For problems 1 & 2, you’ll need kinetic data. There are many sources for such data, but
the primary data comes from individual literature studies. Compilations of reactions into
mechanisms (e.g. GRI, Konnov, Leeds, San Diego, and others – see for example the list
at https://combustion.llnl.gov/mechanisms) include lots of reaction data, but some are
“tuned” so that individual reaction rates are not extractable. Watch out for that. Sites
like the NIST Chemical Kinetics Database have more fundamental data.

(1) A possible reaction in the hydrogen/oxygen system is:

$$\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{O}$$

which would represent a key step in a very simple mechanism for combustion. Estimate
the value of $f_r$ for that reaction at 1000 K and compare to the value of $f_r$ for the reaction of
$\text{H}_2$ with a radical like OH:

$$\text{H}_2 + \text{OH} \rightarrow \text{H}_2\text{O} + \text{H}$$

Which of those pathways is more likely to contribute to decomposition of $\text{H}_2$ and to $\text{H}_2\text{O}$
formation early in hydrogen/oxygen flames?

(2) Now consider all possible reactions involving $\text{H}_2 + \text{O}_2$ as reactants for which kinetic
data are available. Sum up all the $f_r$ values and compare to reaction of $\text{H}_2$ with OH. Is
the reaction of $\text{H}_2$ directly with $\text{O}_2$ an important pathway in hydrogen oxygen flames?

(3) For the reaction $\text{H}_2 + \text{OH} \rightarrow \text{H}_2\text{O} + \text{H}$, calculate the reverse $f_r$ for 500 to 2500 K.
Over what range of temperatures would you expect this system to be in partial
equilibrium? Next, for the range of 1000 to 2500 K, make two plots. On the first plot,
show experimental data for the reverse reaction, and compare that to reverse reaction rate
predictions using experimental data for the forward reaction rate and the equilibrium
constant. On the second plot, show experimental data for the forward reaction, and
compare that to forward reaction rate data obtained from experimental data for the
reverse reaction and the equilibrium constant. Comment on the agreement between the
two sets of lines in each plot.

(4) For problem (3) compare the equilibrium constant at 1000 K as obtained from data
from Burcat and from the GRI mechanism 3.0. Is there a significant difference? Would
you expect one for this well studied reaction? If there is a difference, explain where it
comes from.