Chapter 20 Worksheet 1 (Ch 20.1-20.5)

Name: Answer Key

UGA myID:

Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname).
- Your UGA myID is a combination of letters and numbers (example: mine is aw00285). **Do not use your 81x number.**
- If you do not have a printer, type your answers in the boxes then upload the worksheet template to Gradescope by **Thursday, January 28th at 11:59 p.m.** Write your work on separate sheets of paper, convert to a PDF and upload to the dropbox on eLC.
- If you have a printer download the worksheet, write your answers and show your work on the worksheet template, convert it to a PDF and upload to Gradescope by **Thursday, January 28th at 11:59 p.m.**

$[HNO_2]_0 = 1.00\ M$

$[HNO_2]_f = 0.73$

$\Delta t = 41.6$

Chapter 20-Part 1

Question 1: For the reaction of the ammonium ion with nitrous acid, the net reaction is

$\mathbf{NH_4^+(aq) + HNO_2(aq) \rightarrow N_2(g) + 2\ H_2O(\mathit{l}) + H^+(aq)}$

If the initial concentration of nitrous acid is 1.00 M and, after 41.2 s has elapsed, the concentration of nitrous acid has fallen to 0.73 M, what is the average rate of the reaction over this time interval?

A

A. 0.0065 M/s
B. 0.017 M/s
C. –0.055 M/s
D. –0.03 M/s
E. 0.041 M/s

$$\text{Rate} = \frac{1.00 - 0.73}{41.6} = 0.00649\ \frac{M}{s} = 0.0065\ \frac{M}{s}$$

Question 2: For the hypothetical reaction 2A + B→ 2C + D, the initial rate of disappearance of A is 2.0 × 10^{-2} mol/L · s. What is the initial rate of disappearance of B?

B

A. 8.0 × 10^{-2} mol/L · s
B. 1.0 × 10^{-2} mol/L · s
C. 1.4 × 10^{-1} mol/L · s
D. 4.0 × 10^{-4} mol/L · s
E. 1.4 × 10^{-2} mol/L · s

$$\text{Rate} = -\frac{1}{2}\frac{\Delta A}{\Delta t} = -\frac{\Delta B}{\Delta t}, \quad \boxed{\frac{\Delta A}{\Delta t} = 2.0\times10^{-2}}$$

$$-\frac{\Delta B}{\Delta t} = -\frac{1}{2}\frac{\Delta A}{\Delta t} \Rightarrow \frac{\Delta B}{\Delta t} = \frac{1}{2}(2.0\times10^{-2}) = 1.0\times10$$

Question 3: Consider the general reaction:

$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(aq)$

For this reaction, the rate when expressed as $\Delta[Br_2]/\Delta t$ is the same as

D

A. $-\Delta[H_2O]/\Delta t$
B. $-3\ \Delta[BrO_3^-]/\Delta t$
C. $-5\ \Delta[Br^-]/\Delta t$
D. $-0.6\ \Delta[Br^-]/\Delta t$
E. None of the above

$$-\frac{1}{5}\frac{\Delta[Br^-]}{\Delta t} = -\frac{\Delta[BrO_3^-]}{\Delta t} = +\frac{1}{3}\frac{\Delta[Br_2]}{\Delta t} = +\frac{1}{3}\frac{\Delta[H_2O]}{\Delta t}$$

$$\frac{\Delta[Br_2]}{\Delta t} = -\frac{3}{5}\frac{\Delta[Br^-]}{\Delta t} = -0.6\frac{\Delta[Br^-]}{\Delta t}$$

Question 4: A certain reaction is zero order in reactant A and second order in reactant B. If the concentrations of both reactants are doubled, what happens to the reaction rate?

A

A. The rate of reaction is quadrupled.
B. The rate of reaction is doubled.
C. The rate of reaction remains the same.
D. The rate of reaction is halved.
E. The rate of reaction is quartered.
D. increase the rate by an order of 9.

$\text{Rate} = k[A]^0 = k$

No dependence on concentration.

$[OH^-]$ does not affect the rate, hence zero order.

Question 5: Consider the reaction $C_4H_9Br + OH^- \rightarrow C_4H_9OH + Br^-$. When the concentration of C_4H_9Br is doubled, the rate of the reaction increases by a factor of two. When the concentrations of all reactants and products are doubled, the rate also doubles. What is the overall order of the reaction?

B

A. Zero order
B. First order
C. Second order
D. Third order
E. Fourth order
F. Fifth order

$Rate = [C_4H_9Br]^x [OH^-]^y$

$Rate = [C_4H_9Br]^x$

$2^x = 2$, $x = 1$

Question 6: The rate expression for a reaction is shown to be rate = $k[A]^2[B_2]$. If, during a reaction, the concentration of A was suddenly halved and the concentration of B was suddenly doubled, the rate of reaction would

E

A. increase by a factor of 8.
B. increase by a factor of 4.
C. increase by a factor of 2.
D. remain the same.
E. decrease by a factor of 2.
F. decrease by a factor of 4.
G. decrease by a factor of 8.

