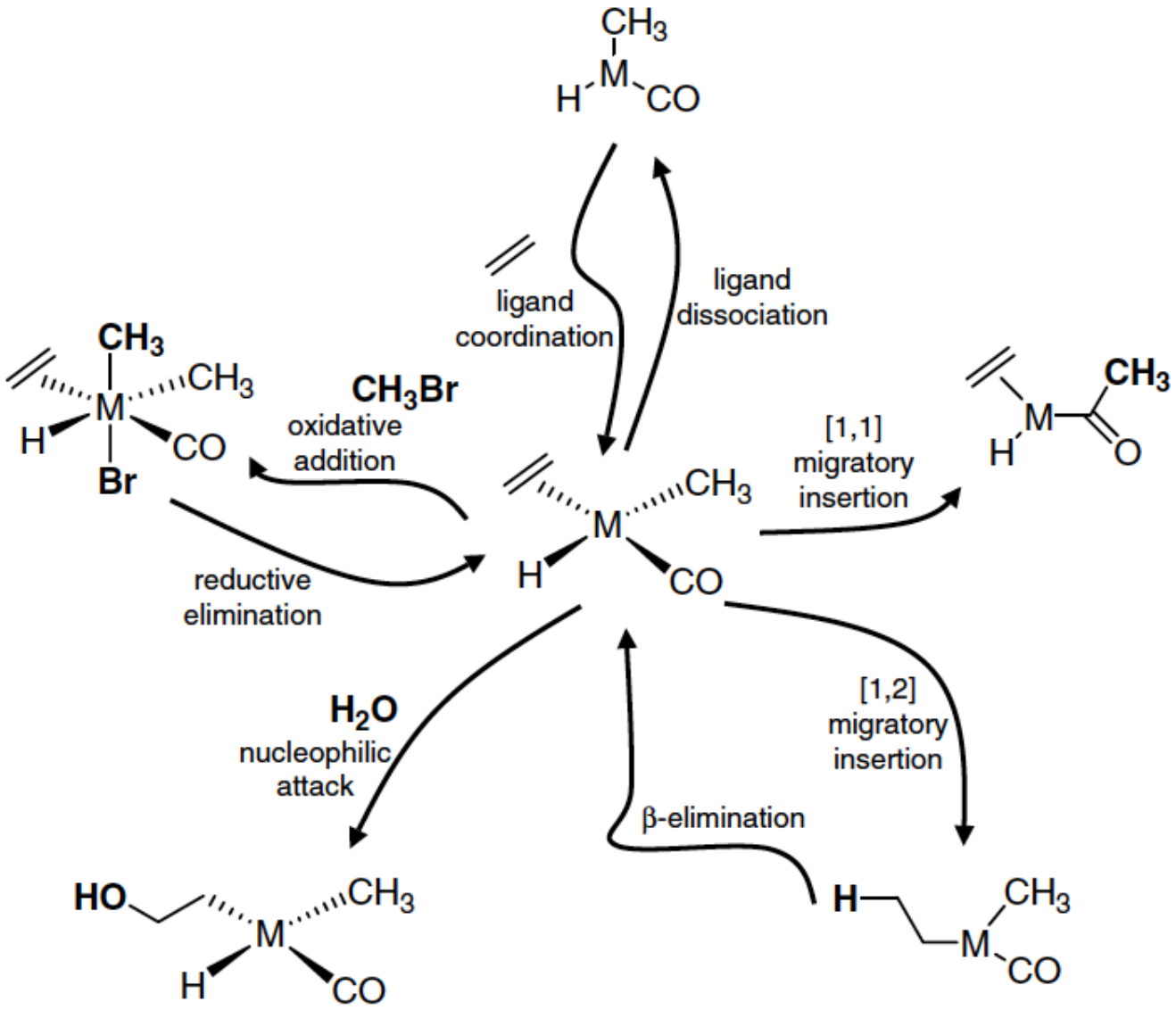
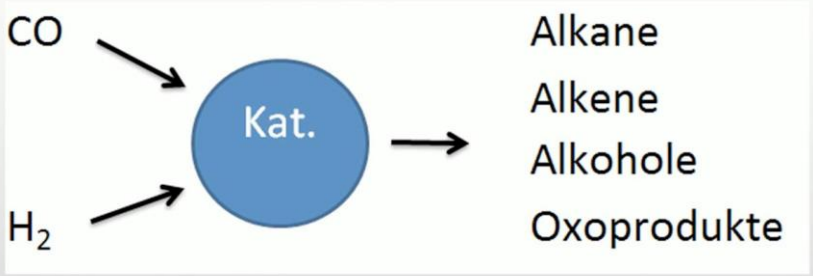
The main elementary steps in homogeneous catalysis

