Exam Chapter 14-15 Exam A KEY

Name

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Of the following, all are valid units for a reaction rate except ________. 1) ______

A) g/s
B) mol/hr
C) mol/L-hr
D) mol/L
E) M/s

2) At elevated temperatures, dinitrogen pentoxide decomposes to nitrogen dioxide and oxygen: 2) ______

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

When the rate of formation of $O_2$ is $2.2 \times 10^{-4}$ M/s, the rate of decomposition of $N_2O_5$ is ________ M/s.

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

$$2.2\times10^{-4}\frac{mol\ O_2}{L\,s} \times \frac{2\ mol\ N_2O_5}{mol\ O_2} =$$

3) Of the units below, ________ are appropriate for a first-order reaction rate constant. 3) ______

A) mol/L
B) $M^{-1}\ s^{-1}$
C) $s^{-1}$
D) $M\ s^{-1}$
E) $L\ mol^{-1}\ s^{-1}$

$$\left(\frac{1}{s}\right)\left(\frac{mol}{L}\right) =$$

$$[\ ]k = Rate \quad \frac{mol}{L\,s}$$

*The data in the table below were obtained for the reaction:*

$A + B \rightarrow P$

| Experiment Number | [A] (M) | [B] (M) | Initial Rate (M/s) |
|---|---|---|---|
| 1 | 0.273 | 0.763 | 2.83 |
| 2 | 0.273 | 1.526 | 2.83 |
| 3 | 0.819 | 0.763 | 25.47 |

4) The rate law for this reaction is rate = ________. 4) ______

A) k[P]
B) $k[A]^2$
C) k[A][B]
D) $k[A]^2[B]$
E) $k[A]^2[B]^2$

5) The magnitude of the rate constant is ________. 5) ______

A) 38.0 B) 42.0 C) 13.2 D) 0.278 E) 2.21

6) The reaction 6) ______

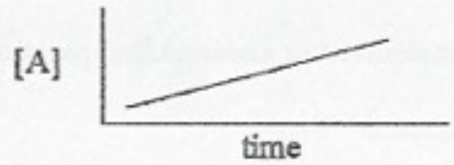
$CH_3\text{-}N{\equiv}C \rightarrow CH_3\text{-}C{\equiv}N$

is a first-order reaction. At 230.3 °C, $k = 6.29 \times 10^{-4}\ s^{-1}$. If $[CH_3\text{-}N{\equiv}C]$ is $1.00 \times 10^{-3}$ initially, $[CH_3\text{-}N{\equiv}C]$ is ________ after $1.000 \times 10^3$ s.

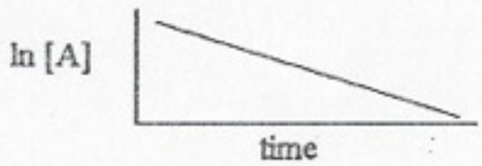
A) $5.33 \times 10^{-4}$
B) $1.88 \times 10^{-3}$
C) $1.00 \times 10^{-6}$
D) $2.34 \times 10^{-4}$
E) $4.27 \times 10^{-3}$

7) Which one of the following graphs shows the correct relationship between concentration and time for a reaction that is second order in [A]? 7) _______

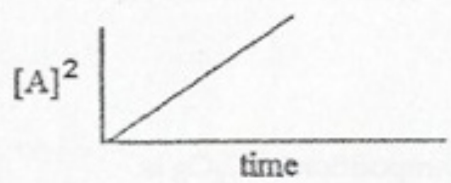
A)



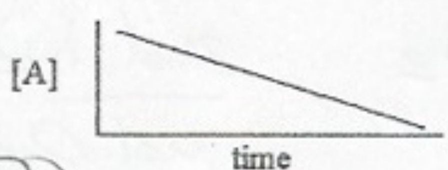

B)



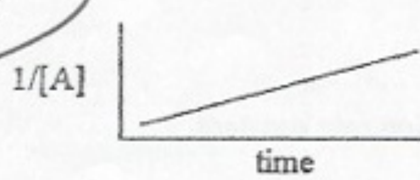

C)