$Rate = k[A]^2[B_2]$

$A_{new} = \frac{1}{2} A_{old}$, $(B_2)_{new} = (2 \cdot B_2)_{old}$

$Rate = k \cdot \left(\frac{1}{2} A\right)^2 (2B) = k \cdot \frac{1}{4} A^2 \cdot 2B$

$= k \frac{1}{2} \cdot A^2 \cdot B$

Question 7: Over the time interval 300 to 400 seconds, the rate of reaction with respect to A is $\Delta[A]/\Delta t = 3.7 \times 10^{-5}$ M/s. Over the same time interval what is the rate of reaction with respect to B, $\Delta[B]/\Delta t$?

B

$$4A(g) + B(g) \rightarrow 2C(g)$$

$-\frac{1}{4}\frac{\Delta A}{\Delta t} = -\frac{\Delta B}{\Delta t}$

A. $\Delta[B]/\Delta t = \Delta[A]/\Delta t = 3.7 \times 10^{-5}$ M/s
B. $\Delta[B]/\Delta t = (-1/4)(\Delta[A]/\Delta t) = (-1/4)(-3.7 \times 10^{-5}\text{ M/s}) = 9.2 \times 10^{-6}$ M/s
C. $\Delta[B]/\Delta t = (1/2)(\Delta[A]/\Delta t) = (1/2)(3.7 \times 10^{-5}\text{ M/s}) = 1.8 \times 10^{-5}$ M/s
D. $\Delta[B]/\Delta t = -(1/2)(\Delta[A]/\Delta t) = -(1/2)(3.7 \times 10^{-5}\text{ M/s}) = -1.8 \times 10^{-5}$ M/s

$\frac{\Delta B}{\Delta t} = \frac{1}{4}\frac{\Delta A}{\Delta t}$

$\frac{\Delta B}{\Delta t} = \frac{1}{4}(3.7 \times 10^{-5})$

$= 9.2 \times 10^{-6}$ M

Question 8: For the reaction:
2A + B + 2C → D + E
the following initial rate data were collected at constant temperature. Determine the correct rate law for this reaction. All units are arbitrary.

Trial	[A]	[B]	[C]	Rate
1	0.225	0.150	0.350	0.0217
2	0.320	0.150	0.350	0.0439
3	0.225	0.250	0.350	0.0362
4	0.225	0.150	0.600	0.01270

with respect to C: (Trial 1, Trial 4)

$\left(\frac{0.600}{0.350}\right)^z = \frac{0.01270}{0.0217}$, $(1.714)^z = 0.5852$, $\boxed{z = -1}$

D

A. Rate = k[A][B][C]
B. Rate = $k[A]^2[B][C]$
C. Rate = $k[A][B]^2[C]^{-1}$
D. Rate = $k[A]^2[B][C]^{-1}$
E. None of these

With Respect to A: (Trial 1 and Trial 2):

$\left(\frac{0.320}{0.225}\right)^x = \left(\frac{0.0439}{0.0217}\right)$, $(1.422)^x = 2.00$, $\boxed{x = 2}$

(second-order)

With Respect to B: (Trial 1 and Trial 3):

$\left(\frac{0.250}{0.150}\right)^y = \left(\frac{0.0362}{0.0217}\right)$, $(1.666)^y = (1.668)$, $\boxed{y = 1}$

Question 9: The reaction that occurs in a Breathalyzer, a device used to determine the alcohol level in a person's bloodstream, is given below. If the rate of appearance of $Cr_2(SO_4)_3$ is 1.24 mol/min at a particular moment, what is the rate of disappearance of C_2H_6O at that moment?

$$\frac{\Delta[Cr_2(SO_4)_3]}{\Delta t} = 1.24 \frac{mol}{min}$$

$\boxed{D}$

$$2 K_2Cr_2O_7 + 8 H_2SO_4 + 3 C_2H_6O \rightarrow 2 Cr_2(SO_4)_3 + 2 K_2SO_4 + 11 H_2O$$

A. 3.72 mol/min
B. 0.413 mol/min
C. 0.826 mol/min
D. 1.86 mol/min
E. None of these.

$$-\frac{1}{3}\frac{\Delta[C_2H_6O]}{\Delta t} = \frac{1}{2}\frac{\Delta[Cr_2(SO_4)_3]}{\Delta t}$$

$$\frac{\Delta[C_2H_6O]}{\Delta t} = \frac{3}{2}\left(1.24 \frac{mol}{min}\right) = 1.86 \frac{mol}{min}$$

Question 10: The reaction A → B is first order in [A]. Consider the following data.