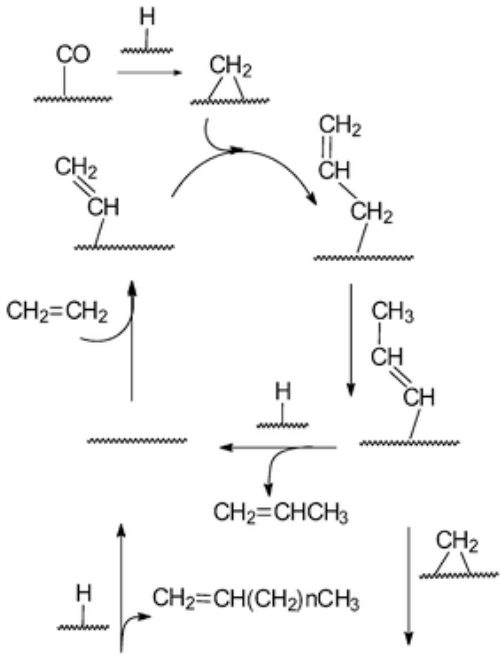
From “Catalysis” Gadi Rothenburg, Wiley, 2008

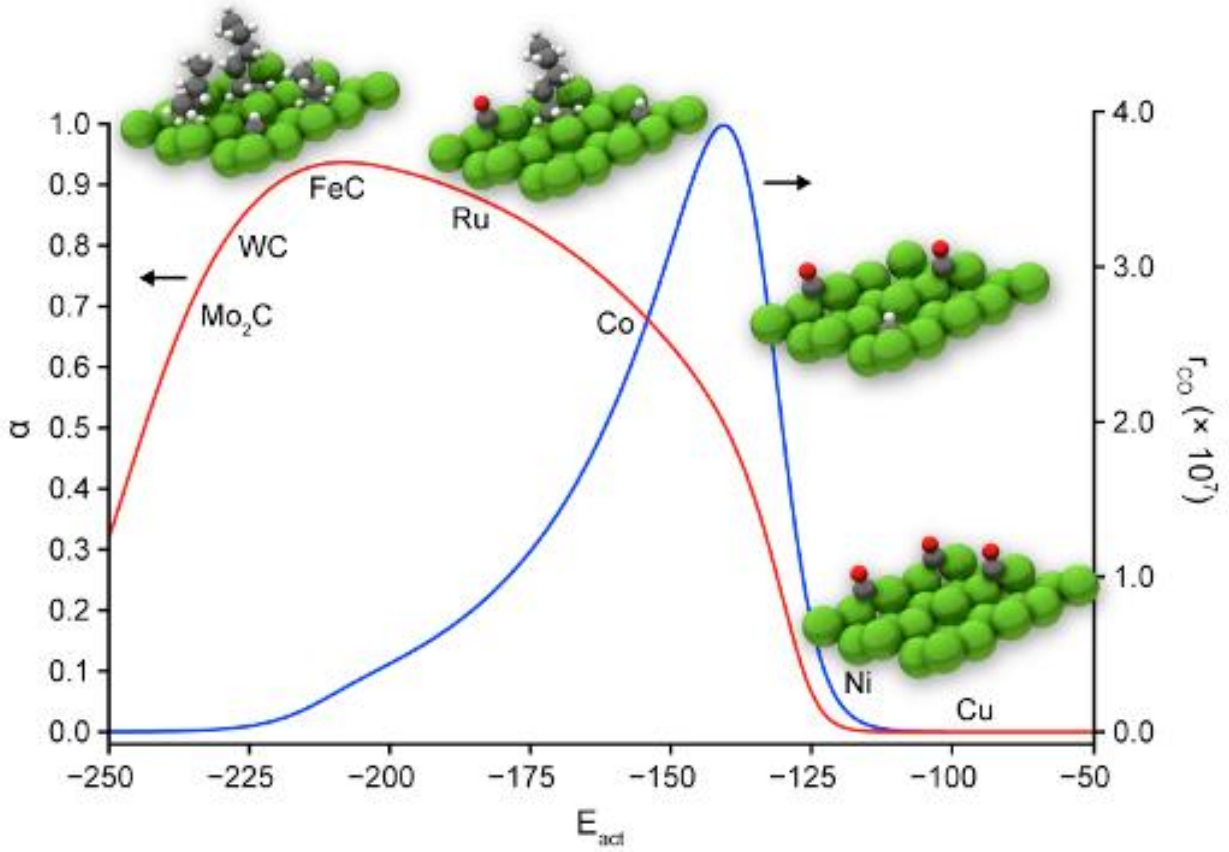


Fischer-Tropsch-Synthese



https://de.wikipedia.org/wiki/Datei:Fischer-tropsch2.png





Comparison of heterogeneous and homogeneous catalysis