D)




E)




$\frac{1}{[\,]} = kt + \frac{1}{[\,]_0}$

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

| time (s) | [A] (M) |
|---|---|
| 0.0 | 1.60 |
| 10.0 | 0.40 |
| 20.0 | 0.10 |

$\ln(.4) = -k(10\,sec) + \ln[1.6]$

$\frac{\ln(.4) - \ln(1.6)}{-10\,s} = k = 0.138$

8) The rate constant for this reaction is _________ $s^{-1}$. 8) ______

A) 3.0 B) $3.1 \times 10^{-3}$ C) 0.030 D) 0.013 E) 0.14

9) The rate constant of a first-order process that has a half-life of 3.50 min is _________ $s^{-1}$. 9) ______

A) 0.693
B) $3.30 \times 10^{-3}$
C) .198
D) $1.65 \times 10^{-2}$
E) 1.98

$t_{1/2} = \frac{0.693}{k}$

$0.198\,\frac{1}{min} \times \frac{1\,min}{60\,sec} = \frac{0.693}{3.5\,min} = k$

10) As the temperature of a reaction is increased, the rate of the reaction increases because the ______. 10) ______

A) reactant molecules collide more frequently and with greater energy per collision
B) reactant molecules collide more frequently with less energy per collision
C) reactant molecules collide less frequently and with greater energy per collision
D) activation energy is lowered
E) reactant molecules collide less frequently

11) Which of the following is true? 11) ______

A) In a reaction mechanism, an intermediate is identical to an activated complex.
B) If we know that a reaction is an elementary reaction, then we know its rate law.
C) The rate-determining step of a reaction is the rate of the fastest elementary step of its mechanism.
D) Since intermediate compounds can be formed, the chemical equations for the elementary reactions in a multistep mechanism do not always have to add to give the chemical equation of the overall process.
E) All of the above statements are true.

12) Which of the following expressions is the correct equilibrium-constant expression for the equilibrium between dinitrogen tetroxide and nitrogen dioxide? 12) ______

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g)$$

A) $[NO_2]^2[N_2O_4]$

B) $\dfrac{[NO_2]^2}{[N_2O_4]}$ = k

C) $[NO_2][N_2O_4]$

D) $\dfrac{[NO_2]}{[N_2O_4]^2}$

E) $\dfrac{[NO_2]}{[N_2O_4]}$

13) The $K_{eq}$ for the equilibrium below is $7.52 \times 10^{-2}$ at 480.0 °C. 13) ______

$$2Cl_2\,(g) + 2H_2O\,(g) \rightleftharpoons 4HCl\,(g) + O_2\,(g)$$

What is the value of $K_{eq}$ at this temperature for the following reaction?

$$4HCl\,(g) + O_2\,(g) \rightleftharpoons 2Cl_2\,(g) + 2H_2O\,(g)$$

$k = \dfrac{1}{7.52 \times 10^{-2}}$

$= 13.29$

A) -0.0752
B) 13.3
C) 0.0752
D) $5.66 \times 10^{-3}$
E) 0.150

14) The equilibrium constant for the gas phase reaction 14) ______

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

is $K_{eq} = 4.34 \times 10^{-3}$ at 300 °C. At equilibrium, ________.

A) only products are present
B) products predominate
C) reactants predominate
D) roughly equal amounts of products and reactants are present
E) only reactants are present

15) Consider the following reaction at equilibrium: 15) ______

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g) \quad \Delta H° = +92.4 \text{ kJ}$$

Le Châtelier's principle predicts that adding $N_2(g)$ to the system at equilibrium will result in ________.

A) removal of all of the $H_2(g)$
B) a decrease in the concentration of $H_2(g)$
C) an increase in the value of the equilibrium constant
D) a lower partial pressure of $N_2$
E) a decrease in the concentration of $NH_3(g)$

16) Given the following reaction at equilibrium, if $K_c = 6.34 \times 10^5$ at 230.0 °C, $K_p$ = ________. 16) ______

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

A) $2.62 \times 10^7$
B) $6.44 \times 10^5$
C) $2.61 \times 10^6$
D) $1.53 \times 10^4$
E) $3.67 \times 10^{-2}$

17) Consider the following chemical reaction: 17) ______

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

At equilibrium in a particular experiment, the concentrations of $H_2$, $I_2$, and HI were 0.25 M, 0.035 M, and 0.55 M, respectively. The value of $K_{eq}$ for this reaction is ________.

