Solution:

Animal dung (mainly cow dung), poultry wastes, human excreta, plant wastes, papers etc are the raw materials which can be utilised for biogas manufacture.

4. Arrange the following in increasing order of their calorific value and moisture content.

Peat, lignite, anthracite, bituminous.

Solution:

Coal	Calorific value (kcal/kg)
Peat	5,400
Lignite	6,500-7,100
Bituminous	7,000-8,600
Anthracite	8,650-8,700

Increasing order of calorific value

Peat < Lignite < Bituminous < Anthracite.

The decreasing order of moisture content is

Peat > Lignite > Bituminous > Anthracite.

Type-II

Problems Based on Bomb Calorimeter

5. The following data is obtained in a Bomb calorimeter experiment:

Weight of crucible	=	3.649 gm.
Weight of crucible + fuel	=	4.687 gm.
Water equivalent of calorimeter	=	570 gm.
Water taken in calorimeter	=	2200 gm.
Observed rise in temperature	=	2.3°C.
Cooling correction	=	0.047°C.
Acid correction	=	62.6 calories.
Fuse wire correction	=	3.8 calories.
Cotton thread correction	=	1.6 calories.

Calculate the gross calorific value of the fuel sample. If the fuel contains hydrogen, determine the net calorific value. [UPTU...]

lution:

$$HCV = \frac{(W+w)(t_2 - t_1 + C_C) - (C_A + C_F + C_{CT})}{m}$$

$$= \frac{(2200+570)(2.3+0.047) - (62.6+3.8+1.6)}{(4.687-3.649)}$$

$$= \frac{(2200+570)(2.3+0.047)-(62.6+3.8+1.6)}{(4.687-3.649)}$$

$$= \frac{(2770 \times 2.347) - 68}{1.038}$$

$$HCV = 6197.67 \text{ cal/gm}$$

nce the fuel contains 6.5% hydrogen,

$$LCV = (HCV - 0.09 \times H \times 587) \text{ cal/gm}$$

$$LCV = 6261 - 0.09 \times 6.5 \times 587$$

$$= 6261 - 343.4$$

$$LCV = 5854.28 \text{ cal/gm}$$

A sample of coal containing 80% C, 15% H and 5% ash is tested in bomb calorimeter. The following results were obtained.

Weight of coal burnt	= 0.98 gm.
Weight of water taken	= 1000 gm.
Water equivalent of bomb and calorimeter	= 2500 gm.
Rise in temperature	= 2.5 °C.
Cooling correction	= 0.02°C.
Fuse wire correction	= 8 .0 calories.
Acid correction	= 50.0 calories.

suming the latent heat of condensation of steam as 580 cal/gm, calculate the er (*ii*) Lower calorific value of the fuel.

ion:

$$HCV = \frac{(W+w)(t_2 - t_1 + C_C) - (C_A + C_F)}{m}$$

$$HCV = \frac{(1000+2500)(2.5+0.02)-(50+8)}{0.98} \text{ cal/gm}$$

$$= 8940.82 \text{ cal/gm}$$

$$LCV = HCV - 0.09 \times H \times 580$$

$$= 8940.82 - 0.09 \times 15 \times 580 \text{ cal/gm}$$

$$= 8940.82 - 783$$

$$LCV = 8157.82 \text{ cal/gm.}$$

.85 gm of a fuel is burnt completely in excess supply of oxygen. The increa emperature of water in the calorimeter containing 1800 gm of water was fou

be 3°C. Calculate the higher calorific value of the fuel. Given that the water equivalent of calorimeter etc is 180 gm.

lution:

$$HCV = \frac{(W+w)(t_2-t_1)}{m}$$

$$= \frac{(1800+180)(3)}{0.85} \text{ cal/gm}$$

$$HCV = 6988.23 \text{ cal/gm}$$

3. A sample of coal containing 90% C, 8% H and 2% ash. When this coal sample was burnt in bomb calorimeter, the following results were obtained:

Weight of coal burnt	= 0.90 gm.
Weight of water taken	= 800 gm.
Water equivalent of calorimeter	= 2,000 gm.
Rise in temperature	= 2.40 °C.
Cooling correction	= 0.02°C.
Fuse wire correction	= 10 .0 calories.
Acid correction	= 60.0 calories.

Calculate the net and gross calorific values of the coal in cal/gm. Assume the latent heat of condensation of steam as 580 cal/gm.

lution:

$$HCV = \frac{(W+w)(t_2-t_1+C_C)-(C_A+C_F)}{m}$$

$$= \frac{(800+2000)(2.40+0.02)-(60+10)}{0.90}$$

$$= \frac{(2,800\times 2.42)-70}{0.90}$$

$$= 7451.11 \text{ cal/gm}$$

Type-III

Problems Based on HCV and LCV (Dulong's Formula)

9. Calculate the gross and net calorific value of coal having the following tions:

Carbon = 85%, Hydrogen = 8%, Sulphur = 1%
Nitrogen = 2%, Ash = 4%,
Latent heat of combustion of steam = 587 cal/g

Solution:

According to Dulong's formula

$$HCV = \frac{1}{100}\left[8{,}080C + 34{,}500\left(H - \frac{O}{8}\right) + 2{,}240S\right] \text{ cal/gm}$$

Given that

$$C = 85\%$$

$$H = 8\%$$

$$S = 1\%$$

Nitrogen and ash, don't contribute to the calorific value.

$$\therefore \quad HCV = \frac{1}{100}\left[8{,}080 \times 85 + 34{,}500\left(8 - \frac{0}{8}\right) + 2{,}240 \times 1\right]$$

$$= \frac{1}{100}[6{,}86{,}800 + 2{,}76{,}000 + 2{,}240] \text{ cal/gm}$$

$$= \frac{1}{100}[9{,}65{,}040] = 9{,}650.4 \text{ cal/gm.}$$

10. A coal has the following composition by weight: C = 90%, O = 3.0%, S
N = 0.5% and ash = 2.5%. Net calorific value of coal was found to be 8,490
Calculate the percentage of hydrogen and higher calorific value of coal.
[GG

Solution:

Given that $C = 90\%, O = 3\%, S = 0.5\%,$

$$LCV = 8{,}490.5 \text{ kcal/kg.}$$

$$HCV = LCV + 0.09H \times 587 \text{ kcal/kg}$$

or

$$HCV = 8{,}490.5 + 0.09 \times H \times 587$$

or

$$HCV = (8{,}490.5 + 52.8H) \text{ kcal/kg}$$

According to Dulong's formula

$$HCV = \frac{1}{100}\left[8{,}080 \times 90 + 34{,}500\left(H - \frac{3.0}{8}\right) + 2{,}240 \times 0.5\right] k$$

or

$$HCV = [7{,}272 + 345\,H - 129.4 + 11.2] \text{ kcal/kg}$$

or

$$HCV = (7{,}754.8 + 345\,H) \text{ kcal/kcal}$$

From 2 and 3 we have

$$7{,}754.8 + 345H = 8{,}490.5 + 52.8H$$

or $$(345 - 52.8)\,H = 8{,}490.5 - 7{,}754.8$$

or $$\%\ H = \frac{1{,}335.7}{292.2} = 4.575\%$$

From 2 and 4

$$HCV = (8{,}490.5 + 52.8 \times 4.575)\ \text{kcal/kg}$$

$$= (8{,}490.5 + 241.3) = 8{,}731.8\ \text{kcal/kg}$$

Type-IV

Problems Based on Boy's Gas Calorimeter

11. The following data were obtained in a Boy's [illegible] **experiment:**