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WASTE TO ENERGY CONVERSION

- Dr. P Mondal
IIT Rourkee

HARISANKAR S
DEPARTMENT OF CHEMICAL ENGINEERING
IIT MADRAS

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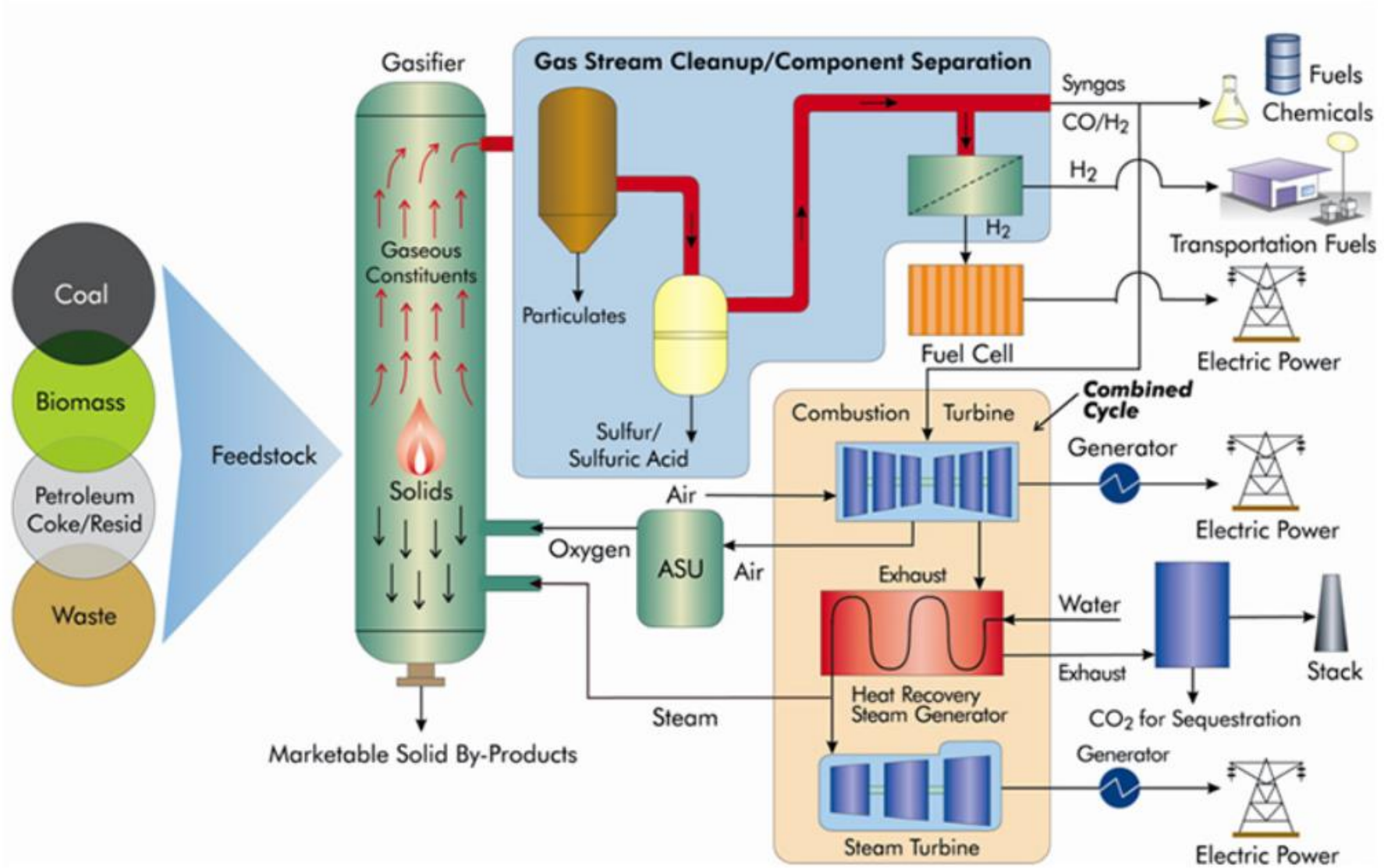
Gasification



Syngas clean up:

- Particulates
- Sulphur
- NH_3 and HCN
- Alkali and heavy metals
- Chlorides (HCl)
- Tar
  - Thermal cracking
  - Hydrogenation
  - Steam reforming

https://netl.doe.gov/research/Coal/energy-systems/gasification/gasifipedia/intro-to-gasification#:~:text=Gasification%20is%20a%20technological%20process,gas%20(syngas%20for%20short).&text=Syngas%20is%20so%20called%20because,production%20of%20synthetic%20natural%20gas.