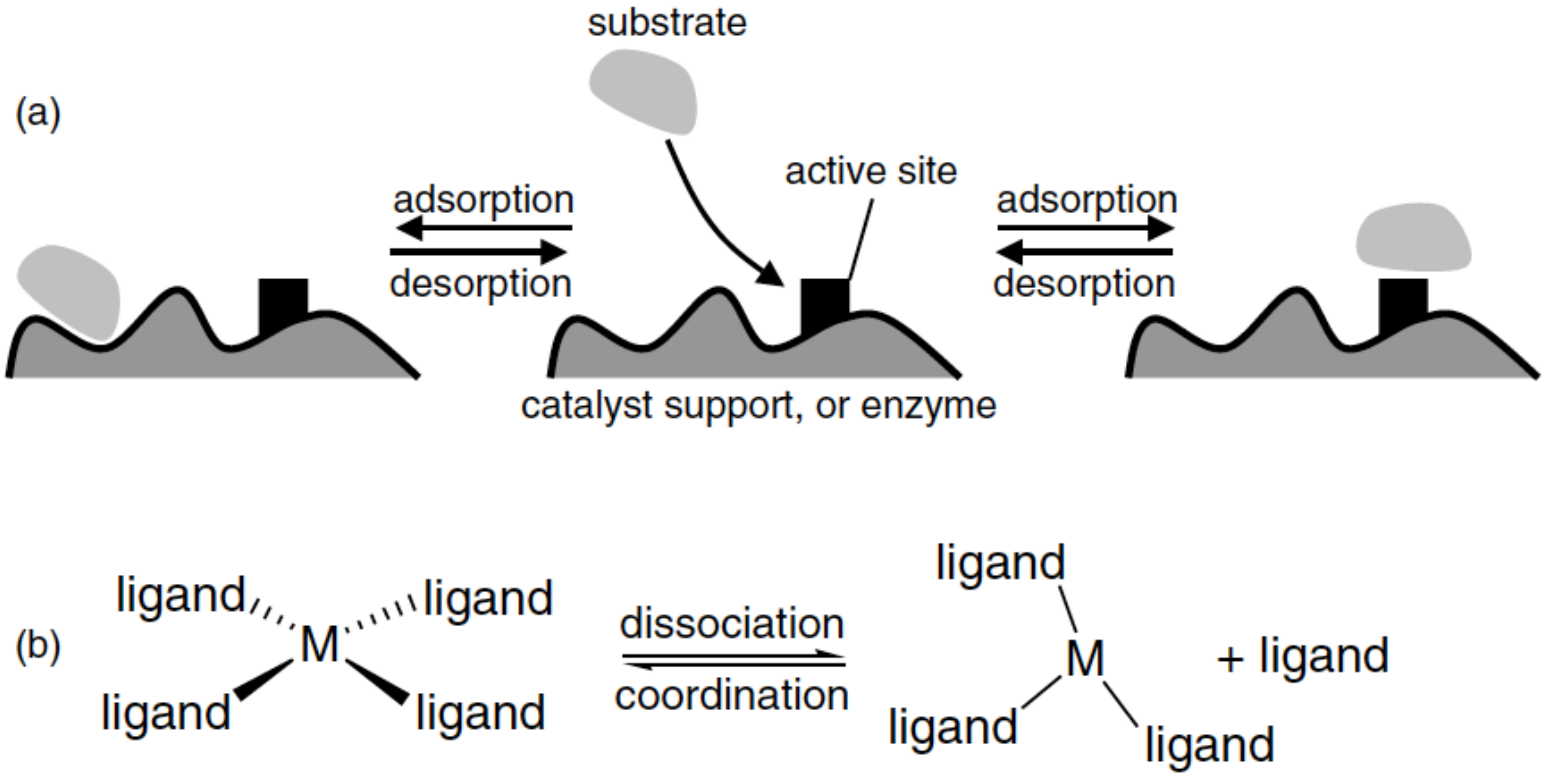


Figure 3.3 **a** Dynamic adsorption/desorption in heterogeneous catalysis and in enzymatic systems occurs both at active sites and elsewhere on the support; **b** similar coordination/dissociation occurs also in homogeneous complexes.

