

Name: LSR

Grade: \_\_\_\_\_

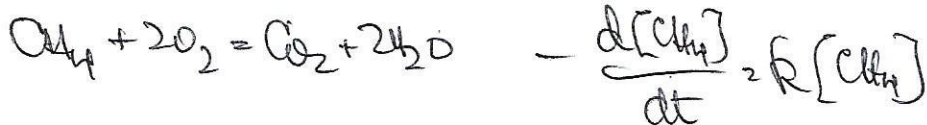
FSC 401

Quiz #2

Read the following statements carefully and indicate whether they are true (T) or false (F).

Note: For partial credit (if an answer is incorrect), summarize the procedure you used to obtain the answer and show the relevant calculations. If necessary, make the most convenient (and hopefully reasonable) assumptions.

F (30%) If the activation energy for natural gas combustion is 40 kcal/mol and the first-order pre-exponential factor is  $3.0 \times 10^7$ , it should take more than 30 ms for 85% of the fuel to be consumed at 1500 °C.



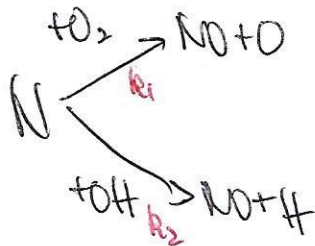
$$k = 351.6 \frac{1}{s} \Rightarrow (-0.85 = \exp(-kt)) \Rightarrow t = 5.4 \text{ ms} < 30 \text{ ms}$$

T (35%) If the pre-exponential factor for natural gas combustion at 2000 K is  $1.0 \times 10^8$  1/s, the fraction of effective collisions exceeds 0.5%. (Assume that the molecular cross-section is  $5.0 \times 10^{-19} \text{ m}^2$  and that the mean molecular mass is 0.020 kg/mol. Reasonable?)

$$\bar{c} = \left( \frac{8RT}{\pi M} \right)^{0.5} = 1455 \frac{\text{m}}{\text{s}} \quad \bar{z} = \frac{\sigma \bar{c} P}{k_B T} \approx 2.85 \times 10^9 \frac{1}{s}$$

$$\% \text{ effective collisions} = \frac{1.0 \times 10^8}{2.85 \times 10^9} = 3.5 > 0.5\% \quad \begin{matrix} ((\text{atm})) \\ ((\text{bar})) \end{matrix} *$$

T (35%) If the rate constants for the parallel reactions  $\text{N} + \text{O}_2 = \text{NO} + \text{O}$  and  $\text{N} + \text{OH} = \text{NO} + \text{H}$  are, respectively,  $1.8 \times 10^4 \cdot T \cdot \exp[-4680/T]$  and  $7.1 \times 10^7 \cdot \exp[-450/T]$ , less than 95% of atomic N will be consumed by OH (rather than O<sub>2</sub>) at 2000 K.



$$\frac{k_2}{k_1 + k_2} = 0.94 \quad \left( \begin{array}{l} \text{neglecting } [\text{O}_2] \\ \text{vs. } [\text{OH}] \dots \end{array} \right)$$

$$[\text{OH}] < [\text{O}_2] \quad \text{assume!} \Rightarrow \frac{k_2}{k_1 + k_2} < 0.94 < 0.95$$