Syngas from gasification

- Synthetic natural gas
- Syngas from coal gasification : 40 – 60% CO, 20 – 30% H_2, 5 – 15% CO_2, 0 – 5% CH_4
- Calorific value : 9 – 15 MJ/m^3
- 117 gasification plants globally
  - 42 – generate fuels
  - 22 – generate electricity
  - 50 – generate chemicals
- Global manufacture
  - 6 EJ (Exajoules = 10^{18} joules)
  - 2% of world's energy consumption
  - 24 GW electricity

- Uses :
  - Generate electricity
  - Intermediate in synthesis of NH_3 and fertilizers
  - Fischer Tropsch synthesis

    $CO + 2H_2 \rightarrow -CH_2- + H_2O$
  - Produce H_2 – Water gas shift reaction

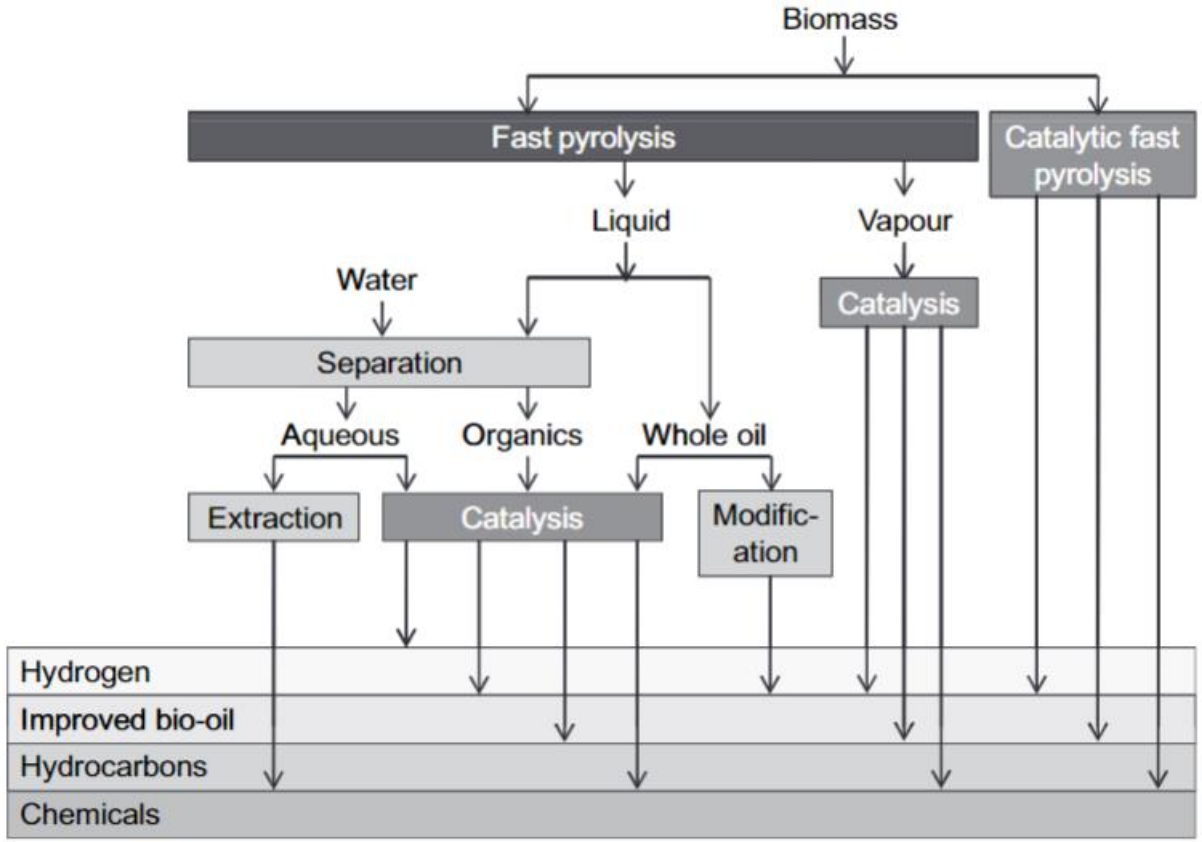
    $CO + H_2O \rightarrow CO_2 + H_2$
- Other fuel gases :
  - Producer gas – CO (20%) + N_2(55%)
  - Water gas – CO + H_2

https://archive.epa.gov/epawaste/hazard/wastemin/web/html/gasdom.html
https://doi.org/10.1080/15567030802466847