Necessity is the Mother of Invention: WWII; Germany; Oil embargo

Fischer Tropsch Process

1) Synthesis Gas Formation

$$CH_n + O_2 \xrightarrow{\text{(Catalyst)}} \tfrac{1}{2}\, n\, H_2 + CO$$

2) Fischer-Tropsch Reaction

$$2n\, H_2 + CO \xrightarrow{\text{Catalyst}} -(CH_2-)_n- + H_2O$$

3) Refining

$$-(CH_2-)_n- \xrightarrow{\text{(Catalyst)}} \text{Fuels, lubricants, etc.}$$

Main Chemical Reactions in Fischer-Tropsch Synthesis

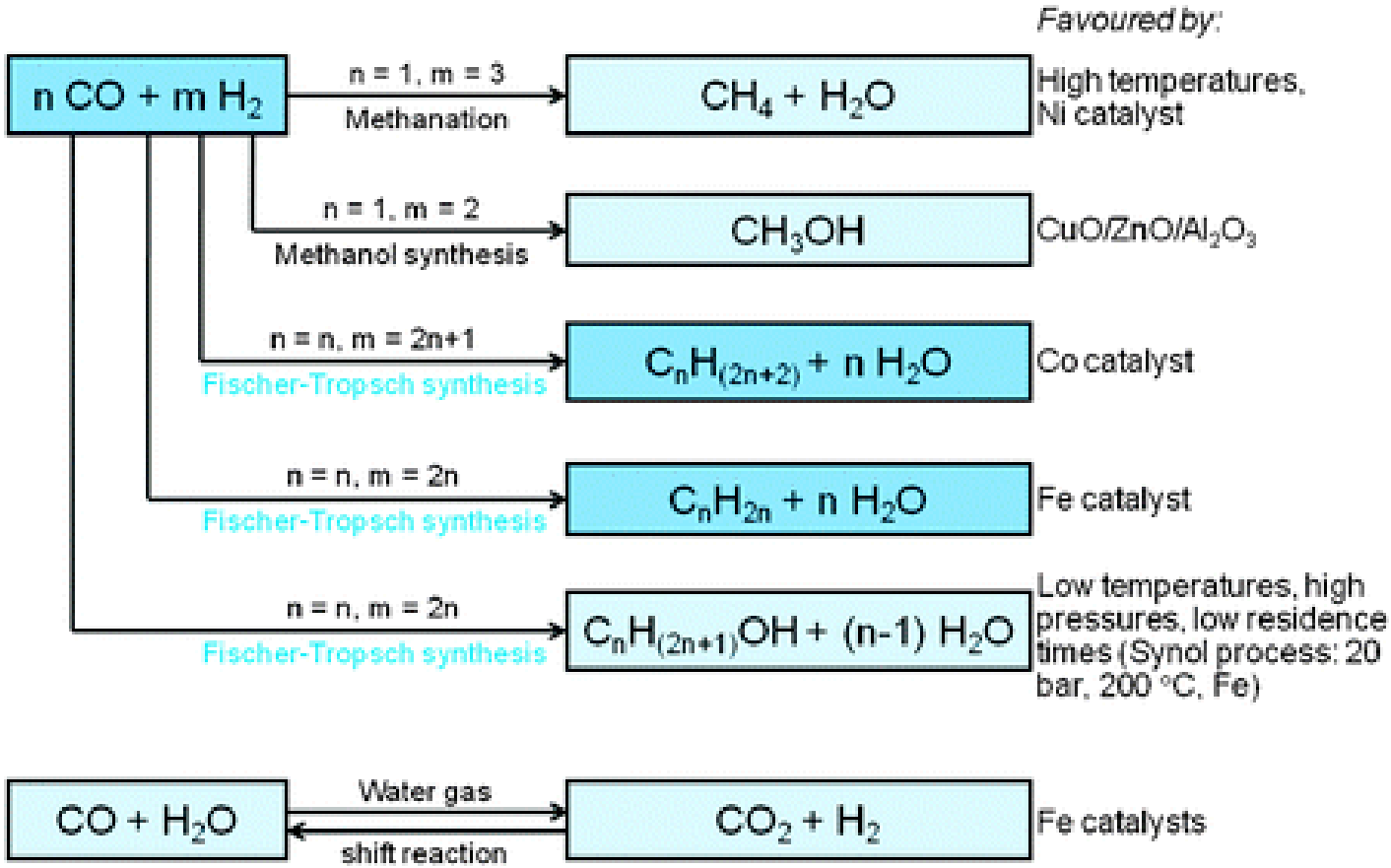
1) $2CH_4 + O_2 \longrightarrow 4H_2 + 2CO$ Conventional Syngas production

