Answers to Chapter 12 Study Questions

1. a) 1 mole CO_2

   b) 0.050 - 0.030 moles/liter = 0.020 moles/liter

   c) conc. of CO_2 produced = conc. of CH_4 used up

   conc. of CO_2 after 20 min = 0.050 - 0.020 = 0.030 mol/L

   d) $rate = \frac{\Delta[CO_2]}{\Delta time}$

   e) $rate = \frac{\Delta[CO_2]}{\Delta time} = \frac{0.030 - 0.020\ mol\ /\ L}{20 - 10\ \text{min}} = 0.0010\ mol\ /\ L\ /\ \text{min}$

   f) conc. of CO_2 after 30 min = 0.050 - 0.015 = 0.035 mol/L

   $$rate = \frac{\Delta[CO_2]}{\Delta time} = \frac{0.035 - 0\ mol\ /\ L}{30 - 0\ \text{min}} = 1.2\ x\ 10^{-3}\ mol\ /\ L\ /\ \text{min}$$

   g) $rate = \frac{\Delta[CO_2]}{\Delta time} = -\frac{\Delta[O_2]}{2\Delta t};\quad \frac{\Delta[O_2]}{\Delta t} = -2\frac{\Delta[CO_2]}{\Delta time}$

   h) $rate = \frac{\Delta[O_2]}{\Delta t} = -2\frac{\Delta[CO_2]}{\Delta time}$ *from e)* $\frac{\Delta[CO_2]}{\Delta time} = 0.0010\ mol\ /\ L\ /\ \text{min}$

   $\frac{\Delta[O_2]}{\Delta t}$ = -2(0.0010) = - 0.0020 mol/L/min

2 a) The mechanism, and therefore the number of steps in a reaction, are determined experimentally.

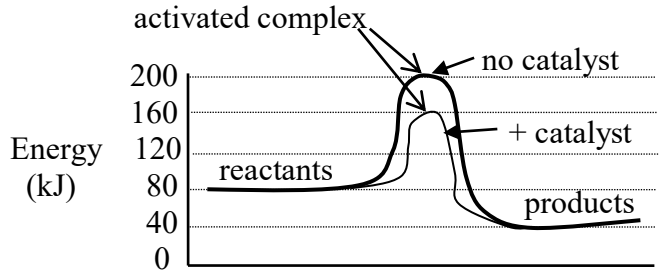
   b) The second step; it's the slowest step.

   c) rate = k x (concentration NO_3) x (concentration NO)

   d) rate increases by a factor of (1/2 x 3 = 3/2) 3/2

   e) the order with respect to NO is 1; the overall order is 2.

3.



4. 1) **concentration of reactants**: Reaction rate increases as concentration of reactants increases because number of collisions increases, making reaction more likely to occur.

   2) **surface area of reactants**: Rate increases as surface area of reactants increases because the greater the area of reactant exposed, the more likely are collisions that will result in product formation.

3) **temperature**: As temperature increases, rate increases because at higher temperature, a greater proportion of reactant molecules have a kinetic energy greater than the activation energy so a greater proportion of collisions result in product formation.
4) **catalyst**: Catalysts increase reaction rate by lowering the activation energy.
5) **inhibitors**: Inhibitors decrease reaction rate by destroying a catalyst, reducing effective surface area or by using up reactant.

5. a) $2\ N_2O(g) \rightarrow 2\ N_2(g) + O_2(g)$
b) $N_2O(g) \rightarrow N_2 + O$; $N_2O(g) + O \rightarrow N_2 + O_2$
c) O

6. a) rate = $k\ [HgCl_2]^n$ x $[C_2O_4^{2-}]^m$

$$\frac{rate_2}{rate_1} = \frac{k[HgCl_2]_2^{\,n}}{k[HgCl_2]_1^{\,n}} = \left(\frac{[HgCl_2]_2}{[HgCl_2]_1}\right)^n \qquad \frac{2.6x10^{-7}}{1.3x10^{-7}} = \left(\frac{0.20}{0.10}\right)^n \qquad 2 = 2^n;\ \ n = 1$$

order with respect to $HgCl_2$ is 1. (Rate is proportional to $[HgCl_2]$.)

$$\frac{rate_2}{rate_1} = \frac{k[C_2O_4^{2-}]_2^{\,m}}{k[C_2O_4^{2-}]_1^{\,m}} = \left(\frac{[C_2O_4^{2-}]_2}{[C_2O_4^{2-}]_1}\right)^m \qquad \frac{5.2\ x\ 10^{-7}}{1.3\ x\ 10^{-7}} = \left(\frac{0.20}{0.10}\right)^m \qquad 4 = 2^m;\ \ m = 2$$

order with respect to $C_2O_4^{2-}$ is 2. Overall order is 3.

b) rate = k $[HgCl_2]$ $[C_2O_4^{2-}]^2$
c) rate = k $[HgCl_2]$ $[C_2O_4^{2-}]^2$; 1.3 x 10^{-7} = k $(0.10)(0.10)^2$; k = 1.3 x 10^{-7}/0.001 = 1.3 x 10^{-4}
d) rate = 1.3 x 10^{-4} x $[HgCl_2]$ $[C_2O_4^{2-}]^2$; rate = 1.3 x 10^{-4} x (0.30) $(0.30)^2$ = 3.5 x 10^{-6} mol/L/s