CHM 152/54 Exam 1 Fall 2004 100 Pts Name: Key

1. In the reaction
   $2NO_2 \rightarrow 2NO + O_2$
   at 300°C, [NO_2] drops from 0.0100 to 0.00650 M in 100 s. The rate of disappearance of NO_2 for this period is ________ M/s.
   a. 0.35
   b. 0.0035
   c. 0.000035
   d. 0.0070
   e. 0.0018

   $-\frac{\Delta[NO_2]}{\Delta t} = -\frac{0.00650 - 0.0100}{100} = 3.5 \times 10^{-5}$

2. A reaction was found to be second order in carbon monoxide concentration. The rate of the reaction ____________ if the concentration of carbon monoxide is doubled with everything else kept the same.
   a. doubles
   b. remains unchanged
   c. triples
   d. increases by a factor of 4
   e. is reduced by a factor of 2.

   $rate = k[CO]^2$
   $[2]^2 = 4$

3. The rate law of a reaction is rate = $k[A]^x$. The units of k, if the reaction is second order in A, are __________.
   a. M/s
   b. $M^{-1}s^{-1}$
   c. $1/s$
   d. $1/M$
   e. s/M^2

   $rate = k[A]^2$
   $\frac{M}{s} = \frac{}{Ms} M^2$

4. A reaction was found to be third order in A. Increasing the concentration of A by a factor of 3 will cause the reaction rate to __________.
   a. remain constant
   b. increase by a factor of 27
   c. increase by a factor of 9
   d. triple
   e. decrease by a factor of the cube root of 3

   $rate = k[A]^3$
   $[3]^3 = 27$

Key

5. Using the information below, the rate constant for the following reaction is ________ $M^{-1}s^{-1}$.

$A + B \rightarrow P$

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

$rate = k[A]^x[B]^y$

a. 38.0
b. 0.278
c. 13.2
d. 42.0
e. 2.21

for B: from Exp 1 + 2 $y = 0$ since rate does not change

for A: from Exp 1 & 3 $\frac{25.47}{2.83} = \left(\frac{0.819}{0.273}\right)^x$

$9 = 3^x \quad x = 2$

$rate = k[A]^2$

$k = \frac{2.83}{(0.273)^2}$

$k = 37.97$

6. The rate constant for a particular reaction is $1.3 \times 10^{-4} M^{-1}s^{-1}$ at 100°C, and $1.1 \times 10^{-3} M^{-1}s^{-1}$ at 150°C. What is the overall order of the reaction?

a. 1
b. 0
c. 2
d. 3
e. 4

from units:

$rate = k[A]^x$

$\frac{M}{s} = \frac{}{Ms}(M)^x \leftarrow 2$

7. The rate constant for a particular reaction is $1.3 \times 10^{-4} M^{-1}s^{-1}$ at 150°C, and $1.1 \times 10^{-3} M^{-1}s^{-1}$ at 200°C. What is the energy of activation for this reaction at 250°C?

a. 132
b. 56
c. 99
d. 71
e. 22

$\ln\left(\frac{1.3 \times 10^{-4}}{1.1 \times 10^{-3}}\right) = \frac{E_a}{8.314\ (J)}\left(\frac{1}{473_{(K)}} - \frac{1}{423_{(K)}}\right)$

$E_a = 71047\ J = 71\ kJ$

8. The reaction

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

is a first-order reaction. At 230.3°C, $k = 6.29 \times 10^{-4}\ s^{-1}$. If $[CH_3\text{-}N{\equiv}C]_0$ is 0.00100 M, $[CH_3\text{-}N{\equiv}C]$ in M after 1.000×10^3 s is

a. 5.33×10^{-4}
b. 2.34×10^{-4}
c. 1.88×10^{-3}
d. 4.27×10^{-3}
e. 1.00×10^{-6}

$\ln[A]_t = -kt + \ln[A]_0$

$\ln[A]_t = \left(-\frac{6.29 \times 10^{-4}}{s}\right)(1.000 \times 10^3\ s) + \ln[0.00100]$