2) $CO_2 + CH_4 \longrightarrow 2H_2 + 2CO$ Syngas production from CO_2

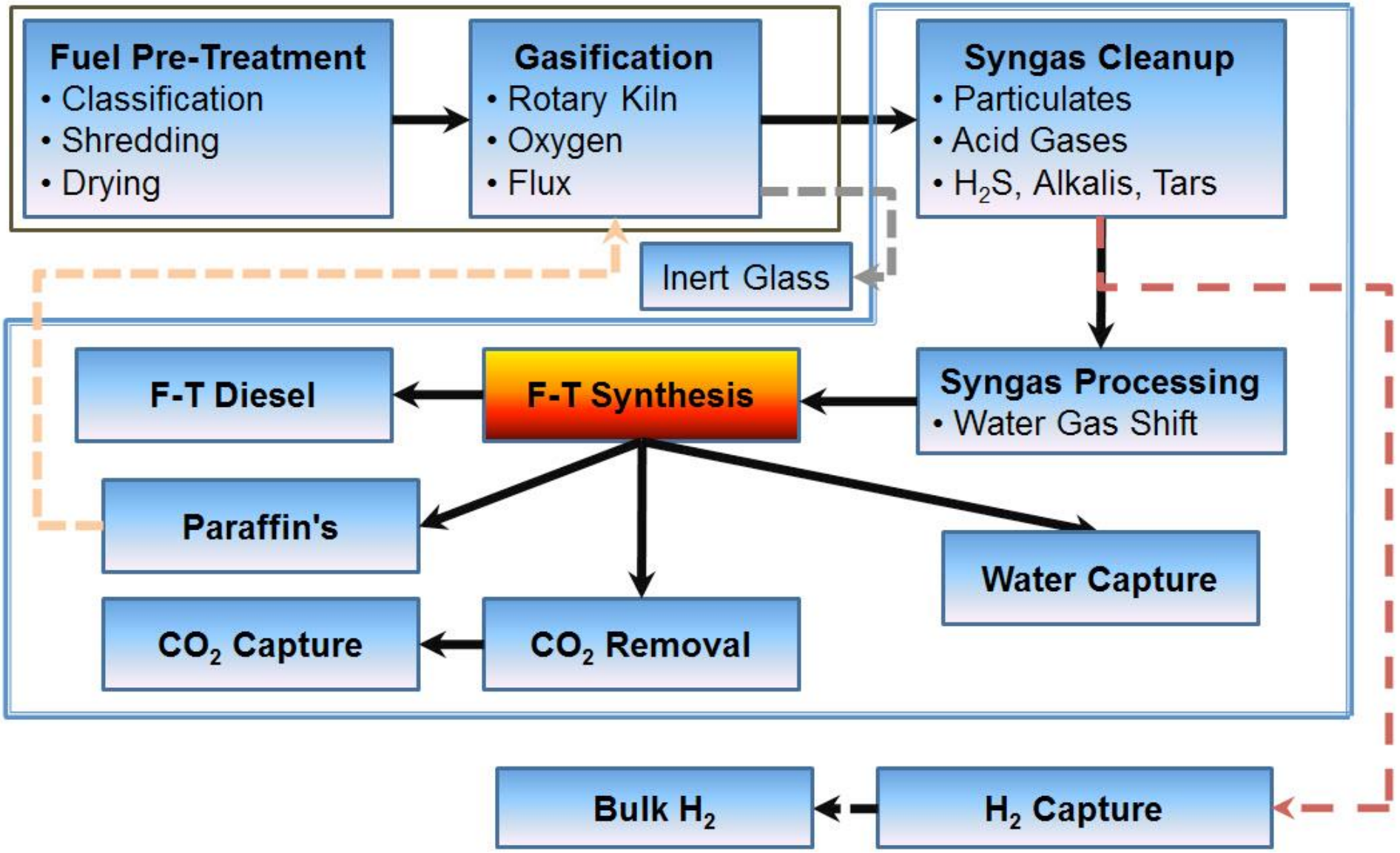
3) $nCO + (2n + 1)H_2 \longrightarrow C_nH_{2n+2} + nH_2O$ Alkanes Production

4) $nCO + (2n)H_2 \longrightarrow C_nH_{2n} + nH_2O$ Alkenes Production

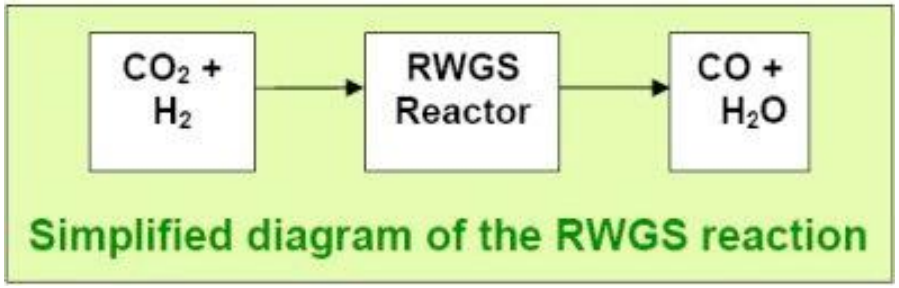
5) $nCO + (2n)H_2 \longrightarrow C_nH_{2n+1} + (n-1)H_2O$ Alcohols production

