Take Home Test Chapter 13 and 14

1) At elevated temperatures, dinitrogen pentoxide decomposes to nitrogen dioxide and oxygen:

\[ 2\text{N}_2\text{O}_5(\text{g}) \rightarrow 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g}) \]

When the rate of formation of O\(_2\) is \(2.2 \times 10^{-4}\) M/s, the rate of decomposition of N\(_2\)O\(_5\) is \__________ M/s.

A) \(1.1 \times 10^{-4}\)
B) \(2.2 \times 10^{-4}\)
C) \(2.8 \times 10^{-4}\)
D) \(4.4 \times 10^{-4}\)
E) \(5.5 \times 10^{-4}\)

2) The rate law of a reaction is \(\text{rate} = k[D][X]\). The units of the rate constant are \__________.

A) mol L\(^{-1}\)s\(^{-1}\)
B) L mol\(^{-1}\)s\(^{-1}\)
C) mol2 L\(^{-2}\)s\(^{-1}\)
D) mol L\(^{-1}\)s\(^{-2}\)
E) L\(^2\) mol\(^{-2}\)s\(^{-1}\)

3) Under constant conditions, the half-life of a first-order reaction \__________.

A) is the time necessary for the reactant concentration to drop to half its original value
B) is constant
C) can be calculated from the reaction rate constant
D) does not depend on the initial reactant concentration
E) All of the above are correct.

4) The reaction

\[ \text{CH}_3\text{-N≡C} \rightarrow \text{CH}_3\text{-C≡N} \]

is a first-order reaction. At 230.3 °C, \(k = 6.29 \times 10^{-4}\) s\(^{-1}\). If [CH3-N≡C] is \(1.00 \times 10^{-3}\) initially, [CH3-N≡C] is \__________ after \(1.000 \times 10^{3}\) s.

A) \(5.33 \times 10^{-4}\)
B) \(2.34 \times 10^{-4}\)
C) \(1.88 \times 10^{-3}\)
D) \(4.27 \times 10^{-3}\)
E) \(1.00 \times 10^{-6}\)
5) A compound decomposes by a first-order process. If 25.0% of the compound decomposes in 60.0 minutes, the half-life of the compound is ________.
A) 65 minutes  
B) 120 minutes  
C) 145 minutes  
D) 180 minutes  
E) 198 minutes

6) Which one of the following graphs shows the correct relationship between concentration and time for a reaction that is first order in [A]?
A)  
B)  
C)  
D)  
E)  

7) The following reaction is first order in [A] and the rate constant is 0.039 M⁻¹s⁻¹:

\[ \text{A} \rightarrow \text{B} \]

The concentration of A was 0.30 M at 23 s. The initial concentration of A was _________ M.
A) 1.34  
B) 0.27  
C) 0.41  
D) 3.7  
E) 1.2 \times 10^{-2}
8) The following reaction is second order in [A] and the rate constant is 0.025 M⁻¹s⁻¹:

\[ \text{A} \rightarrow \text{B} \]

The concentration of A was 0.35 M at 33 s. The initial concentration of A was _________ M.
A) 2.4
B) 0.27
C) 3.46
D) 1.4
E) 1.2 \times 10^{-2}

The reaction A \rightarrow B is second in [A]. Consider the following data.

<table>
<thead>
<tr>
<th>time (s)</th>
<th>[A] (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.60</td>
</tr>
<tr>
<td>10.0</td>
<td>0.40</td>
</tr>
<tr>
<td>20.0</td>
<td>0.10</td>
</tr>
</tbody>
</table>

9) The rate constant for this reaction is ___________ s⁻¹.
A) 0.013
B) 0.468
C) 0.14
D) 3.0
E) 3.1 \times 10^{-3}

10) The half-life of this reaction is ___________ s.
A) 0.97
B) 7.1
C) 5.0
D) 1.33
E) 0.14

The reaction A \rightarrow B is second order in [A]. Consider the following data.

