1.The number of catalytic active sites of supported transition metals can be determined by chemisorption of carbon monoxide. Carbon monoxide was chemisorbed on ruthenium supported catalyst at 100 $^{o}$C. Use the following uptake data for chemisorption of CO on 10 mass % Ru supported on $Al_2O_3$ at 100 $^{o}$C to determine the equilibrium constant of CO chemisorption and the number of Ru active sites assuming Langmuir chemisorption isotherm.

| $P_{CO}$ (Pa) | 13330 | 19995 | 26660 | 33325 | 39990 | 53320 |
|---|---|---|---|---|---|---|
| $n_{CO,}$ chemisorbed (μmol/gcat) | 1.28 | 1.63 | 1.77 | 1.94 | 2.06 | 2.21 |

Solution

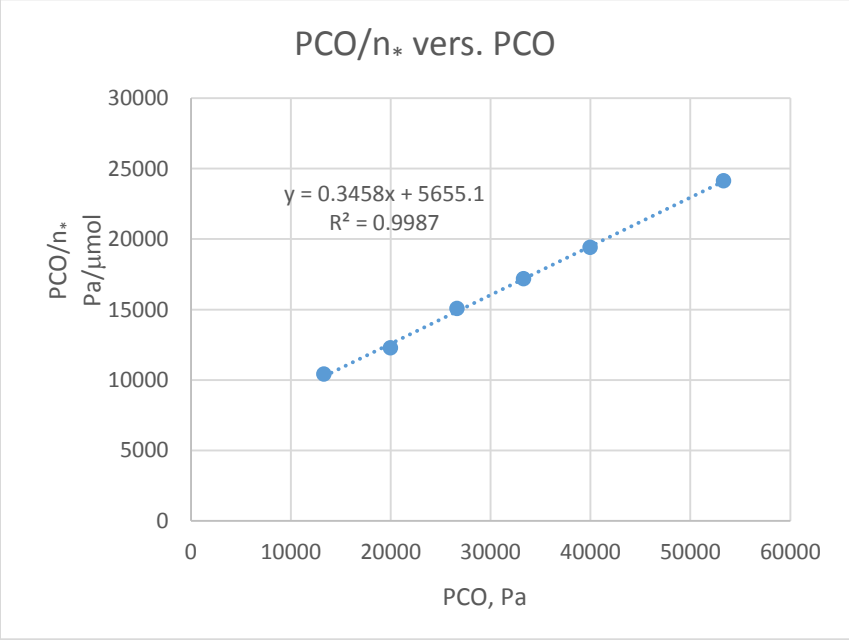
$$\frac{n_{CO}}{n_*} = \frac{K_{CO}P_{CO}}{1+K_{CO}P_{CO}}$$

$$\frac{P_{CO}}{n_{CO}} = \frac{1}{n_* K_{CO}} + \frac{1}{n_*} P_{CO}$$

from below presented chart:

$$\frac{1}{n_*} = 0.3458 \Rightarrow n_* = 2.892 \text{ μmol/g of catalyst}$$

$$\frac{1}{n_* K_{CO}} = 5655.1 \Rightarrow K_{CO} = 6.115\text{x}10^{-5} \text{ Pa}^{-1}$$



2. Hydrogen chemisorbs with dissociation on metals as atoms. Derive the Langmuir chemisorption isotherms for hydrogen.

3. The irreversible gas phase catalytic reaction

$$H_{2(g)} + \tfrac{1}{2} O_{2(g)} \rightarrow H_2O_{(g)}$$

has a rate determining step (RDS)

$$H^* + O^* \rightarrow OH^* + * \qquad \text{with rate } r_{RDS} = k_{RDS} \Theta_H \Theta_O$$

Derive a reaction rate expression $r(P_{H2},P_{O2})$ for this catalytic reaction assuming Langmuir – Hishelwood kinetics with equilibrium chemisorption steps.

4. On platinum hydrogen chemisorbs dissociatively and CO chemisorbs without dissociation.

(a) Write Langmuir chemisorption isotherm for simultaneous chemisorption of these gases assuming ideal (Langmuir) chemisorption.

(b) What would be a reasonable rate expression for catalytic reaction of $H_{2(g)}$ and $CO_{(g)}$ over Pt

$$H_{2(g)} + CO_{(g)} \leftrightarrow HCOH_{(g)}$$

5. A certain spherical porous catalyst with a pellet diameter of 3 mm has a Thiele modulus of 0.5 for first-order reaction and gives 90 % fractional conversion of reactant component A in a isothermal packed bed reactor. Reaction rate is based on the mass of catalyst as mol/kg/s. It is proposed to replace this catalyst by the exact same catalyst but with pellets of 6 mm or 12 mm, to reduce the pressure drop. If the total mass of catalyst in reactor is same for all three pellets, how will the conversion of A change with these catalysts? Constant total molar flow rate is assumed.