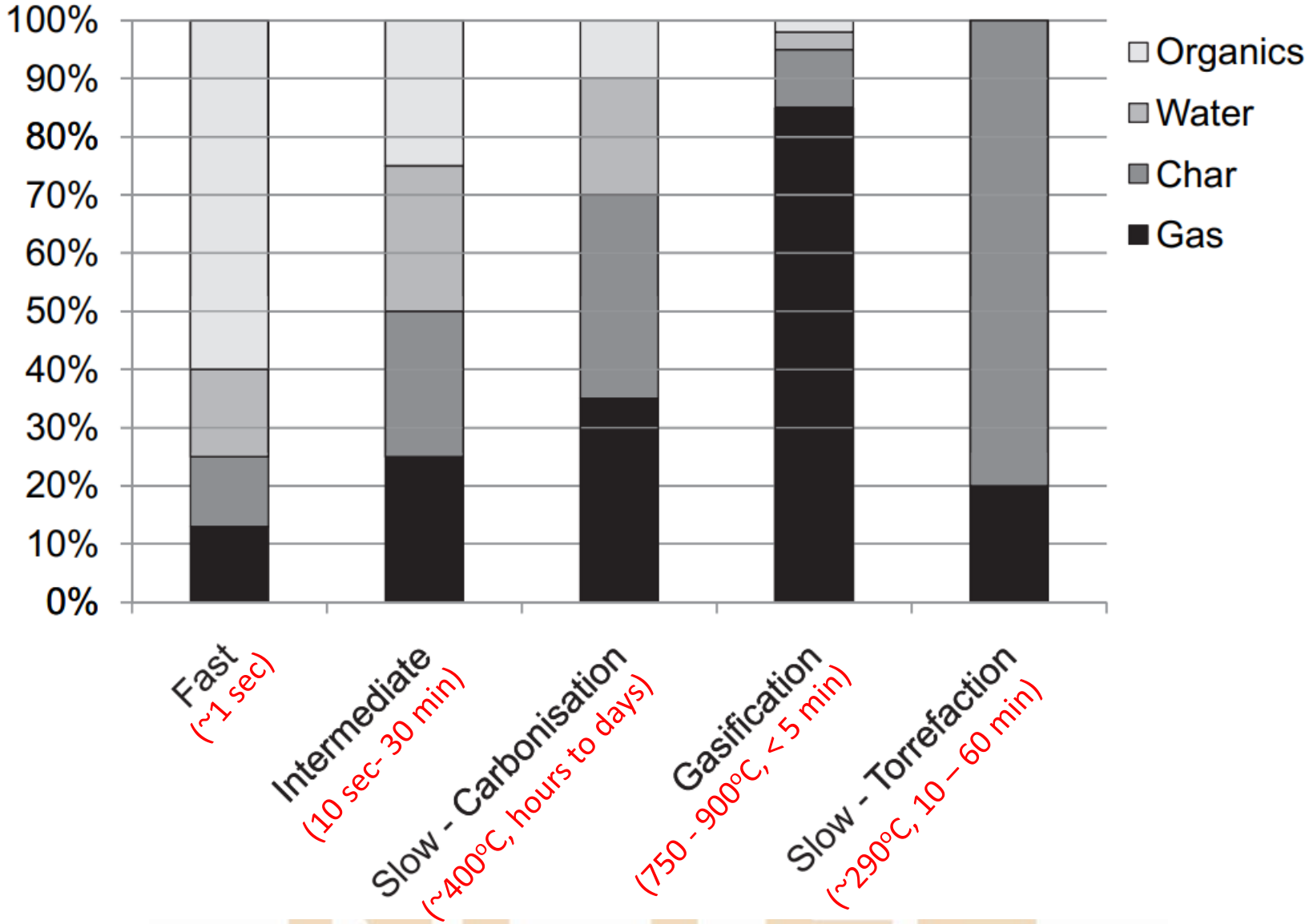
Pyrolysis

Catalytic / Non-catalytic fast pyrolysis | **Hydropyrolysis** | **Slow pyrolysis (Torrefaction)**

- Cracking and thermal degradation under inert atmosphere
- Fast pyrolysis
  - Very short residence times
  - Main product – bio-oil
- Hydropyrolysis
  - Pyrolysis under H_2 atmosphere
  - Upgraded products
  - Shell's IH^2 (Integrated hydropyrolysis and hydroconversion)
- Slow pyrolysis
  - Very long residence time
  - Main product – bio-char



https://doi.org/10.1016/j.biombioe.2011.01.048



https://doi.org/10.1016/j.biombioe.2011.01.048

1) Which of the below statement is most appropriate about dimethyl ether (DME)?