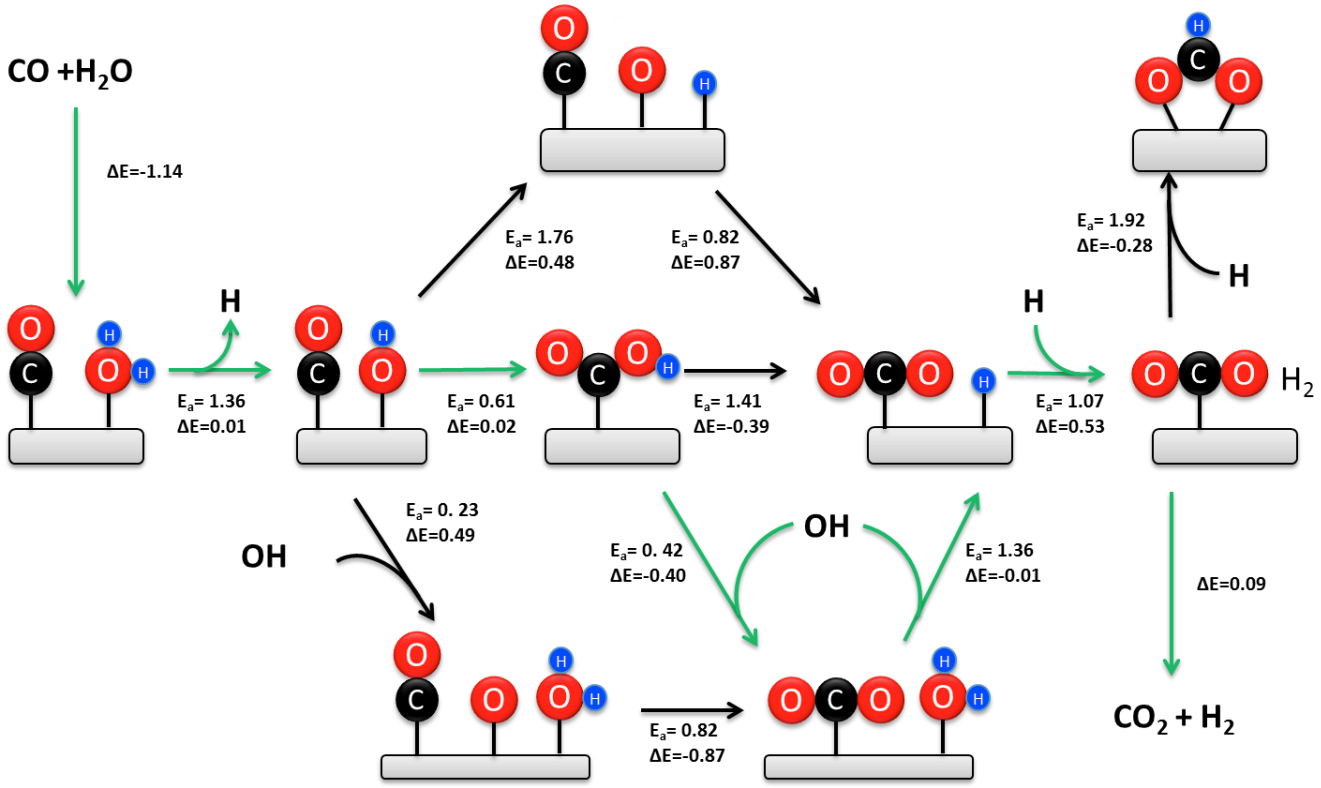

Favoured by:
n CO + m H2
n = 1, m = 3
Methanation
CH4 + H2O
High temperatures, Ni catalyst
n = 1, m = 2
Methanol synthesis
CH3OH
CuO/ZnO/Al2O3
n = n, m = 2n+1
Fischer-Tropsch synthesis
CnH(2n+2) + n H2O
Co catalyst
n = n, m = 2n
Fischer-Tropsch synthesis
CnH2n + n H2O
Fe catalyst
n = n, m = 2n
Fischer-Tropsch synthesis
CnH(2n+1)OH + (n-1) H2O
Low temperatures, high pressures, low residence times (Synol process: 20 bar, 200 °C, Fe)
CO + H2O
Water gas
shift reaction
CO2 + H2
Fe catalysts