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>0.0</th>
<th>5.0</th>
<th>10.0</th>
<th>15.0</th>
<th>20.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>[A] (M)</td>
<td>0.20</td>
<td>0.14</td>
<td>0.10</td>
<td>0.071</td>
<td>0.050</td>
</tr>
</tbody>
</table>

11) The rate constant for this reaction is ___________ s⁻¹.
A) 7.5 \times 10^{-1}
B) 3.0 \times 10^{-2}
C) 14
D) 0.46
E) 4.0 \times 10^{2}
12) The concentration of A is ________ M after 40.0 s.
   A) $1.3 \times 10^{-2}$
   B) 1.2
   C) 0.17
   D) $3.5 \times 10^{-4}$
   E) 0.028

13) The rate constant of a first-order process that has a half-life of 125 s is ________ s$^{-1}$.
   A) 0.693
   B) $3.08 \times 10^{-3}$
   C) 1.25
   D) 12.5
   E) 0.00554

14) The rate constant of a second-order process that has a half-life of 2.50 min is ________ M$^{-1}$s$^{-1}$.
    if the initial concentration is 0.5M.
   A) 0.800
   B) $1.65 \times 10^{-2}$
   C) 1.98
   D) .198
   E) $3.30 \times 10^{-3}$

15) The reaction A (aq) $\rightarrow$ B (aq) is first order in [A]. A solution is prepared with [A] = 1.22 M. The
    following data are obtained as the reaction proceeds:
    | Time (s) | 0.0 | 6.0 | 12.0 | 18.0 |
    | [A] (M)  | 1.22 | 0.61 | 0.31 | 0.15 |

    The rate constant for this reaction is ________ s$^{-1}$.
   A) 0.23
   B) 1.0
   C) 0.17
   D) 0.12
   E) -0.12

16) One difference between first- and second-order reactions is that ________.
    A) the half-life of a first-order reaction does not depend on [A]$_0$; the half-life of a second-order reaction does depend on [A]$_0$
    B) the rate of both first-order and second-order reactions do not depend on reactant concentrations
    C) the rate of a first-order reaction depends on reactant concentrations; the rate of a second-order reaction does not depend on reactant concentrations
    D) a first-order reaction can be catalyzed; a second-order reaction cannot be catalyzed
    E) None of the above are true.
17) At elevated temperatures, methylisonitrile (CH₃NC) isomerizes to acetonitrile (CH₃CN):

\[ \text{CH₃NC (g)} \rightarrow \text{CH₃CN (g)} \]

The reaction is first order in methylisonitrile. The attached graph shows data for the reaction obtained at 198.9°C.

The rate constant for the reaction is \[ \text{_________ s}^{-1} \].
A) \(-1.9 \times 10^4\)
B) \(+1.9 \times 10^4\)
C) \(-5.2 \times 10^{-5}\)
D) \(+5.2 \times 10^{-5}\)
E) \(+6.2\)

18) Which energy difference in the energy profile below corresponds to the activation energy for the forward reaction?

A) x
B) y
C) x + y
D) x - y
E) y - x
19) In the energy profile of a reaction, the species that exists at the maximum on the curve is called the ________.
   A) product
   B) activated complex
   C) activation energy
   D) enthalpy of reaction
   E) atomic state

20) In the Arrhenius equation,

\[ k = Ae^{-E_a/RT} \]

______ is the activation energy.
   A) k
   B) A
   C) e
   D) E_a
   E) R

21) In general, as temperature goes down, reaction rate ________.
   A) goes down if the reaction is endothermic
   B) goes down if the reaction is endothermic
   C) goes down regardless of whether the reaction is exothermic or endothermic
   D) stays the same regardless of whether the reaction is exothermic or endothermic
   E) stays the same if the reaction is first order

22) In general, as temperature goes up, reaction rate ________.
   A) goes up if the reaction is exothermic
   B) goes down if the reaction is endothermic
   C) stays the same regardless of whether the reaction is exothermic or endothermic
   D) goes up regardless of whether the reaction is exothermic or endothermic
   E) none of the above
23) At elevated temperatures, methylisonitrile (CH₃NC) isomerizes to acetonitrile (CH₃CN):

\[ \text{CH₃NC (g)} \rightarrow \text{CH₃CN (g)} \]

The dependence of the rate constant on temperature is studied and the graph below is prepared from the results.

