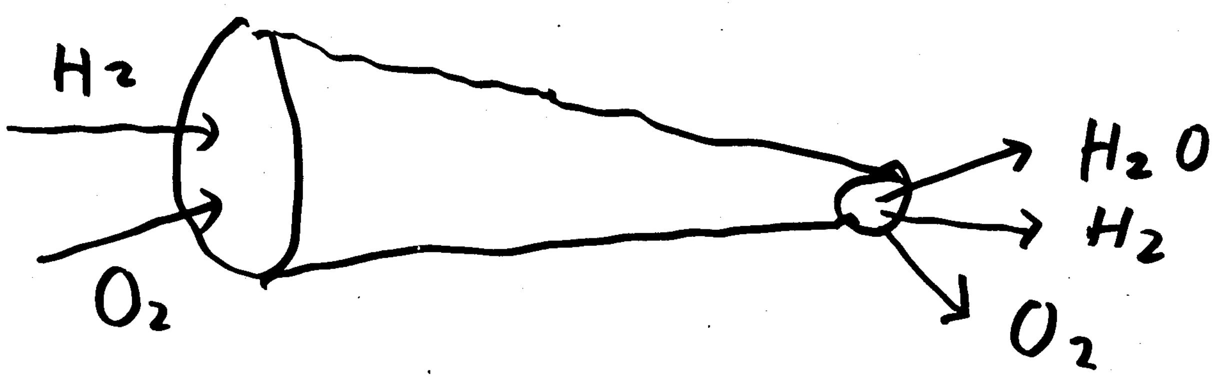
Q5 Plug Flow Reactor

Hydrogen and Oxygen



Assume: A lot of Oxygen pumped in at velocity u

Hydrogen pumped in at velocity u

keep pumping

cross-section area

$$A(x) = A_0 e^{-\gamma x}$$

At $t=0$, $x=0$

At time t, $x = ut$

$$A(x) = A_0 e^{-\gamma ut}$$

we may write $A(t) = A_0 e^{-\gamma ut}$

Let $C(t)$ be concentration of H_2 at time t

i.e., $C(t) = \#$ of H_2 molecules $/ m^3$ at t

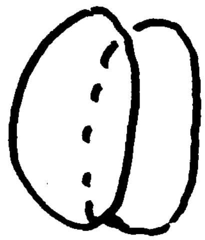
Let $R(t)$ be total $\#$ of the following chemical reaction occurring up to time t $/ m^3$

$$2H_2 + O_2 \longrightarrow 2H_2O .$$

Let $r(t) = \dfrac{dR(t)}{dt}$.

given : $r(t) = k\, C(t)$

For the small plug



of H_2 molecules flows in at time t at the rate

$$C(t)\,A(t)\,u$$

where u is the velocity of the flow

of H_2 molecules flows out at time $t+\delta t$ at the rate

$$C(t+\delta t)\,A(t+\delta t)\,u$$

It is clear from

$$2H_2 + O_2 \rightarrow 2H_2O$$

that in each chemical reaction, 2 H_2 molecules destroyed

Hence

$$C(t+\delta t)\, A(t+\delta t)\, u - C(t)\, A(t)\, u$$

$$= (-2) \left[R(t+\delta t) - R(t) \right] A(t)\, u$$

$$\therefore \quad \frac{d\, C(t) A(t)}{dt} = (-2) \left[\frac{dR(t)}{dt} \right] A(t)$$

$$= (-2)\, r(t)\, A(t)$$

$$= (-2)\, k\, C(t)\, A(t)$$

$$C(t) A(t) = C(0) A(0)\, e^{-2kt}$$

$$C(t)\, A(0)\, e^{-\gamma u t} = C(0) A(0)\, e^{-2kt}$$

$$C(t) = C(0)\, e^{-2kt + \gamma u t}$$

$$= C(0)\, e^{-2\left(k - \frac{\gamma u}{2}\right) t}$$

$$C(x) = C(0)\, e^{-2\left(k - \frac{\gamma u}{2}\right) \frac{x}{u}}$$