- Has low oxygen content
- Has low auto-ignition temperature
- Has very low cetane number
- Shows very high particulate emissions

Accepted Answers:
Has low auto-ignition temperature

2) What is the value of pressure in fixed bed gasifier?

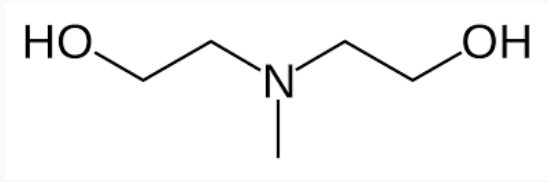
- 0 – 0.05 MPa
- 4 – 4.5 MPa
- 2.94 - 3.43 MPa
- 0.15 - 2.45 MPa

Accepted Answers:
0.15 - 2.45 MPa

3) Which of the following solvent is used in chemical absorption method for acid gas removal?

- MDEA
- Rectisol™
- Selexol™
- None of these

Accepted Answers:
MDEA



Methyl diethanolamine

Selexol™ and Rectisol™ are also acid removal processes, but the solvents are physical solvents

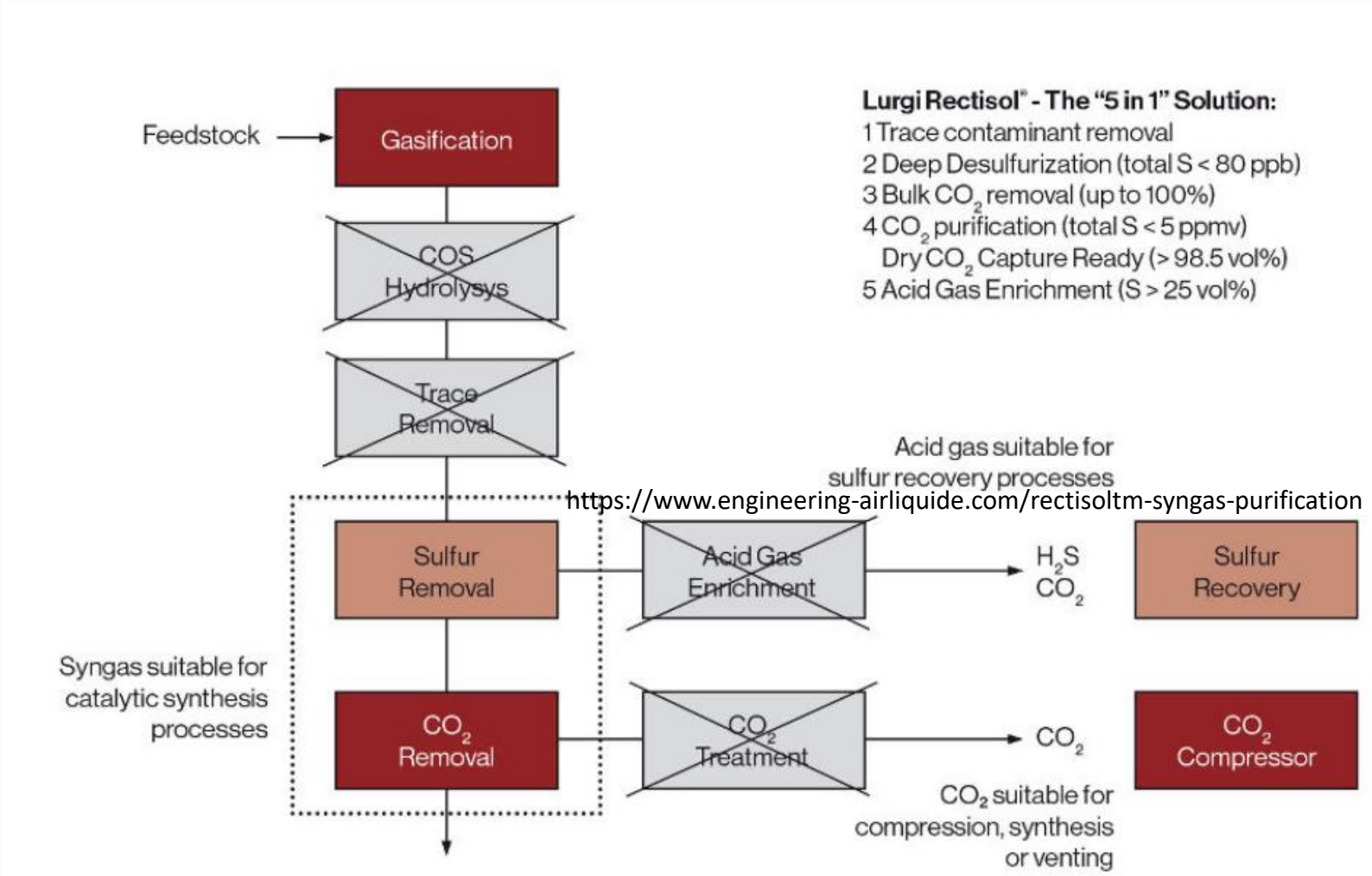
4) How much percent of H_2S and CO_2 are removed in physical absorption method of acid gas removal using Rectisol as a solvent?

