statistical physics \rightarrow reaction kinetics

Production of Hydrogen Bromide

Consider the reaction for the production of hydrogen bromide gas from hydrogen and bromine gas:

$$H_2 + Br_2 \rightarrow HBr + HBr.$$

Let $H = [H_2]$, $B = [Br_2]$ and P = [HBr].

(a) Write down the naïve rate of production for hydrogen bromide, up to an overall rate constant.

In fact, the rate law is

$$\dot{P} = \frac{\alpha H B^{3/2}}{B + \eta P}$$

for constants α and η .

The presence of a nontrivial reaction rate law suggests a subtle mechanism behind the reaction. It is believed the mechanism behind this reaction is given by the following set of reactions, which involve hydrogen and bromine radical molecules which are highly reactive:

$$Br + Br \xrightarrow{\omega} Br_{2}$$

$$Br_{2} \xrightarrow{\gamma} Br + Br$$

$$H + Br_{2} \xrightarrow{\theta} Br + HBr$$

$$H_{2} + Br \xrightarrow{\zeta} H + HBr$$

$$H + HBr \xrightarrow{\lambda} Br + H_{2}$$

Let b = [Br] and h = [H].

- (b) Why do you think the radicals are so highly reactive? What does this imply about the rates? Justify why the assumption that the radicals are in steady-state is reasonable.
- (c) Solve for b and h in terms of H, B, P and the rate constants.
- (d) Verify that the reaction rate is of the form shown above. What are α and η in terms of ω, γ, ζ, θ and λ?