MATERIAL BALANCE

The naphtha has the following composition by weight

Hydrogen 16.2%

Carbon 83.0%

Sulphur 0.8%

Composition of the same naphtha by mole is

Hydrogen (H_2) 53.85%

Carbon (C) 45.98%

Sulphur (S) 0.17%

Desulphurizer

Sulphur present is removed as Hydrogen Sulphide in the desulphurizer

Input

Naptha :

Hydrogen (H_2)	2454.7 kmol/hr
Carbon (C)	1929.7 kmol/hr
Sulphur (S)	11.1 kmol/hr

Hydrogen gas stream(H_2) 209.8 kmol/hr

Output

Desulphurized Naptha :

Hydrogen (H_2)	2454.7 kmol/hr
Carbon (C)	1929.7 kmol/hr

Hydrogen gas (H_2) 198.1 kmol/hr

Hydrogen Sulphide (H_2S) 11.1 kmol/hr

Primary Reformer

In the primary reformer the desulphurized naphtha is made to react with Steam to yield Hydrogen, Carbon monoxide, Carbon dioxide, Methane.

To prevent the formation of carbon the steam to carbon ratio is maintained at 3.9

Input

Desulphurized Naptha:

Hydrogen (H_2)	2454,7	kmol/hr
Carbon (C)	1929.7	kmol/hr
Hydrogen gas	198.1	kmol/hr
Steam (H_2O)	7525.8	kmol/hr

Output

Hydrogen (H_2)	3745.8	kmol/hr
Carbon monoxide (CO)	964.8	kmol/hr
Carbon dioxide (CO_2)	567.6	kmol/hr
Methane (CH_4)	397.4	kmol/hr
Steam (H_2O)	5440.0	kmol/hr

Secondary Reformer

Input

Hydrogen (H_2)	3745.8	kmol/hr
Carbon monoxide (CO)	964.8	kmol/hr
Carbon dioxide (CO_2)	567.6	kmol/hr
Methane (CH_4)	397.4	kmol/hr

Air:

Nitrogen (N_2)	2148,4	kmol/hr
Oxygen (O_2)	596.4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr
Water vapour (H_2O)	428.4	kmol/hr

Steam (H_2O)	5440	kmol/hr

Output

Hydrogen (H_2)	5418.4	kmol/hr
Carbon monoxide (CO)	1093.2	kmol/hr
Carbon dioxide (CO_2)	817.5	kmol/hr
Methane (CH_4)	19.0	kmol/hr

Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr
Steam (H_2O)	5350.5	kmol/hr

High Temperature Shift Converter

Input

Hydrogen (H_2)	5418.4	kmol/hr
Carbon monoxide (CO)	1093.2	kmol/hr
Carbon dioxide (CO_2)	817.5	kmol/hr
Methane (CH_4)	19.0	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr
Steam (H_2O)	5350.5	kmol/hr

Output

Hydrogen (H_2)	6202.9	kmol/hr
Carbon monoxide (CO)	308.9	kmol/hr
Carbon dioxide (CO_2)	1602.0	kmol/hr
Methane (CH_4)	19.0	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr
Steam (H_2O)	4566.5	kmol/hr

Low Temperature Shift Converter

Input

Hydrogen (H_2)	6202.9	kmol/hr
Carbon monoxide (CO)	308.9	kmol/hr
Carbon dioxide (CO_2)	1602.0	kmol/hr
Methane (CH_4)	19.0	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr
Steam (H_2O)	4566.5	kmol/hr

Output

Hydrogen (H_2)	6474.9	kmol/hr
Carbon monoxide (CO)	31.7	kmol/hr
Carbon dioxide (CO_2)	1879.0	kmol/hr
Methane (CH_4)	19.0	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr
Steam (H_2O)	4289.5	kmol/hr

Condenser

The exit stream from the Low temperature Converter is sent into a condenser to remove the steam present which would be an additional excess load on the Absorber

Within the condenser all the water is removed as condensate. Only water is removed and the exit stream from this goes to the Absorber

Input

Hydrogen (H_2)	6474.9	kmol/hr
Carbon monoxide (CO)	31.7	kmol/hr
Carbon dioxide (CO_2)	1879.0	kmol/hr
Methane (CH_4)	19.0	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr
Steam (H_2O)	4289.5	kmol/hr

Output

Hydrogen (H_2)	6474.9	kmol/hr
Carbon monoxide (CO)	31.7	kmol/hr
Carbon dioxide (CO_2)	1879.0	kmol/hr
Methane (CH_4)	19.0	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr

Absorber

Within the absorber Carbon dioxide is absorbed using Monoethanolamine. It is assumed that only Carbon dioxide is soluble in MEA solution. Solubility of other gases in MEA is assumed to be negligible. It is further obtained from literature that the CO_2 content in the exit stream is 0.5% of the total gas stream.

Input

Hydrogen (H_2)	6474.9	kmol/hr
Carbon monoxide (CO)	31.7	kmol/hr
Carbon dioxide (CO_2)	1879.0	kmol/hr
Methane (CH_4)	19.0	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr

Output

Hydrogen (H_2)	6474.9	kmol/hr
Carbon monoxide (CO)	31.7	kmol/hr
Carbon dioxide (CO_2)	1879.0	kmol/hr
Methane (CH_4)	19.0	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr

Methanator

Within the Methanator Oxides of Carbon are made to react with Hydrogen in the presence of catalysts because oxides of carbon act as poisons for the catalysts in the Ammonia synthesis loop. CO and CO_2 react with Hydrogen to form Methane and steam. Steam is removed by condensation and separated from the gaseous mixture going into the synthesis loop. Methane is an inert material in the synthesis loop.

Input

Hydrogen (H_2)	6474.9	kmol/hr
Carbon monoxide (CO)	31.7	kmol/hr

Carbon dioxide (CO_2)	1879.0	kmol/hr
Methane (CH_4)	19.0	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	9.5	kmol/hr

Output

Hydrogen (H_2)	6367.9	kmol/hr
Methane (CH_4)	60.1	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	34.5	kmol/hr
Steam (H_2O)	25.3	kmol/hr

Ammonia Synthesis Loop

Make up Gas

Hydrogen (H_2)	6367.4	kmol/hr
Methane (CH_4)	60.1	kmol/hr
Nitrogen (N_2)	2148,4	kmol/hr
Inerts (Ar +others)	34.5	kmol/hr

Recycle Stream

Hydrogen (H_2)	18624.3	kmol/hr
Nitrogen (N_2)	6182.2	kmol/hr
Ammonia (NH_3)	774.9	kmol/hr
Inerts (Ar + CH_4)	4555.0	kmol/hr

Gas into Converter

Hydrogen (H_2)	24991.7	kmol/hr
Nitrogen (N_2)	8330.6	kmol/hr
Ammonia (NH_3)	774,9	kmol/hr
Inerts (Ar + CH_4)	4649.6	kmol/hr

Purge

Hydrogen (H_2)	560.5	kmol/hr
Nitrogen (N_2)	69.8	kmol/hr
Ammonia (NH_3)	74.2	kmol/hr
Inerts (Ar + CH_4)	72.4	kmol/hr

Storage

Ammonia (NH_3)	3676.4	kmol/hr
Nitrogen (N_2)	204.2	kmol/hr
Hydrogen (H_2)	183.8	kmol/hr
Inerts (Ar + CH_4)	20.4	kmol/hr