Chapter 12 Chemical Kinetics

1) Given the following balanced equation, determine the rate of reaction with respect to [SO₂].
   \[ 2 \text{SO}_2 (g) + \text{O}_2(g) \rightarrow 2 \text{SO}_3(g) \]

   A) \[ \text{Rate} = \frac{1}{2} \frac{\Delta [\text{SO}_2]}{\Delta t} \]
   B) \[ \text{Rate} = + \frac{1}{2} \frac{\Delta [\text{SO}_2]}{\Delta t} \]
   C) \[ \text{Rate} = - \frac{\Delta [\text{SO}_2]}{\Delta t} \]
   D) \[ \text{Rate} = + \frac{2\Delta [\text{SO}_2]}{\Delta t} \]
   E) It is not possible to determine without more information

2) Which balanced reaction describes the following rate relationships.

   \[ \text{Rate} = \frac{1}{2} \frac{\Delta [\text{N}_2\text{O}_5]}{\Delta t} = \frac{1}{4} \frac{\Delta [\text{NO}_2]}{\Delta t} = \frac{\Delta [\text{O}_2]}{\Delta t} \]

   A) \( 2 \text{N}_2\text{O}_5 \rightarrow 4 \text{NO}_2 + \text{O}_2 \)
   B) \( 4 \text{NO}_2 + \text{O}_2 \rightarrow 2 \text{N}_2\text{O}_5 \)
   C) \( 2 \text{N}_2\text{O}_5 \rightarrow \text{NO}_2 + 4 \text{O}_2 \)
   D) \( \frac{1}{4} \text{NO}_2 + \text{O}_2 \rightarrow \frac{1}{2} \text{N}_2\text{O}_5 \)
   E) \( \frac{1}{2} \text{N}_2\text{O}_5 \rightarrow \frac{1}{4} \text{NO}_2 + \text{O}_2 \)

3) Given the following balanced equation, determine the rate of reaction with respect to [NOCl].
   If the rate of Cl₂ loss is \( 4.84 \times 10^{-2} \text{ M/s} \), what is the rate of formation of NOCl?
   \[ 2 \text{NO(g)} + \text{Cl}_2(g) \rightarrow 2 \text{NOCl(g)} \]

   A) \( 4.84 \times 10^{-2} \text{ M/s} \)
   B) \( 2.42 \times 10^{-2} \text{ M/s} \)
   C) \( 1.45 \times 10^{-1} \text{ M/s} \)
   D) \( 9.68 \times 10^{-2} \text{ M/s} \)
   E) \( 1.61 \times 10^{-2} \text{ M/s} \)

rate of change for NOCl is twice that of Cl₂
\[ 2 \times 4.84 \times 10^{-2} \text{ M/s} = 9.68 \times 10^{-2} \text{ M/s} \]
4) What is the overall order of the following reaction, given the rate law?
\[ \text{NO}(g) + \text{O}_3(g) \rightarrow \text{NO}_2(g) + \text{O}_2(g) \quad \text{Rate} = k[\text{NO}][\text{O}_3] \]

A) 1st order
B) 2nd order
C) 3rd order
D) \(\frac{1}{2}\) order
E) 0th order

My answer is letter \(B\)

1 + 1 = 2

5) i. Given the rate law, \(\text{Rate} = k [X][Y]^2\), how does the rate of reaction change if the concentration of \(Y\) is doubled?

ii. For this same rate law, how does the rate of reaction change if the concentration of \(X\) is doubled?

A) The rate of reaction will increase by a factor of 2.
B) The rate of reaction will increase by a factor of 4.
C) The rate of reaction will increase by a factor of 5.
D) The rate of reaction will decrease by a factor of 2.
E) The rate of reaction will remain unchanged

My answer is letter

i. \(B\)

ii. \(A\)

6) The first-order decomposition of cyclopropane has a rate constant of \(6.7 \times 10^{-4} \text{ s}^{-1}\). If the initial concentration of cyclopropane is 1.33 M, what is the concentration of cyclopropane after 644 s?