RK Fischer-Tropsch



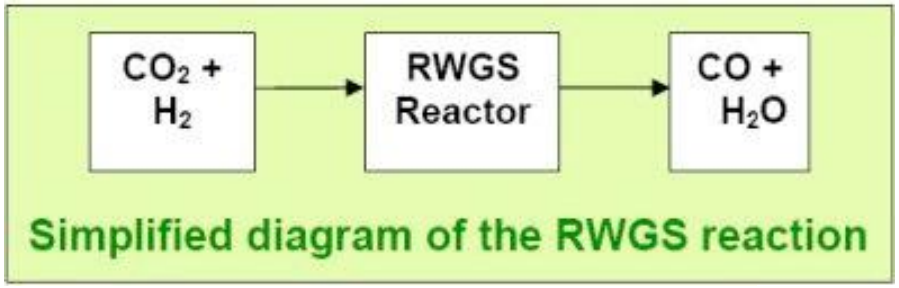
Water Gas Shift Reaction: $CO_2 + H_2 = H_2O + CO$

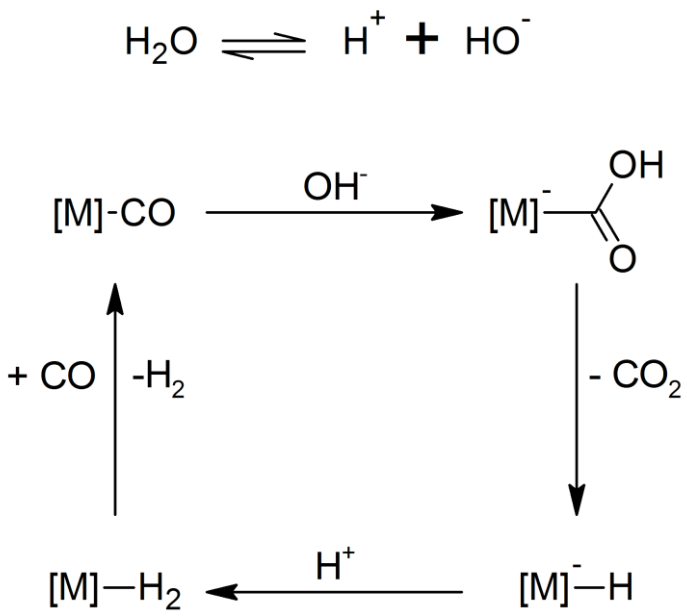


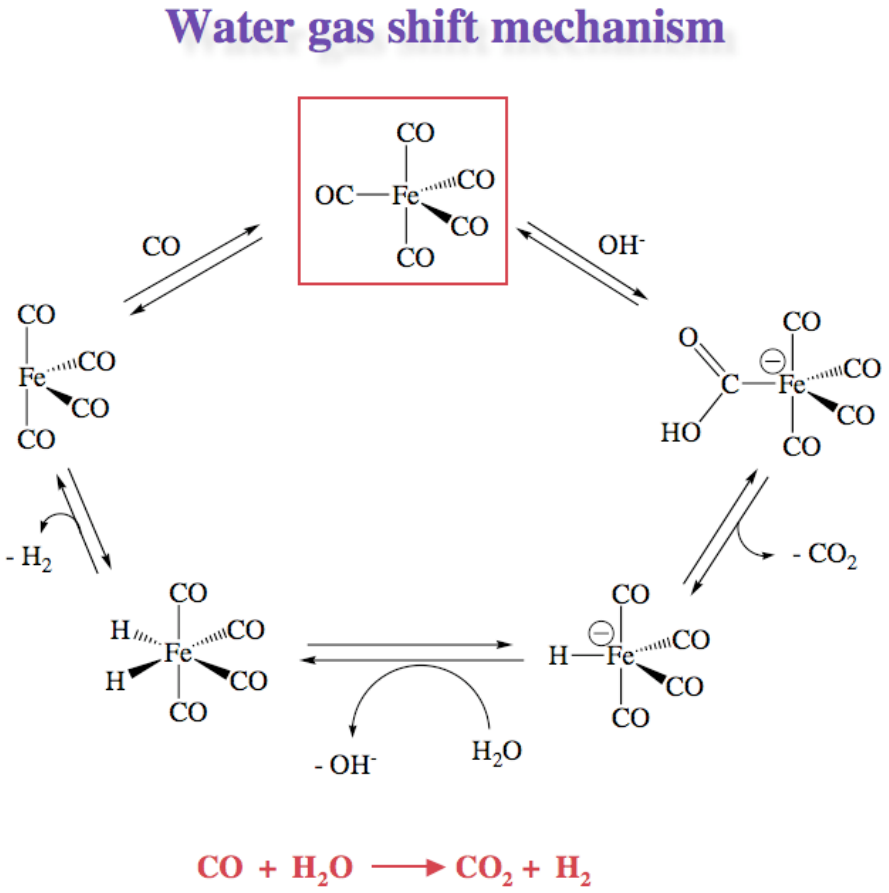


