

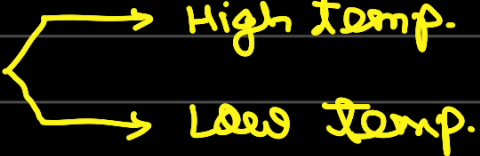
## Day-3

→ SMR steps:

(i) Feedstock pre-treatment

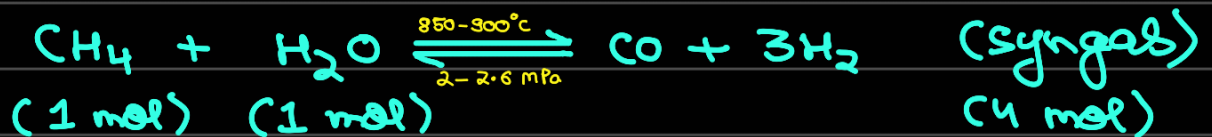
(Removing impurities to prevent poisoning in the later steps / preparing feedstock for later steps)

(ii) Steam reforming

(iii) Water gas shift 

(iv) Purification steps

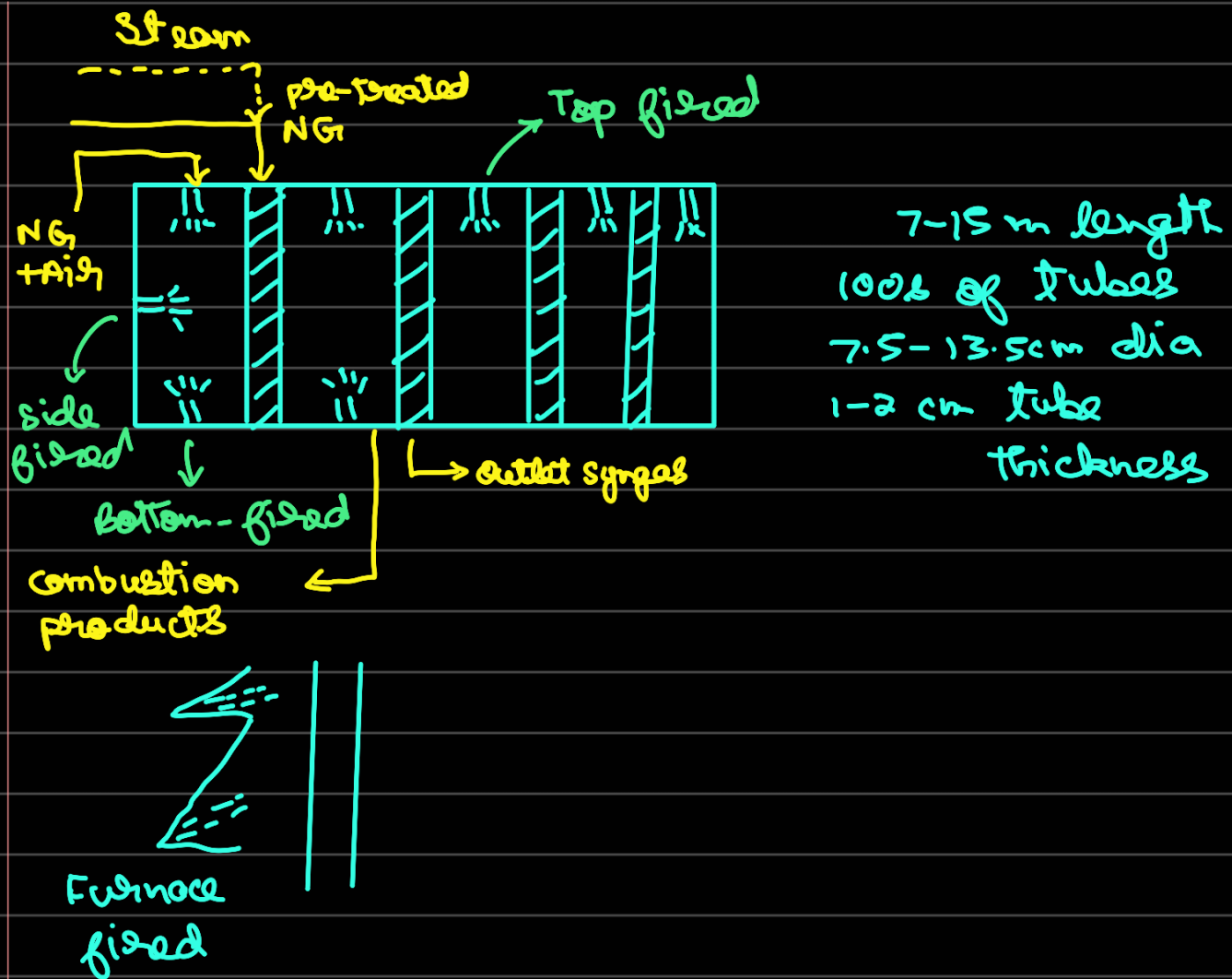
→ Steam methane reforming:



