Module 3 Lesson 6 Exercises Answer Key

1. Since the reaction is first order, the rate changes by the same factor the concentration changes.

   Reducing the concentration to one-half results in the rate reducing by one-half to 0.250 mol/Ls.

   Reducing the concentration to one-fourth will reduce the rate to one-fourth, or 0.125 mol/Ls.

2. a) Since O_2 is first order, $2 \times [O_2] = 2 \times$ rate

   b) If the volume of the entire container is reduced to one-half, the concentration of all the reactants will double. Both reactants are first order so,
   $(2 \times [N_2O]) \times (2 \times [O_2]) = 4 \times$ rate

   Another way to look at this is the total order of the reaction (sum of the exponents) is 2 so,

   $2 \times$ [reactants] $= 2^2 \times$ rate$= 4\times$rate

3. a) Since H_2 is first order, $3 \times [O_2] = 3 \times$ rate

   b) Since NO is second order,
   $2 \times [NO] = 2^2 \times$ rate $= 4 \times$ rate

   c) If the volume of the entire container is reduced to one-half, the concentration of all the reactants will double.

   $(2 \times [NO])^2 \times (2 \times [O_2]) = 2^3 \times$ rate $= 8 \times$ rate

   Another way to look at this is the total order of the reaction (sum of the exponents) is 3 so,

   $2 \times$ [reactants] $= 2^3 \times$ rate$= 8\times$rate

4. From Trial 1 & 2, [B] constant

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \frac{\left[\text{A}\right]_2}{\left[\text{A}\right]_1}$$

$$\frac{1.5}{0.50} = \left(\frac{3.0}{1.0}\right)^{order}$$

$$3 = 3^{order}$$

$$1 = order$$

From Trial 2 & 3, [A] constant

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \frac{\left[\text{B}\right]_2}{\left[\text{B}\right]_1}$$

$$\frac{3.0}{1.5} = \left(\frac{2.0}{1.0}\right)^{order}$$

$$2 = 2^{order}$$

$$1 = order$$

rate = k[A][B]

$$\text{rate} = k[\text{A}][\text{B}]$$

$$k = \frac{\text{rate}}{[\text{A}][\text{B}]}$$

$$= \frac{0.50}{(1.0)(1.0)}$$

$$k = 0.50$$

5. From trials 1 &2, $[OCl^-]$ constant

$$\frac{\text{Rate}_1}{\text{Rate}_2} = \frac{\left[\text{I}^-\right]_1}{\left[\text{I}^-\right]_2}$$

$$\frac{7.91 \times 10^{-2}}{3.95 \times 10^{-2}} = \left(\frac{0.12}{0.060}\right)^{order}$$

$$2 = 2^{order}$$

$$1 = order$$

5. (con't) From Trials 2 &4, $[I^-]$ constant

$$\frac{\text{Rate}_2}{\text{Rate}_4} = \frac{\left[OCl^-\right]_2}{\left[OCl^-\right]_4}$$

$$\frac{3.95\times10^{-2}}{1.98\times10^{-2}} = \left(\frac{0.18}{0.090}\right)^{order}$$

$$4 = 2^{order}$$

$$2 = order$$

rate = k[I⁻][OCl⁻]²

$$\text{rate} = k[I^-][OCl^-]^2$$

$$k = \frac{\text{rate}}{[I^-][OCl^-]^2}$$

$$= \frac{7.91\times10^{-2}}{(0.12)(0.18)^2}$$

$$k = 20.3$$

6. Trials 1 &2, [B] & [C] constant

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \frac{\left[A\right]_2}{\left[A\right]_1}$$

$$\frac{1.40}{0.35} = \left(\frac{2.0}{1.0}\right)^{order}$$

$$4 = 2^{order}$$

$$2 = order$$

Trials 2&3, [A]&[C] constant

$$\frac{\text{Rate}_2}{\text{Rate}_3} = \frac{\left[B\right]_2}{\left[B\right]_3}$$

$$\frac{1.40}{1.40} = \left(\frac{2.0}{1.0}\right)^{order}$$

$$1 = 2^{order}$$

$$0 = order$$

Trials 1&4, [A]&[B] constant

$$\frac{\text{Rate}_4}{\text{Rate}_1} = \frac{\left[\text{C}\right]_4}{\left[\text{C}\right]_1}$$

$$\frac{0.70}{0.35} = \left(\frac{1.0}{0.50}\right)^{order}$$

$$2 = 2^{order}$$

$$1 = order$$

rate = k[A]^2[C]

$$\text{rate} = k[\text{A}]^2[\text{C}]$$

$$k = \frac{\text{rate}}{[\text{A}]^2[\text{C}]}$$

$$= \frac{0.35}{(1.0)^2(0.50)}$$

$$k = 0.70$$

7. Trials 1 &2, [Y] & [Z] constant

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \frac{\left[\text{X}\right]_2}{\left[\text{X}\right]_1}$$

$$\frac{5.94}{0.66} = \left(\frac{1.35}{0.45}\right)^{order}$$

$$9 = 3^{order}$$

$$2 = order$$

Trials 1&3, [X]&[Z] constant

$$\frac{\text{Rate}_3}{\text{Rate}_1} = \frac{\left[\text{Y}\right]_3}{\left[\text{Y}\right]_1}$$

$$\frac{1.98}{0.66} = \left(\frac{0.60}{0.20}\right)^{order}$$

$$3 = 3^{order}$$

$$1 = order$$

7.(con't) Trials 3&4, [X]&[Y] constant

$$\frac{Rate_4}{Rate_3} = \frac{[Z]_4}{[Z]_3}$$

$$\frac{1.98}{1.98} = \left(\frac{1.10}{0.55}\right)^{order}$$

$$1 = 2^{order}$$

$$0 = order$$

rate = k$[X]^2$[Y]