The energy of activation of this reaction is ________ kJ/mol.
A) 160
B) \(1.6 \times 10^5\)
C) \(4.4 \times 10^{-7}\)
D) \(4.4 \times 10^{-4}\)
E) \(1.9 \times 10^4\)

24) The mechanism for formation of the product X is:

\[
\begin{align*}
\text{A + B} & \rightarrow \text{C + D} \quad \text{(slow)} \\
\text{B + D} & \rightarrow \text{X} \quad \text{(fast)}
\end{align*}
\]

The intermediate reactant in the reaction is _________.
A) A
B) B
C) C
D) D
E) X
25) A possible mechanism for the overall reaction

\[ \text{Br}_2 (g) + 2\text{NO} (g) \rightarrow 2\text{NOBr} (g) \]

is

\[ \text{NO} (g) + \text{Br}_2 (g) \underset{k_1}{\overset{k_{-1}}{\rightleftharpoons}} \text{NOBr}_2 (g) \quad \text{(fast)} \]

\[ \text{NOBr}_2 (g) + \text{NO} (g) \underset{k_2}{\rightarrow} 2\text{NOBr} \quad \text{(slow)} \]

The rate law for formation of NOBr based on this mechanism is rate = __________.
A) \( k_1[\text{NO}]^{1/2} \)
B) \( k_1[\text{Br}_2]^{1/2} \)
C) \( (k_2k_1/k_{-1})[\text{NO}]^2[\text{Br}_2] \)
D) \( (k_1/k_{-1})2[\text{NO}]^2 \)
E) \( (k_2k_1/k_{-1})[\text{NO}]2[\text{Br}_2]^2 \)

26) Of the following, __________ will increase the rate of a reaction.
A) increasing the concentrations of reactants
B) raising the temperature of the reaction
C) adding a catalyst for the reaction
D) none of these
E) increasing the pressure

27) The rate law of the overall reaction

\[ \text{A} + \text{B} \rightarrow \text{C} \]

is rate = \( k[\text{A}]^2 \). Which of the following will not increase the rate of the reaction?
A) increasing the concentration of reactant A
B) increasing the concentration of reactant B
C) increasing the temperature of the reaction
D) adding a catalyst for the reaction
E) All of these will increase the rate.

28) A catalyst can increase the rate of a reaction __________.
A) by changing the value of the frequency factor (A)
B) by increasing the overall activation energy \( (E_a) \) of the reaction
C) by lowering the activation energy of the reverse reaction
D) by providing an alternative pathway with a lower activation energy
E) All of these are ways that a catalyst might act to increase the rate of reaction.
29) The rate of disappearance of HBr in the gas phase reaction

\[ 2\text{HBr (g)} \rightarrow \text{H}_2 (\text{g}) + \text{Br}_2 (\text{g}) \]

is 0.130 Ms\(^{-1}\) at 150°C. The rate of reaction is \(_______\) Ms\(^{-1}\).
A) 3.85
B) 0.0650
C) 0.0169
D) 0.260
E) 0.0860

30) The combustion of ethylene proceeds by the reaction

\[ \text{C}_2\text{H}_4(\text{g}) + 3\text{O}_2 (\text{g}) \rightarrow 2\text{CO}_2 (\text{g}) + 2\text{H}_2\text{O (g)} \]

When the rate of disappearance of O\(_2\) is 0.28 Ms\(^{-1}\), the rate of appearance of CO\(_2\) is \(_______\) Ms\(^{-1}\).
A) 0.19
B) 0.093
C) 0.84
D) 0.42
E) 0.56

31) At elevated temperatures, methylisonitrile (CH\(_3\)NC) isomerizes to acetonitrile (CH\(_3\)CN):

\[ \text{CH}_3\text{NC (g)} \rightarrow \text{CH}_3\text{CN (g)} \]

At the start of an experiment, there are 0.200 mol of reactant and 0 mol of product in the reaction vessel. After 25 min, 0.106 mol of reactant (CH\(_3\)NC) remain. There are \(_______\) mol of product (CH\(_3\)CN) in the reaction vessel.
A) 0.022
B) 0.106
C) 0.200
D) 0.306
E) 0.094
32) The isomerization of methylisonitrile to acetonitrile

\[ \text{CH}_3\text{NC} (g) \rightarrow \text{CH}_3\text{CN} (g) \]

is second order in CH\text{3}NC. The rate constant for the reaction is \( 9.45 \times 10^{-5} \text{s}^{-1} \) at 478 K. The half-life of the reaction when the initial \([\text{CH}_3\text{NC}]\) is 0.030 M is _________ s.