How do you know this is a first-order?

Time (s)	0.0	5.0	10.0	15.0	20.0
[A] (M)	0.20	0.14	0.10	0.071	0.040

What is the rate constant (s-1) for this reaction?

$\boxed{E}$

A. 3.0×10^{-2}
B. 14
C. 0.46
D. 4.0×10^{2}
E. None of these.

$$\ln[A]_t = -k \cdot t + \ln[A]_0$$

$$\ln(0.040) - \ln(0.20) = -k(20.0)$$

$$-1.609 = -k(20.0)$$

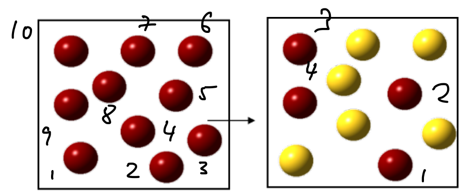
$$8 \times 10^{-2}$$

Question 11: A particular first order reaction was monitored over a period of time. The figure to the right summarizes the experimental results where each sphere represents 3.0 mol L^{-1}. The average reaction rate is,

$\boxed{D}$

A. 5.0 mol/L·s
B. 1.0 mol/L·s
C. 1.0 s^{-1}
D. 0.20 mol/L·s
E. 0.20 s^{-1}

$$\frac{10(3.0) - 4(3.0)}{90} =$$



time, t =0 time, t =1 min 30 s

Question 12: The decomposition of ammonia on a metal surface to form nitrogen gas and hydrogen gas is a zero-order reaction. At 873 °C, the value of the rate constant is 1.5×10^{-3} mol/L·sec. Determine the number of seconds needed to decompose 90.0% of the ammonia in a solution containing 1.00 grams of ammonia in a 250 mL flask.

$\boxed{140}$ seconds

$$[A]_t = -k \cdot t + [A]_0$$

$$[A]_0 = 0.2353 \frac{Mol}{L}$$

$$[A]_t = (0.2353 - \underbrace{0.21177}_{90\% \text{ of } [A]_0}) = 0.02353 \text{ M}$$

$$t = -\frac{[A]_t - [A]_0}{k} = -\frac{(0.02353 - 0.2353)}{(1.5\times10^{-3})}$$

$$t = 141.2 \text{ sec} \sim 140 \text{ seconds}$$

$Rate = k[A]^2 \Rightarrow k = \frac{Rate}{[A]^2} = \frac{(2.5\times10^{-5})}{(0.030)^2}$

Cuestión 13: Data for the reaction A + B → C are given below. Find the rate constant for this system.

$\boxed{k = 2.77\times10^{-2}}$

Experiment	[A]0, M	[B]0, M	Initial rate, M/s
1	0.030	0.060	2.5×10^{-5}
2	0.030	0.020	2.5×10^{-5}
3	0.060	0.060	10.0×10^{-5}

$\boxed{A}$

A. 2.8×10^{-2} M^{-1} s^{-1}
B. 2.8×10^{-2} M s^{-1}
C. 2.8×10^{-2} M^2 s^{-1}
D. 1.7×10^{-3} M^{-1} s^{-1}
E. 1.7×10^{-3} M s^{-1}

With respect to A: (E_3 vs. E_1)

$\left(\frac{0.060}{0.030}\right)^x = \frac{10.0\times10^{-5}}{2.5\times10}$, $2^x = 4$, $x = 2$

With respect to B: (E_2 vs. E_1)

$\left(\frac{0.020}{0.060}\right)^y = 1$, NO, change

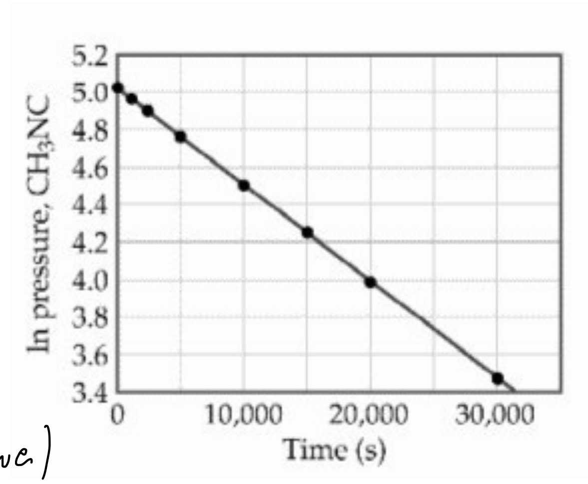
Question 14: At elevated temperatures, methylisonitrile (CH_3NC) isomerizes to acetonitrile (CH_3CN):

CH_3NC (g) → CH_3CN (g)

The reaction is first order in methylisonitrile. The attached graph shows data for the reaction obtained at 198.9 °C. What is the rate constant (s^{-1}) for the reaction?

