1. The oxidation of ammonia produces nitrogen and water via the reaction

   $4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l)$

   If ammonia is being consumed at at rate of 0.72 M/s, how fast is oxygen being consumed?

   a) 0.24 M/s
   b) 0.48 M/s
   c) 0.54 M/s
   d) 0.63 M/s
   e) 0.96 M/s

2. The rate law for the reaction

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

   has been experimentally determined to be

   $rate = k[Br^-][BrO_3^-][H^+]^2$

   What is the overall order for this reaction?

   a) 1
   b) 2
   c) 3
   d) 4
   e) The order of the reaction cannot be determined from the information provided.

3. What are the units of the rate constant for a second-order reaction?

   a) $M \cdot s^{-1}$
   b) $s^{-1}$
   c) $M^{-1}s^{-1}$
   d) $M^2s^{-1}$
   e) $M^{1/2}s^{-1}$

4. Consider the hypothetical reaction:

   $A + B + C \rightarrow$ products

   The following initial concentrations and initial rates were obtained for the reaction at 25°C:

| $[A]_0$ (M) | $[B]_0$ (M) | $[C]_0$ (M) | Initial Rate (M/s) |
|---|---|---|---|
| 0.100 | 0.200 | 0.300 | $4.20 \times 10^{-3}$ |
| 0.100 | 0.200 | 0.600 | $1.68 \times 10^{-2}$ |
| 0.100 | 0.400 | 0.300 | $4.20 \times 10^{-3}$ |
| 0.300 | 0.200 | 0.300 | $1.26 \times 10^{-2}$ |

   What is the correct rate law for this reaction?

   a) $rate = k[A]^3[B][C]^4$
   b) $rate = k[A][B][C]^2$
   c) $rate = k[A][B][C]$
   d) $rate = k[A][C]^2$
   e) $rate = k[A]^3[C]^4$

5. The decomposition of ethylene oxide,

   $(CH_2)_2O(g) \rightarrow CH_4(g) + O_2(g)$,

   is first order with a half-life of 56.3 min at 415°C. How long (in min.) will it take for 90.0% of a sample of ethylene oxide to decompose at this temperature?

   a. 11.3 b. 81.2 c. 282 d. 8.56 e. 187

6. Suppose that the reaction A → products is a <u>second</u>-order reaction. Which of the following, when drawn on a graph, would be a straight line?

   a) [A] vs. time
   b) $[A]^2$ vs. time
   c) $[A]^{1/2}$ vs. time
   d) ln [A] vs time
   e) $\frac{1}{[A]}$ vs. time

**Questions 7 and 8 refer to the information below:**

Consider the reaction

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The mechanism for this reaction is believed to be the two-step mechanism below:

step 1 $H_2O_2(aq) + I^-(aq) \rightarrow H_2O(l) + IO^-(aq)$ (slow)

step 2 $H_2O_2(aq) + IO^-(aq) \rightarrow H_2O(l) + O_2(g) + I^-(aq)$ (fast)

7. What rate law is consistent with this mechanism?

   a) rate = $k [H_2O_2]^2$
   b) rate = $k [H_2O_2] [I^-]$
   c) rate = $k [H_2O_2]^2 [I^-] [IO^-]$
   d) rate = $k [H_2O_2] [IO^-]$
   e) rate = $k [H_2O_2]$

8. What is the catalyst, and what is the reactive intermediate in the reaction above?

   a) $I^-(aq)$ is the catalyst, and $IO^-(aq)$ is the reactive intermediate.
   b) $IO^-(aq)$ is the catalyst, and $I^-$ is the reactive intermediate.
   c) $I^-(aq)$ is the catalyst, and there is no reactive intermediate.
   d) $IO^-(aq)$ is the catalyst, and there is no reactive intermediate.
   e) $IO^-(aq)$ is the catalyst, and $H_2O_2$ is the reactive intermediate.

9. Which of the following statements below is/are <u>true</u> concerning the activation energy for a reaction?

I. $E_a$ is the difference in energy between reactants and activated complex.
II. $E_a$ decreases with increasing temperature.
III. The greater the activation energy, the faster the reaction.
IV. Catalysts generally work by lowering the $E_a$ for a reaction.

   a) III and IV
   b) I, II, and IV
   c) II, III, and IV
   d) I and IV
   e) I, II, III, and IV

10. The rates of chemical reactions increase with increasing temperature. Which of the following statements best explains this observation?

   a) Increasing the temperature lowers the activation energy for a reaction.
   b) Increasing the temperature raises the activation energy for a reaction.
   c) Increasing the temperature allows more energy to be released in an exothermic reaction.
   d) At higher temperatures, more molecules collide with sufficient energy to react.
   e) Choices (a) and (d) are both correct.

11. Dinitrogen tetroxide, $N_2O_4$, decomposes to nitrogen dioxide, $NO_2$, in a first-order process. If $k = 2.5 \times 10^3\ s^{-1}$ at –5°C, and $k = 3.5 \times 10^4\ s^{-1}$ at 25°C, what is the activation energy for the decomposition?

   a) 0.73 kJ/mol
   b) 58 kJ/mol
   c) 140 kJ/mol
   d) 580 kJ/mol
   e) 93 kJ/mol

**Answers**

1. C
2. D
3. C
4. D
5. E
6. E
7. B
8. A
9. D
10. D
11. B