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Chapter 12 Chemical Kinetics

1) Given the following balanced equation, determine the rate of reaction with respect to $[SO_2]$.

$2\ SO_2\ (g) + O_2(g) \rightarrow 2\ SO_3(g)$

My answer is letter A

A) $\text{Rate} = -\frac{1}{2}\frac{\Delta[SO_2]}{\Delta t}$

B) $\text{Rate} = +\frac{1}{2}\frac{\Delta[SO_2]}{\Delta t}$

C) $\text{Rate} = -\frac{\Delta[SO_2]}{\Delta t}$

D) $\text{Rate} = +\frac{2\Delta[SO_2]}{\Delta t}$

E) It is not possible to determine without more information

2) Which balanced reaction describes the following rate relationships.

$$\textbf{Rate} = -\frac{1}{2}\frac{\Delta[N_2O_5]}{\Delta t} = \frac{1}{4}\frac{\Delta[NO_2]}{\Delta t} = \frac{\Delta[O_2]}{\Delta t}$$

My answer is letter A

A) $2\ N_2O_5 \rightarrow 4\ NO_2 + O_2$

B) $4\ NO_2 + O_2 \rightarrow 2\ N_2O_5$

C) $2\ N_2O_5 \rightarrow NO_2 + 4\ O_2$

D) $\frac{1}{4}\ NO_2 + O_2 \rightarrow \frac{1}{2}\ N_2O_5$

E) $\frac{1}{2}\ N_2O_5 \rightarrow \frac{1}{4}\ NO_2 + O_2$

3) Given the following balanced equation, determine the rate of reaction with respect to [NOCl]. If the rate of Cl_2 loss is 4.84×10^{-2} M/s, what is the rate of formation of NOCl?

$2\ NO(g) + Cl_2(g) \rightarrow 2\ NOCl(g)$

My answer is letter D

A) 4.84×10^{-2} M/s

B) 2.42×10^{-2} M/s

C) 1.45×10^{-1} M/s

D) 9.68×10^{-2} M/s

E) 1.61×10^{-2} M/s

rate of change for NOCl is twice that of Cl_2

$2 \times 4.84 \times 10^{-2}\ M/s = 9.68 \times 10^{-2}\ M/s$

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4) What is the overall order of the following reaction, given the rate law?

$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$ Rate = k[NO][O3]

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

1st order for NO
1st order for O_3

2nd order overall

1+1 = 2

My answer is letter **B**

5) i. Given the rate law, **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**

For the first order integrated rate law: $\ln[A]_t = -kt + \ln[A]_0$

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

A) 0.43 M
B) 0.15 M
C) 0.94 M
D) 0.86 M
E) 0.67 M

$[\text{cyclopropane}]_0 = 1.33\,M$

$k = 6.7 \times 10^{-4}\ s^{-1}$

$t = 644\,s$

My answer is letter **D**

$$\ln[\text{cyclopropane}]_{t=644s} = (-6.7\times10^{-4}\,s^{-1})(644\,s) + \ln 1.33\,M$$

$\ln[CP] = -.146$ $\quad [CP] = e^{-.146}$

$[CP]_{t=644s} = 0.86\,M$

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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

My answer is letter E

$250_g \xrightarrow{1^{st}\text{ half life}} 125_g$ in 3.823 days

$125_g \xrightarrow{2^{nd}\text{ half life}} 62.5_g$ in 3.823 days

7.646 days

OR

$\ln \frac{N_1}{N_0} = -kt$ where $t_{1/2} = 0.693/k$ $\quad 3.823 = 0.693/k \quad k = 0.181$

$\ln \frac{N_1}{250} = -0.181(7.646\text{days}) \quad \therefore \ln N = 4.1355 \quad N = e^{4.1355} = 62.5_g$

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

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) $1.0 \times 10^{-2}\ M^{-1}s^{-1}$
B) $4.5 \times 10^{-2}\ M^{-1}s^{-1}$
C) $9.7 \times 10^{-2}\ M^{-1}s^{-1}$
D) $2.2 \times 10^{-2}\ M^{-1}s^{-1}$
E) $3.8 \times 10^{-2}\ M^{-1}s^{-1}$

My answer is letter C

$t_{1/2} = 15.4\ s$

$[HI]_0 = 0.67M$

$15.4s = 1/0.67M\ k$

$k = 1/0.67M \times 15.4s = 9.7 \times 10^{-2}\ M^{-1}s^{-1}$

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

9) The first-order rearrangement of CH_3NC 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

My answer is letter A

$T_1 = 298°K \quad k_1 = 3.61 \times 10^{-15}\ s^{-1}$

$T_2 = 425°K \quad k_2 = 8.66 \times 10^{-7}\ s^{-1}$

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

$\ln (2.4 \times 10^8) = \frac{E_a}{8.314\ J/mol\,K\ (.001K)}$

$\frac{(8.314\ J/mol\,K)\ 19.3}{.001} = E_a = 160\ kJ/mol$

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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?

My answer is letter C

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

$T_1 = 275K \quad k_1 = 4.60\times10^{-6}\ s^{-1}$

$T_2 = 366K \quad k_2 = ?$

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

$$\ln k_2 = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) + \ln k_1 = \frac{108000\ J/mol}{8.314\ J/mol\,K}\left(\frac{1}{275K} - \frac{1}{366K}\right) - \ln 4.60\times10^{-6}\ s^{-1}$$

$\ln k_2 = -.5495 \quad k_2 = e^{-.5495} = 0.58\ s^{-1}$

11) Match the following. Write your letter answer below:

i) k	E	A) reaction order
ii) $t_{1/2}$	D	B) activation energy
iii) E_a	B	C) frequency factor
iv) A	C	D) half-life
v) *n*, in Rate = $k[A]^n$	A	E) rate constant