General Chemistry II

RR # 4
Summer 2022

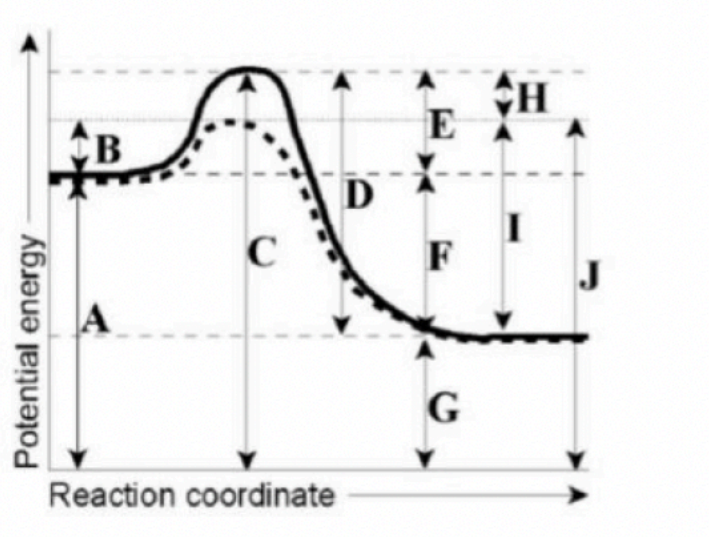
1. The decomposition of XY is second order in XY and has a rate constant of $7.02*10^{-3}$ M^{-1} s^{-1} at a certain temperature:
    a. How long will it take for the concentration of XY to decrease to 12.5% of its initial concentration when the initial concentration is 0.100 M?

    b. How long will it take for the concentration of XY to decrease to 12.5% of its initial concentration when the initial concentration is 0.200 M?

    c. If the initial concentration of XY is 0.052 M, what is the concentration of XY after 64 s?

2. Consider the equation for the decomposition of SO_2Cl_2: $SO_2Cl_2(g) \rightarrow SO_2(g) + Cl_2(g)$. The concentration of SO_2Cl_2 was monitored at a fixed temperature as a function of time during the decomposition. The reaction was determined to be first order and has a rate constant of $2.90*10^{-4}$ s^{-1}. If the reaction is carried out at the same temperature, and the initial concentration of SO_2Cl_2 is 0.0255 M, what will the SO_2Cl_2 concentration be after 865 seconds?

3. Consider the following reaction coordinate diagram.



a. Is the reaction above exothermic or endothermic?
b. Which letter represents the total energy of the reactants?
c. Which letter represents the total energy of the products?
d. Which letter represents ΔH for the catalyzed reaction?
e. Which letter represents ΔH for the uncatalyzed reaction?
f. Which letter represents the activation energy for the catalyzed reaction?
g. Which letter represents the activation energy for the uncatalyzed reaction?
h. Which letter represents the total energy of the transition state for the
i. catalyzed reaction?
j. Which letter represents the total energy of the transition state for the
k. uncatalyzed reaction?

4. The half-life of a first-order reaction is 1.5 hours. How much time is needed for 94% of the reactant to change to product?

5. The half-life for the radioactive decay of uranium-238 is 4.5 billion years and is independent of initial concentration. How long will it take for 21% of the U-238 atoms in a sample of U-238 to decay? If a sample of U-238 initially contained 1.5×10^{18} atoms when the universe was formed 13.8 billion years ago, how many U-238 atoms does it contain today?

6. The mechanism for the reaction of CH_3OH and HBr is believed to involve two steps. The overall reaction is exothermic.
   Step 1: $CH_3OH + H^+ \leftrightarrow CH_3OH_2^+$ Fast

   Step 2: $CH_3OH_2+ + Br^- \rightarrow CH_3Br + H_2O$ Slow

   a. Write out the overall reaction.

   b. Which step is the rate determining step?

7. The data below were collected for this reaction at 500˚C: $CH_3CN(g) \rightarrow CH_3NC\ (g)$

Time (hr)	$[CH_3CN]$ (M)
0.0	1.000
5.0	0.794
15.0	0.501
20.0	0.393
25.0	0.316

   a. What is the order of the reaction? Please explain your reasoning.

   b. What is the value of the rate constant at this temperature?

   c. What is the half life of this reaction (at the initial concentration)?

   d. How long will it take for 90% of the CH_3CN to convert to CH3NC?

8. The gas phase reaction $2N_2O_5\ (g) \rightarrow 4NO_2\ (g) + O_2\ (g)$ has an activation energy of 103 kJ/ mol, and the rate constant is 0.0900 at 328.0 K. Find the rate constant at 308.9 K.