\[ \ln [\text{cyclopropane}]_{t=644s} = (-6.7 \times 10^{-4} \text{ s}^{-1}) (644 \text{ s}) + \ln 1.33 \text{ M} \]

\[ \ln [\text{cyclopropane}]_{t=644s} = -1.146 \]

\[ [\text{cyclopropane}]_{t=644s} = e^{-1.146} \]

\[ [\text{cyclopropane}]_{t=644s} = 0.86 \text{ M} \]
7) The first-order decay of radon has a half-life of 3.823 days. How many grams of radon remain after 7.646 days if the sample initially weighs 250.0 grams?
A) 4.21 g  
B) 183 g  
C) 54.8 g  
D) 76.3 g  
E) 62.5 g

\[
\ln \frac{N_t}{N_0} = -kt \quad \text{where} \quad k = \frac{0.693}{r} \quad 3.823 = 0.693/r \quad r = 0.181
\]

\[
\ln \frac{N_t}{N_0} = -0.181(7.646\text{days}) \quad \ln N = 4.1355 \quad N = e^{4.1355} = 62.5 \text{g}
\]

For the SECOND order half life expression: \( t_{1/2} = \frac{1}{[A]_0}k \)

8) The half-life for the second-order decomposition of HI is 15.4 s when the initial concentration of HI is 0.67 M. What is the rate constant for this reaction?
A) \( 1.0 \times 10^{-2} \text{ M-s}^{-1} \)  
B) \( 4.5 \times 10^{-2} \text{ M-s}^{-1} \)  
C) \( 9.7 \times 10^{-2} \text{ M-s}^{-1} \)  
D) \( 2.2 \times 10^{-2} \text{ M-s}^{-1} \)  
E) \( 3.8 \times 10^{-2} \text{ M-s}^{-1} \)

\[
15.4 = 1/0.67 \text{ M} \quad k = 1/0.67 \text{ M} \times 15.4 = 9.7 \times 10^{-2} \text{ M-s}^{-1}
\]

Given: \( \ln \left( \frac{k_2}{k_1} \right) = -E_a/R \left( \frac{1}{T_2} - \frac{1}{T_1} \right) \)

9) The first-order rearrangement of CH₃NC is measured to have a rate constant of \( 3.61 \times 10^{-15} \) s⁻¹ at 298 K and a rate constant of \( 8.66 \times 10^{-7} \) s⁻¹ at 425 K. Determine the activation energy for this reaction.
A) 160. kJ/mol  
B) 240. kJ/mol  
C) 417 kJ/mol  
D) 127 kJ/mol  
E) 338 kJ/mol

\[
\ln \left( \frac{8.66 \times 10^{-7} \text{s}^{-1}}{3.61 \times 10^{-15} \text{s}^{-1}} \right) = \left( \frac{+E_a}{8.314 \text{ J/mol K}} \right) \left( \frac{425 \text{K} - 298 \text{K}}{298 \text{K}} \right)
\]

\[
\ln \left( 8.4 \times 10^8 \right) = \frac{E_a}{8.314 \text{ J/mol K}} \left( \frac{401 \text{K}}{298 \text{K}} \right)
\]

\[
\frac{8.314 \text{ J/mol K}}{19.3 \text{ K}} = \frac{E_a}{.001 \text{ K}}
\]

\[
E_a = 160 \text{ kJ/mol}
\]
10) A reaction is found to have an activation energy of 108 kJ/mol. If the rate constant for this reaction is $4.60 \times 10^{-6}$ s$^{-1}$ at 275 K, what is the rate constant at 366 K?

A) 11.7 s$^{-1}$  
B) 1.72 s$^{-1}$  
C) 0.580 s$^{-1}$  
D) $5.40 \times 10^{-5}$ s$^{-1}$  
E) $1.85 \times 10^{-4}$ s$^{-1}$

My answer is letter C

\[ \ln h_2 = \frac{E_a}{R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right) \]

\[ \ln h_2 = \frac{E_a}{R} \left( \frac{1}{275} - \frac{1}{366} \right) + \ln h_1 = \frac{108000 \text{ J/mol}}{8.314 \text{ J/mol K}} \left( \frac{1}{275} - \frac{1}{366} \right) - \ln 4.60 \times 10^{-6} \text{ s}^{-1} \]

\[ \ln h_2 = -0.5495 \]

\[ h_2 = e^{-0.5495} = 0.58 \text{ s}^{-1} \]

11) Match the following.

Write your letter answer below:

i) \( k \)  

ii) \( t_{1/2} \)  

iii) \( E_a \)  

iv) \( A \)  
v) \( n \), in Rate = \( k[A]^n \)

E  

D  

B  

C  

A  

A) reaction order  

B) activation energy  

C) frequency factor  

D) half-life  

E) rate constant