$\ln[A]_t = -7.5367\ldots$

$[A]_t = e^{-7.5367\ldots} = 5.33 \times 10^{-4} M$

Key

9. The rate constant for a second-order reaction is 0.13 $M^{-1}s^{-1}$. If the initial concentration of reactant is 0.26 mol/L, it takes ______________ s for the concentration to decrease to 0.13 mol/L.

a. 0.017
b. 0.50
c. 1.0
(d) 30
e. 4.4×10^{-3}

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

$$\frac{1}{[0.13]} = (0.13)t + \frac{1}{[0.26]}$$

$t = 29.6$

10. The half-life of a first-order reaction is 13 min. If the initial concentration of reactant is 0.085 M, it takes ____________ min for it to decrease to 0.055 M.

(a) 8.2
b. 11
c. 3.6
d. 0.048
e. 8.4

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

$k = 0.0533\ min^{-1}$

$$\ln[A]_t = -kt + \ln[A]_0$$

$$\ln[0.055] = (-0.0533)t + \ln[0.085]$$

$t = 8.16$ min

11. The reaction A → B is first order in [A]. Using the data below, the rate constant for this reaction is __________ s^{-1}.

time(s)	[A](M)
0.0	1.60
5.0	0.80
10.0	0.40
15.0	0.20
20.0	0.10

a. 0.013
b. 0.030
(c) 0.14
d. 3.0
e. 3.1×10^{-3}

2 ways:
(1) Graph ln[ ] (y) vs t (x) and find slope
(2) Use two pts. with:
$$\ln[A]_t = -kt + \ln[A]_0$$

12. The rate constant of a first-order process that has a half-life of 225 s is ________ s^{-1}.

a. 0.693
(b) 3.08×10^{-3}
c. 1.25
d. 12.5
e. 4.44×10^{-3}

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

$$k = \frac{0.693}{225\ s} = 0.00308\ s^{-1}$$

Key

13. 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 a first-order reaction does not depend on reactant concentrations; the rate of a second-order reaction does 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. the half-life of a first-order reaction depends on $[A]_0$; the half-life of a second-order reaction does not depend on $[A]_0$

14. As the temperature of a reaction is increased, the rate of the reaction increases because the ________________.
   a. reactant molecules collide less frequently
   b. reactant molecules collide with greater energy per collision
   c. activation energy is lowered
   d. reactant molecules collide less frequently <u>and</u> with greater energy per collision
   e. reactant molecules collide more frequently with less energy per collision

15. In the potential 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

16. The activation energy of a first-order reaction that has a rate constant of $4.41 \times 10^{-3} s^{-1}$ at 351K and rate constant of $9.79 \times 10^{-2} s^{-1}$ 588K is ________ kJ/mol.
   a. 2.67
   b. 2.90
   c. 0.0589
   d. 22.4
   e. 0.450

$$\ln \frac{4.41 \times 10^{-3}}{9.79 \times 10^{-2}} = \frac{E_a}{8.314\ J}\left(\frac{1}{588} - \frac{1}{351}\right)$$

$E_a = 22445\ J/mol \quad 22.4\ kJ/mol$

17. The stoichiometric equations and rate laws for several reactions are given below. Of these, only ______ could represent an elementary step.
   a. $2A \rightarrow P$ rate $= k[A]^0$
   b. $A + B \rightarrow P$ rate $= k[A][B]$
   c. $A + 2B \rightarrow P$ rate $= k[A]^2$ (B)
   d. $A + B + C \rightarrow P$ rate $= k[A][C]$ (B)
   e. $A + 2B \rightarrow P$ rate $= k[A][B]$

Key

18. The stoichiometric equation for a reaction is:

$2A + 2B \rightarrow C$

The mechanism for this reaction is:

(1) $A + B \rightarrow D$ (slow) ←
(2) $D + B \rightarrow E$ (fast)
(3) $A + E \rightarrow C$ (fast)

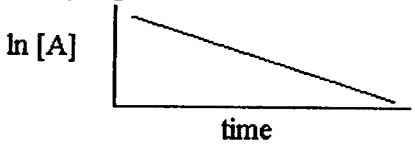
Of the following rate laws, ________ is the correct rate law for this mechanism.