$$\Delta H^\circ = +206 \text{ kJ/mol}$$

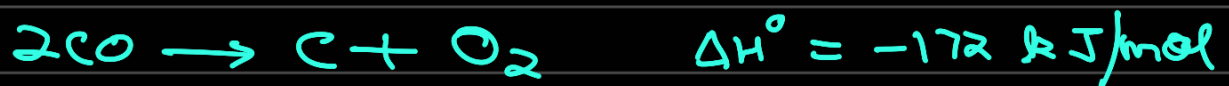
Note:

- Highly endothermic
- 2 mol reactants gives 4 mol products
- Carried out at high T and low P.  
(In a process plant, hard to have low P)
- Steam to carbon ratio is kept 2.5-3.0  
(extra steam may be used to avoid coke deposition on the catalyst; also forward reac<sup>n</sup> favoured)



→ Coke deposition:

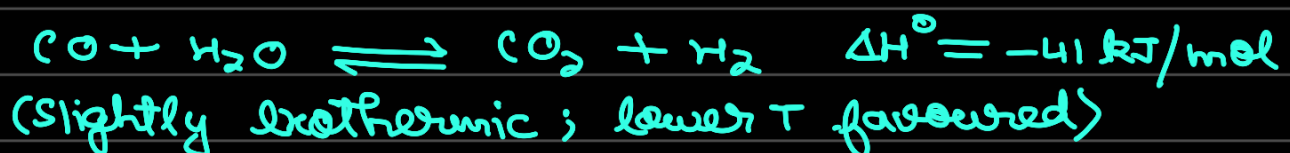
- 1)  $\text{CH}_4 \longrightarrow \text{C} + 2\text{H}_2 \quad \Delta H^\circ = 74.6 \text{ kJ/mol}$
- 2) Disproportionation of CO



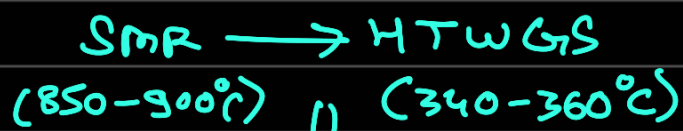
- 3) Heterogeneous water gas reac<sup>n</sup>.



→ water-gas shift (WGS) reaction /  $\text{CO}_2$  shift reac<sup>n</sup>:



- Trade-off: kinetics wants higher T.
- 340–360°C (HT)



Heat  $\rightarrow$  steam generation

	<u>HTWGS</u>	<u>LTWGS</u>
Catalyst	$\text{Fe}_2\text{O}_3 / \text{Cr}_2\text{O}_3$	$\text{CuO}, \text{ZnO}, \text{Al}_2\text{CO}_3$
Temp:	340–360°C	220–250°C
CO content after react	2.5%	0.2–0.4%

$\rightarrow$  Purification step:

<u>Absorption-based</u>	<u>Adsorption-based</u>
<ul style="list-style-type: none"> <li>• <math>\text{CO}_2</math> absorption (by solvents, eg: mono-ethanol amine (MEA), <math>\text{K}_2\text{CO}_3</math>)</li> <li>• 99–99.9% purity of <math>\text{H}_2</math></li> </ul>	<ul style="list-style-type: none"> <li>• Sorbents, molecular sieves, MOF, zeolites</li> <li>• Carbon-based</li> <li>• 99.999% purity of <math>\text{H}_2</math></li> </ul> <p>[MOF <math>\rightarrow</math> Metal Organic Framework] [PSA <math>\rightarrow</math> Pressure Swing Adsorption]</p>

$\rightarrow$  Catalyst:

- Inlet: 450°C–650°C, Outlet: 850°C–900°C
- The catalyst should be robust, thermally

and mechanically stable.

- High activity
- Low cost
- High life
- Good heat transfer characteristics.

Eg:  $Ru > Rh > Ir > \textcircled{Ni} > Pt > Pd$   
(order of activity)

$\rightarrow \geq 5$  yrs life

$\downarrow$   
support:  $Al_2O_3$