$$\text{rate} = k[X]^2[Y]$$

$$k = \frac{\text{rate}}{[X]^2[Y]}$$

$$= \frac{0.66}{(0.45)^2(0.20)}$$

$$k = 16.3$$

8. Trial 1&2, $[I_2]$ constant

$$\frac{Rate_1}{Rate_2} = \frac{[CH_3COCH_3]_1}{[CH_3COCH_3]_2}$$

$$\frac{1.16 \times 10^{-7}}{5.79 \times 10^{-8}} = \left(\frac{0.100}{0.0500}\right)^{order}$$

$$2 = 2^{order}$$

$$1 = order$$

Trial 2&3, $[CH_3COCH_3]$ constant

$$\frac{Rate_3}{Rate_2} = \frac{[I_2]_3}{[I_2]_2}$$

$$\frac{5.77 \times 10^{-8}}{5.79 \times 10^{-8}} = \left(\frac{0.500}{0.100}\right)^{order}$$

$$1 = 5^{order}$$

$$0 = order$$

rate = k$[CH_3COCH_3]$

8. b)

$$\text{rate} = k[\text{CH}_3\text{COCH}_3]$$

$$k = \frac{\text{rate}}{[\text{CH}_3\text{COCH}_3]}$$

$$= \frac{1.16 \times 10^{-7}}{(0.100)}$$

$$k = 1.16 \times 10^{-6}$$

c) Since iodine is zero order we don't use it in our rate calculation.

rate = k[CH_3COCH_3] = ($1.16x10^{-6}$)(0.0700 mol/L) = $8.12x10^{-8}$ mol/Ls

Check the data table and make sure the units are correct.

d)

$$\text{rate} = k[\text{CH}_3\text{COCH}_3]$$

$$[\text{CH}_3\text{COCH}_3] = \frac{\text{rate}}{k}$$

$$= \frac{3.10 \times 10^{-8}}{1.16 \times 10^{-6}}$$

$$= 0.0267 \text{ mol/L}$$

9. Trial 1&2, [A] constant

$$\frac{\text{Rate}_1}{\text{Rate}_2} = \frac{[\text{B}]_1}{[\text{B}]_2}$$

$$\frac{1.45 \times 10^{-4}}{7.25 \times 10^{-5}} = \left(\frac{0.0240}{0.0120}\right)^{order}$$

$$2 = 2^{order}$$

$$1 = order$$

Using trials 2 & 3 (you could also use trials 1 & 3)

Since the concentration of B does not remain constant, we can choose any two trials but we must include the ratio of B concentrations.

We know that B is first order.

$$\frac{Rate_3}{Rate_2} = \left(\frac{[A]_3}{[A]_2}\right)^{order} \left(\frac{[B]_3}{[B]_2}\right)^{order}$$

$$\frac{5.80 \times 10^{-4}}{7.25 \times 10^{-5}} = \left(\frac{0.0200}{0.100}\right)^{order} \left(\frac{0.0480}{0.0120}\right)^{1}$$

$$8 = 2^{order} \times 4^1$$

$$\frac{8}{4} = 2^{order}$$

$$2 = 2^{order}$$

$$1 = order$$

Rate = k[A][B]

10. Trial 2&3, [A] constant

$$\frac{Rate_2}{Rate_3} = \frac{[B]_2}{[B]_3}$$

$$\frac{3.6 \times 10^{-2}}{9.0 \times 10^{-3}} = \left(\frac{0.084}{0.021}\right)^{order}$$

$$4 = 4^{order}$$

$$1 = order$$

Using trials 1 & 2 (you could also use trials 1 & 3)

Since the concentration of B does not remain constant, we can choose any two trials but we must include the ratio of B concentrations.

We know that B is first order.

$$\frac{Rate_1}{Rate_2} = \left(\frac{[A]_1}{[A]_2}\right)^{order} \left(\frac{[B]_1}{[B]_2}\right)^{order}$$

$$\frac{3.6 \times 10^{-2}}{3.6 \times 10^{-2}} = \left(\frac{0.0012}{0.00060}\right)^{order} \left(\frac{0.042}{0.084}\right)^{1}$$

$$1 = 2^{order} \times 0.5^1$$

$$\frac{1}{0.5} = 2^{order}$$

$$2 = 2^{order}$$

$$1 = order$$

Rate = k[A][B]

11. a) Rate = $k[H_2][I_2]$

b)

$$\text{rate} = k[H_2][I_2]$$
$$k = \frac{\text{rate}}{[H_2][I_2]}$$
$$= \frac{1.0 \times 10^{-4}}{(0.025)(0.050)}$$
$$k = 0.080$$

c) Rate = $k[H_2][I_2]$ = (0.080)(0.10)(0.10) = 8.0×10^{-4} mol/Lmin

d) $(2x[H_2])^1(0.5x[I_2])^1$ = (2 x 0.5) x rate = 1 x rate
the rate is unchanged

12. For the one step reaction $A(g) + 2\,B(g) \rightarrow C(g)$

a) Rate = $k[A][B]^2$

b) i) since A is first order, 2x[A] = 2 x rate

ii) since B is second order, 3 x [B] = 3^2 x rate = 9 x rate

iii) doubling the volume makes the concentrations of all reactants one-half. The total order is 3.
½ x [reactants] = $(1/2)^3$ x rate or 1/8 x rate