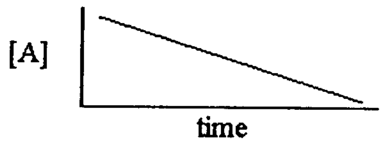
a. Rate = $k_1[A][B]$
b. Rate = $k_3[A][E]$
c. Rate = $k_1[A]^2[B]^2$
d. Rate = $k_2[D][B]$
e. Rate = $k_2k_3[A][B][D]$

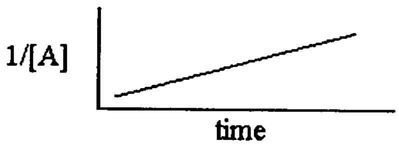
19. Of the following, ________ will lower the activation energy for a reaction.

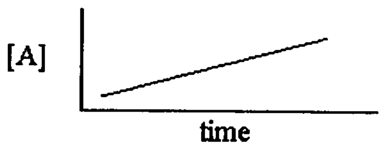
a. increasing the concentrations of reactants
b. raising the temperature of the reaction
c. adding a suitable catalyst
d. all of the above
e. none of the above

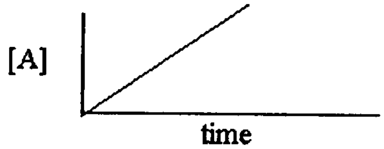
20. Which one of the following graphs shows the correct relationship between concentration and time for a reaction that is second order in [A]?
   a. graph a
   b. graph b
   c. graph c
   d. graph d
   e. graph e

a)


b)


c)


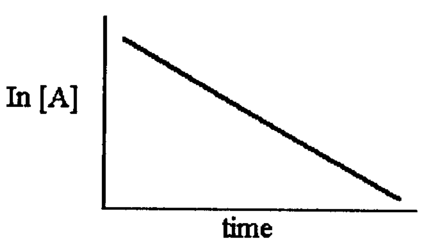
d)


e)


21. The graph shown below depicts the relationship between concentration and time for the following chemical reaction.

   The slope of this line is equal to
   a. k
   b. -1/k
   c. $\ln[A]_0$
   d. -k
   e. 1/k

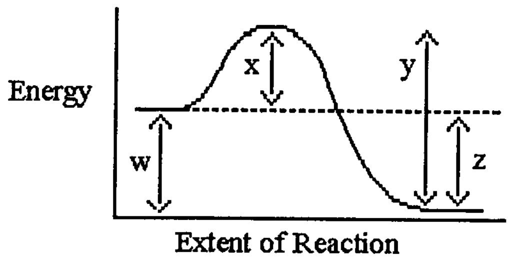
$2A \longrightarrow C$



Key

22. Which energy difference in the reaction profile below corresponds to the activation energy for the forward reaction?

a. w
(b.) x
c. y
d. z
e. w and z



The following table of experimental data is necessary to answer the questions below.

For the reaction: $2\ ClO_2(aq) + 2\ OH^-(aq) \rightarrow ClO_3^-(aq) + ClO_2^-(aq) + H_2O(l)$

Experiment	$[ClO_2]$	$[OH^-]$	initial rate
1	0.060 M	0.030 M	0.0248 M/s
2	0.020	0.030	0.00276
3	0.020	0.090	0.00828

$rate = k[ClO_2]^x[OH^-]^y$

23. What is the order of the reaction with respect to ClO_2?

a. 1
b. 0
(c.) 2
d. 3
e. 4

$\frac{0.0248}{0.00276} = \left(\frac{0.060}{0.020}\right)^x$

$9 = (3)^x \qquad x = 2$

24. What is the order of the reaction with respect to OH^-?

a. 0
(b.) 1
c. 2
d. 3
e. 4

$\frac{0.00828}{0.00276} = \left(\frac{0.090}{0.030}\right)^y$

$3 = (3)^y \qquad y = 1$

25. What is the value of the rate constant for the reaction?

a. 1.15×10^4
b. 4.6
(c.) 230
d. 115
e. 713

$rate = k[ClO_2]^2[OH]^1$

$0.0248 = k[0.060]^2[0.030]^1$

$k = 229.6$