A) 0.0090 B) 34 C) 63 D) 23 E) 5.1

The quantity of ozone in an $O_2/O_3$ mixture can be determined by measuring the amount of potassium iodide necessary to react with it according to the equation:

$$O_3 + 2I^- + H_2O \longrightarrow O_2 + I_2 + 2HO^-$$

18. A reasonable mechanism for this reaction is given by elementary steps (1)-(3):

(1) $O_3 + I^- \xrightarrow{\text{slow}} O_2 + IO^-$

(2) $IO^- + H_2O \xrightarrow{\text{fast}} HOI + HO^-$

(3) $HOI + I^- \xrightarrow{\text{fast}} I_2 + HO^-$

Which of the following statements concerning this proposed mechanism is **true**?

A. $IO^-$ is a catalyst.
B. $IO^-$ is an activated complex.
C. $IO^-$ is an intermediate.
D. The mechanism can't be correct because it involves a species ($IO^-$) that does not appear in the balanced equation.
E. The rate-determining step is unimolecular.

19. What must the observed rate law be in order for the mechanism shown in problem 18 to be valid?

A. Rate = $k[O_3][I^-]$
B. Rate = $k[O_3][I^-]^2$
C. Rate = $k[O_3][I^-]^2[H_2O]$
D. Rate = $k[O_3][I^-][H_2O]$

20. At 35°C, $K = 1.6 \times 10^{-5}$ for the reaction

$$2NOCl\,(g) \rightleftharpoons 2NO\,(g) + Cl_2\,(g)$$

Calculate the concentration of $Cl_2$ at equilibrium assuming the initial concentration of NOCl to be 1.0 M.

A. 0.002 M B. $1.6 \times 10^{-5}$ M C. 0.016 M D. 0.97 M E. $4.06 \times 10^{-3}$ M

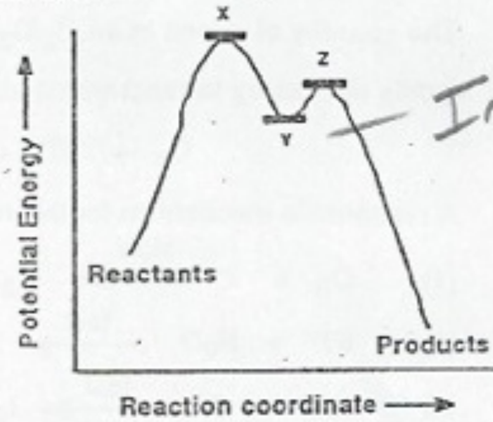
21. Which statement concerning the *catalytic* properties of enzymes is correct?

An enzyme:

A. decreases the number of elementary steps in a reaction mechanism.
B. increases the equilibrium constant for a reaction.
C. increases the reaction rate.
D. transforms a reversible reaction to an irreversible one.
E. transforms an endothermic reaction to an exothermic one.

transition state

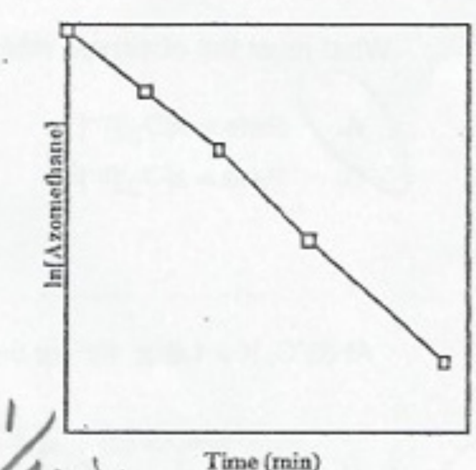
22. Which description of the energy diagram shown at the right is correct?