A) 1.06 \times 10^4  
B) 5.29 \times 10^3  
C) 3.53E \times 10^5  
D) 7.33 \times 10^3  
E) 1.36 \times 10^{-4}

33) The elementary reaction

\[ 2\text{NO}_2 \rightarrow 2\text{NO} + \text{O}_2 \]

is first order in NO\text{2} and the rate constant at 501 K is \( 7.93 \times 10^{-3} \text{M}^{-1} \text{s}^{-1} \). The reaction half-life at this temperature when \([\text{NO}_2]_0= 0.45 \text{ M}\) is _________ s.

A) 3.6 \times 10^{-3}  
B) 0.011  
C) 126  
D) 87  
E) 280

34) The isomerization of methylisonitrile to acetonitrile

\[ \text{CH}_3\text{NC} (g) \rightarrow \text{CH}_3\text{CN} (g) \]

is first order in CH\text{3}NC. The half life of the reaction is \( 5.20 \times 10^1 \text{ s} \) at 545 K. The rate constant when the initial \([\text{CH}_3\text{NC}]\) is 0.030 M is _________ s\textsuperscript{-1}.

A) 75.1  
B) 0.641  
C) 0.0133  
D) 1.56  
E) 2.84 \times 10^4
35) The decomposition of \( \text{N}_2\text{O}_5 \) in solution in carbon tetrachloride proceeds via the reaction

\[
2\text{N}_2\text{O}_5 \text{ (soln)} \rightarrow 4\text{NO}_2 \text{ (soln)} + \text{O}_2 \text{ (soln)}
\]

The reaction is first order and has a rate constant of \( 4.82 \times 10^{-3} \text{ s}^{-1} \) at 64°C. If the reaction is initiated with 0.058 mol in a 1.00-L vessel, how many moles remain after 151 s?

A) 0.055  
B) 0.060  
C) 0.028  
D) 12  
E) \( 2.0 \times 10^3 \)

36) The rate constant for a particular first-order reaction is \( 0.47 \text{ M}^{-1}\text{s}^{-1} \). If the initial concentration of reactant is 0.25 mol/L, it takes ________ s for the concentration to decrease to 0.080 mol/L.

A) 18  
B) 2.4  
C) 8.5  
D) 4.0  
E) 0.08

37) A first-order reaction has a rate constant of 0.33 min\(^{-1}\). It takes ________ min for the reactant concentration to decrease from 0.13 M to 0.095 M.

A) 0.085  
B) 0.13  
C) 0.41  
D) 1.2  
E) 0.95

38) At elevated temperatures, nitrogen dioxide decomposes to nitrogen oxide and oxygen:

\[
\text{NO}_2 \text{ (g)} \rightarrow \text{NO} \text{ (g)} + \frac{1}{2} \text{O}_2 \text{ (g)}
\]

The reaction is second order in \( \text{NO}_2 \) with a rate constant of \( 0.543 \text{ M}^{-1}\text{s}^{-1} \) at 300 °C. If the initial \([\text{NO}_2]\) is 0.260 M, it will take ________ s for the concentration to drop to 0.150 M.

A) 3.34  
B) 0.0880  
C) 1.01  
D) 0.299  
E) 5.19

39) A particular first-order reaction has a rate constant of \( 1.35 \times 10^2 \text{ s}^{-1} \) at 25.0°C. What is the magnitude of \( k \) at 95.0°C if E\(_a\) = 55.5 kJ/mol?

A) \( 9.56 \times 10^3 \)  
B) \( 2.85 \times 10^4 \)  
C) 576  
D) \( 4.33 \times 10^87 \)  
E) \( 1.36 \times 10^2 \)
40) A particular first-order reaction has a rate constant of $1.35 \times 10^2 \text{s}^{-1}$ at 25.0°C. What is the magnitude of $k$ at 75.0°C if $E_a = 85.6 \text{ kJ/mol}$?

A) $3.47 \times 10^4$
B) $1.92 \times 10^4$
C) 670
D) $3.85 \times 10^6$
E) $1.36 \times 10^2$