Water Gas Shift Reaction

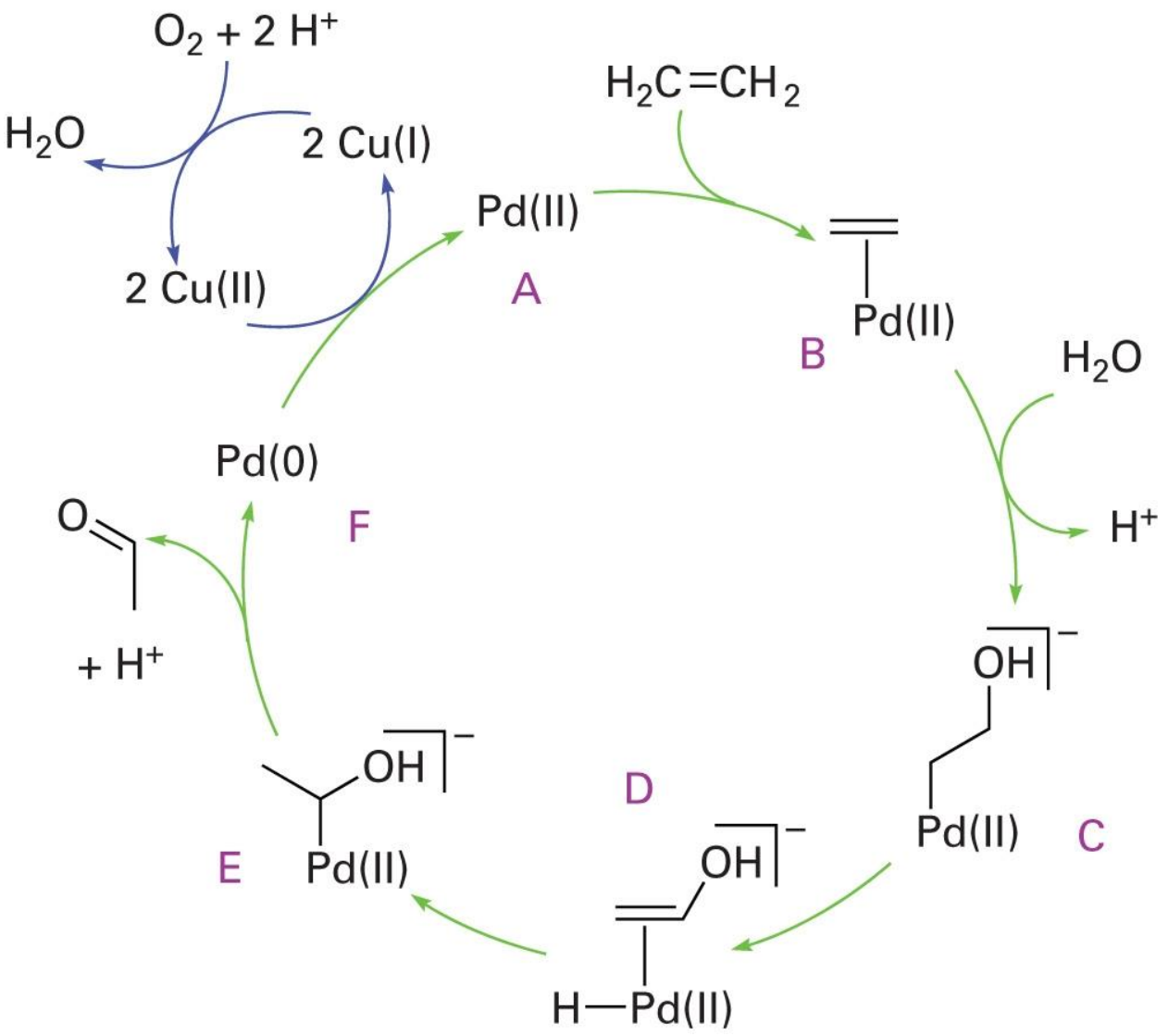
$CO_2 + H_2 = H_2O + CO$







Wacker Oxidation of Olefins: Two parts



The SHOP Process

Shell
Higher
Olefin
Process