Intermediate

| | The overall reaction is | What letter corresponds to the rate-determining transition state? | What letter corresponds to a reactive intermediate? |
|---|---|---|---|
| A. | exothermic | X | Y |
| B. | exothermic | Y | Z |
| C. | exothermic | X | Z |
| D. | endothermic | X | Z |
| E. | endothermic | Y | X |

23. When the rate of decomposition of azomethane was plotted as shown (ln[azomethane] versus time in minutes), a straight line was obtained with a slope of -0.014 $min^{-1}$. What is the half-life of this reaction?




$$CH_3N{=}NCH_3(g) \xrightarrow{297°C} CH_3CH_3(g) + N_2(g)$$

Azomethane

$k = -0.014\ 1/min$

A. 50 min B. 60 min C. 70 min D. 80 min E. 90 min

$t_{1/2} = \frac{0.693}{0.014\ 1/min} = 50\ min$

2

$$2N_2O_5 = 4NO_2 + O_2$$

$$\frac{2.2\times10^{-4}\,mol\,O_2}{L\,s} \times \frac{2\,mol\,N_2O_5}{1\,mol\,O_2}$$

$$= \frac{4.4\times10^{-4}\,mol\,N_2O_5}{L\,s}$$

4

$[B]^0$

$$\frac{1.526}{0.763} = 2 \qquad \Delta\ Rate\ 0$$

$[A]^2$

$$\frac{0.819}{0.273} = 3 \qquad \frac{25.47}{2.83} = 9$$

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

5

$$(0.273)^2 k = 2.83\,\frac{mol}{L\,s}$$

$$k = 37.97\,\frac{L}{mol\,s}$$

6

$$\ln[\,] = -kt + \ln[\,]_0$$

$$\ln[\,] = -1000\left(6.29\times10^{-4}\ 1/s\right) + \ln\left(1\times10^{-3}\right)$$

$$\ln[\,] = -8$$

$$[\,] = 5\times10^{-4}$$

8

$$\ln(0.4) = -k(10\,\text{sec}) + \ln(1.6)$$

$$k = \frac{\ln(0.4) - \ln(1.6)}{-10\,s}$$

$$= 0.138\ 1/s$$

9

$$t_{1/2} = \frac{0.693}{k}$$

$$k = \frac{0.693}{3.5\,\text{min}}$$

$$= 0.198\ \frac{1}{\text{min}} \times \frac{1\,\text{min}}{60\,\text{sec}} = 3.3\times10^{-3}\ 1/s$$

$k = 7.52 \times 10^{-2}$

13 $2Cl_2 + 2H_2O \rightleftharpoons 4HCl + O_2$

$k = (7.52 \times 10^{-2})^{-1}$

$4HCl + O_2 \rightleftharpoons 2Cl_2 + 2H_2O$

$k = 13.29$

$k = 6.34 \times 10^5$

16 $2NO + O_2 \rightleftharpoons 2NO_2$

$K_p = K_c (RT)^{\Delta n}$

$\Delta n = 2 - 3 = -1$

$= 6.34 \times 10^5 \left[ \left(0.0821 \frac{L\,atm}{mol\,K}\right)(503\,K) \right]^{-1}$

$K_p = 1.53 \times 10^4$

17 $H_2 + I_2 \rightleftharpoons 2HI$

$k = \frac{(0.55)^2}{(0.25)(0.035)} = 34$

$k = 1.6 \times 10^{-5}$

**20**

$$2NOCl \rightleftharpoons 2NO + Cl_2$$

$$1 - 2x \qquad 2x \qquad x$$

$$1.6 \times 10^{-5} = \frac{(2x)^2 (x)}{1 - \cancel{2x}}$$

$$1.6 \times 10^{-5} = 4x^3$$

$$[Cl^-] = x = 0.016\ M$$

**23**

$$k = \text{slope} = 0.014\ 1/\text{min}$$

$$t_{1/2} = \frac{0.693}{0.014\ 1/\text{min}} = 50\ \text{min}$$