Interstellar Hydrogen Production

In this problem, we will consider the production of hydrogen gas, H_2 , from individual hydrogen atoms in interstellar space. Because the individual hydrogen atoms have far too much energy, it is nearly impossible to form this gas by simply colliding two H atoms together. Instead, a mechanism that is believed to be dominant is that the hydrogen atoms can become affixed on small "dust" particles. Let us assume that the following are the rates for all possible reactions:

$$H \text{ (free)} \xrightarrow{\alpha} H \text{ (attached)}$$
$$H \text{ (attached)} \xrightarrow{\beta} H \text{ (free)}$$
$$H \text{ (attached)} + H \text{ (attached)} \xrightarrow{\gamma} H_2 \text{ (attached)}$$
$$H_2 \text{ (attached)} \xrightarrow{\eta} H_2 \text{ (free)}$$

We assume that the concentration of free hydrogen atoms is approximately constant, and thus absorb this concentration into the coefficient α .

- (a) Write down the equations for N_1 , the number of H (attached) atoms, and N_2 , the number of H₂ (attached) molecules.
- (b) What is the steady-state solution?
- (c) Discuss what happens in the limit when $\gamma \gg \alpha, \beta$. This is believed to be the physical limit. What is the limiting step in the production of H₂ gas?