$\boxed{E}$

A. -1.9×10^4
B. +6.2
C. $+1.9 \times 10^4$
D. -5.2×10^{-5}
E. $+5.2 \times 10^{-5}$



$\ln[A]_t = -k\cdot t + \ln[A]_0$

$\sim 3.4 = -k \cdot 31{,}000 + \sim 5.1$

$-1.7 = -k \cdot 31{,}000$

$k = \sim 5.4\times10^{-5}$ (closest answer)

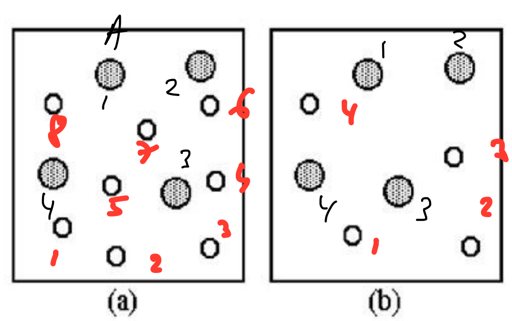
Question 15: The following reaction is first order in A and first order in B:

A + B → Products Rate = k[A][B]

What is the initial rate of this reaction in vessel (b) relative to the initial rate of this reaction in vessel (a)? Each vessel has the same volume. Shaded spheres represent A molecules, and unshaded spheres represent B molecules present at the beginning of the reaction.

$\boxed{A}$

A. rate in vessel (b)/rate in vessel (a) = 1:2
B. rate in vessel (b)/rate in vessel (a) = 1:1
C. rate in vessel (b)/rate in vessel (a) = 2:1
D. rate in vessel (b)/rate in vessel (a) = 4:1



Question 16: The decomposition of a certain insecticide in water at 12 °C follows first-order kinetics with a rate constant of 1.45 yr^{-1}. A quantity of this insecticide is washed into a lake on June 1, leading to a concentration of 5.0 x 10^{-7} g/cm^3. Assume the temperature of the lake is constant.

$[A]_0 = 5.0 \times 10^{-7}$ g/cm^3

$K = 1.45 \cdot \text{YEAR}^{-1}$

$t = 1 \text{ YEAR}$

$$\ln\frac{[A]_0}{[A]_t} = kt$$

Part A: What is the concentration of insecticide on June 1 of the following year?

$\boxed{1.2 \times 10^{-7}}$ g/cm^3.

$\frac{[A_0]}{[A]_t} = e^{kt}$, $[A]_t = \frac{[A_0]}{e^{kt}} = \frac{5.0 \times 10^{-7}}{e^{1 \times 1.45}}$

$= 1.173 \times 10^{-7} \frac{g}{cm^3}$

Part B: How long will it take for the insecticide concentration to decrease to 3.0 x 10^{-7} g/cm^3?

$\boxed{0.35}$ years.

$\ln \frac{(5.0 \times 10^{-7})}{(3.0 \times 10^{-7})} = (1.45 \text{ YEAR}^{-1}) \cdot t$

$0.5108 = (1.45 \text{ YEAR}^{-1}) \cdot t$

$t = 0.352$ YEAR

Question 17: SO_2Cl_2 decomposes by first order kinetics and k = 2.81 x 10^{-3} min^{-1} at a given temperature. The initial concentration of SO_2Cl_2 = 0.015 M. Determine the half-life of the reaction.

$\boxed{B}$

A. $t_{1/2}$ = 0.6931 / 2.81 x 10^{-3} min^{-1} = 246.6 min
B. $t_{1/2}$ = 0.6931 / 2.81 x 10^{-3} min^{-1} = 247 min
C. $t_{1/2}$ = 1 / (2.81 x 10^{-3} min^{-1} (0.015)) = 2.37 x 10^4 min
D. $t_{1/2}$ = 1/(2.81 x 10^{-3} min^{-1} (0.015)) = 2.4 x 10^4 min

$\ln \frac{[A]_0}{[A]_t} = k \cdot t$

$\ln 2 = k \cdot t$

$t = \frac{0.693}{(2.81 \times 10^{-3})}$

Question 18: The first-order reaction, $SO_2Cl_2 \rightarrow SO_2 + Cl_2$, has a half-life of 8.75 hours at 593 K. How long will it take for the concentration of SO_2Cl_2 to fall to 14.5% of its initial value?

$\boxed{24.4}$ hour

$k = \frac{0.693}{8.75h} = 7.92 \times 10^{-2} \text{ hour}^{-1}$

Assume 100 g

$\ln \frac{100}{14.5} = (7.92 \times 10^{-2}) \cdot t$

$1.931 = 7.92 \times 10^{-2} \cdot t$

$t = 24.38 \approx 24.4$ hours