- H_2S: 98 – 98.5 %
  CO_2: 95 %
- H_2S : 92- 95 %
  CO_2 : 90 %
- H_2S: 99.5 – 99.9 %
  CO_2: 98.5 %
- H_2S: 89 – 89.5 %
  CO_2 : 75 %

Accepted Answers:

H_2S: 99.5 – 99.9 %

CO_2: 98.5 %



https://www.engineering-airliquide.com/rectisoltm-syngas-purification

5) Which of the following statement is most appropriate about methanol synthesis?

- Favoured at low pressure
- Favoured at high pressure and low temperature
- Depends on temperature only
- None of the above

Accepted Answers:
Favoured at high pressure and low temperature

$CO + 2H_2 \rightarrow CH_3OH$
$CO_2 + H_2 \rightarrow CO + H2O$
$CO_2 + 3H_2 \leftrightarrow CH_3OH + H_2O$ (ΔH = -49.4 KJ/mol)

Exothermic reaction ➔ Low temperature preferred

No. of moles in reactants > no. of moles in products
By Le Chatelier's, high P favours forward reaction

Equilibrium constant, K $\boldsymbol{\alpha}$ P^{-V}

$$K = \frac{[CH_3OH]^1[H_2O]^1}{[CO_2]^1[H_2]^3}$$

V = Overall stoichiometry = Stoichiometry of products – Stoichiometry of reactants
i.e. V = (1+1) – (1+3) = -2

Higher the value of K, higher the formation of products

Here, K $\boldsymbol{\alpha}$ P^{-V}

i.e. K $\boldsymbol{\alpha}$ P^2

So, as P increases, K also increases, rate of formation of products also increases

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6) Which of the following method of methanol synthesis employs a homogenous Ni catalyst and alkoxide in an organic solvent?

- Methyl Formate (MF) formation method
- Brookhaven National Laboratory (BNL) method
- Both (a) and (b)
- None of these

Accepted Answers:
Brookhaven National Laboratory (BNL) method

7) What should be the level of sulphur in feed gas for methanol synthesis?

- 0.5 ppm - 1 ppm
- < 0.5 ppm
- > 1 ppm
- None of the above

Accepted Answers:
< 0.5 ppm

8) What is the reason behind the significantly lower heating value of pyrolysis bio-oil than fossil oil?

- High oxygen content
- High moisture content
- Lower molecular weight aldehydes and acids
- Heavy molecule contamination

Accepted Answers:
High oxygen content

9) What are the modes of heat transfer in Fluidized bed reactor?

- 90% conduction, 9% convection, 1% radiation
- 50% conduction, 49% convection, 1% radiation
- 80% conduction, 9% convection, 11% radiation
- 9% conduction, 80% convection, 11% radiation

Accepted Answers:
90% conduction, 9% convection, 1% radiation

10) What is the percentage of bio-oil yield in vacuum pyrolysis reactor?

- 35 – 50%
- 85%
- 70%
- 70-75%

Accepted Answers:
35 – 50%

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