4 \text{ residue}}{\text{Mass of coal}} \times \frac{32}{233} \times 100 \\
 &= \frac{0.69 \times 32 \times 100}{1.1 \times 233} \\
 &= 8.61 \%
 \end{aligned}$$

4. Oxygen requirement for combustion for SOLID COAL:

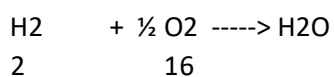


Therefore,

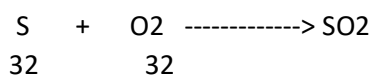
12 gram of carbon required = 32 gram of oxygen for combustion

Hence multiplication factor for oxygen required = $\frac{12}{32}$

Similarly,



Hence, multiplication factor for oxygen required = $\frac{16}{2}$



Multiplication factor for oxygen required = $\frac{32}{32}$
= 1

Element	Multiplication Factor
Carbon	32/12
Hydrogen	16/2
Nitrogen	- (no reaction with oxygen)
Sulphur	32/32
Oxygen	-1

- i) Calculate the amount of oxygen and air required for combustion of 1 Kg coal containing Carbon =80 %, N= 2.5 %H = 3%, S=2.5 % ash = 5 % .
 % O = 100 – (80 + 2.5 +3+2.5+5)
 = 7 %

Element	Quantity present in 1 Kg	Multiplication Factor	Amount of O2 required
Carbon	0.80 Kg	12 /32	= 0.80 x 12/32 = 0.30
Hydrogen	0.03 Kg	16/2	= 0.03 x 16/2 = 0.24
Sulphur	0.025 Kg	32/32	= 0.025 x 32/32 = 0.025
Nitrogen	0.025 kg	- (does not burn)	-
Ash	0.05 kg	- (does not burn)	-
Oxygen	0.07 kg	1	- 0.07 (subtract from total)
Total oxygen required for burning 1 Kg Coal			= 0.30 + 0.24 + 0.025 +(-0.07) = 0.495 Kg

Total oxygen required for burning 1 kg coal = 0.495 kg

100 Kg of air contains = 23 kg of oxygen

Therefore,

Multiplying factor for converting oxygen to air = 100/23

$$\begin{aligned} 0.495 \text{ kg of oxygen} &= 0.495 \times 100/23 \\ &= 2.152 \text{ Kg} \end{aligned}$$

If in case, oxygen is supplied in excess for combustion of coal then we need to supply extra oxygen than what is calculated for combustion.

For e.g.

Suppose if there is 20% excess air is supplied for combustion

$$\begin{aligned} \text{Amount of air required if 20\% excess air is supplied} &= 2.152 \times 120/100 \\ &= 2.5824 \text{ Kg} \end{aligned}$$

5. Oxygen requirement for combustion for Gaseous Fuel:

- i) Calculate volume of oxygen and air required for combustion of 1 m³ gaseous fuel containing following composition:

CH₄ = 20%, C₃H₆ = 15%, H₂=30%, CO=5%, H₂O=8%, C₂H₆=12%, oxygen remaining.

Gaseous Component	Volume present in 1 m ³	Combustion reaction	Multiplication Factor	Volume of Oxygen required for
CH ₄	0.20 m ³	CH ₄ + 2 O ₂ -----> CO ₂ + 2 H ₂ O	2	= 0.20 x 2 = 0.40 dm ³
C ₃ H ₆	0.15 m ³	C ₃ H ₆ + 9/2 O ₂ -----> 3 CO ₂ + 3H ₂ O	9/2	= 0.15 x 9/2 = 0.675 dm ³
H ₂	0.30 m ³	H ₂ + ½ O ₂ -----> H ₂ O	½	=0.30 x ½ = 0.15 dm ³
CO	0.05 m ³	CO + ½ O ₂ -----> CO ₂	½	=0.05 x ½ = 0.025 dm ³
H ₂ O	0.08 m ³	No reaction	-	-
C ₂ H ₆	0.10 m ³	C ₂ H ₆ + 7/2 O ₂ -----> 2CO ₂ + 3 H ₂ O	7/2	= 0.10 x 7/2 =0.35 dm ³
O ₂	0.10 m ³		-1	-0.10 dm ³
Volume of oxygen required for combustion of 1 dm ³ of fuel				= 0.40

$ \begin{aligned} &+0.675+0.15+0.025+ \\ &0.35-0.10 \\ &= 1.5 \text{ dm}^3 \end{aligned} $
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Therefore,

Volume of oxygen required for combustion of 1 dm³ of fuel = 1.5 dm³

Volume of air:

100 dm³ of air contains = 21 dm³ of oxygen

Therefore,

1.5 dm³ of oxygen will be = $1.5 \times 100/21$

= 7.142 dm³ of air

Volume of oxygen required for combustion of 1 dm³ of fuel = 7.142 dm³ of air

UV-Vis SPECTROSCOPY

1. The transmittance of 2×10^{-4} M of solution was found to be 76.2% at a wavelength of 530 nm when placed in cuvette of path length 1 cm. Calculate absorbance, molar absorptivity and transmittance of sample when pathlength is 2 cm.

Solution:

Formula:

$$A = 2 - \log(\%T)$$

$$A = 2 - \log(76.2)$$

$$= 2 - 1.8819$$

$$= 0.1181$$

$$A = \epsilon \cdot b \cdot C$$

$$\epsilon = \frac{A}{b \cdot c}$$