1. The rate of the reaction

$$A \rightarrow X$$

is defined as

A. $-\Delta[A]/\Delta$time.

B. the time it takes to convert all of A to X.

C. $[A]_{\text{initial}}/\Delta$time.

D. $([X]-[A])/\Delta$time.

---

2. For the reaction $H_2(g) + Br_2(g) \rightarrow 2\ HBr$, use the table below to determine the average $\frac{\Delta[Br_2]}{\Delta t}$ from 20.0 to 30.0 seconds.

Time (s)	$[H_2]$, M	$[Br_2]$, M	[HBr], M
20.0	0.820	0.400	0.120
30.0	0.560	0.140	0.640

A. 7.80×10^{-2} M/s

B. 3.60×10^{-3} M/s

C. -2.60×10^{-2} M/s

D. -7.80×10^{-2} M/s

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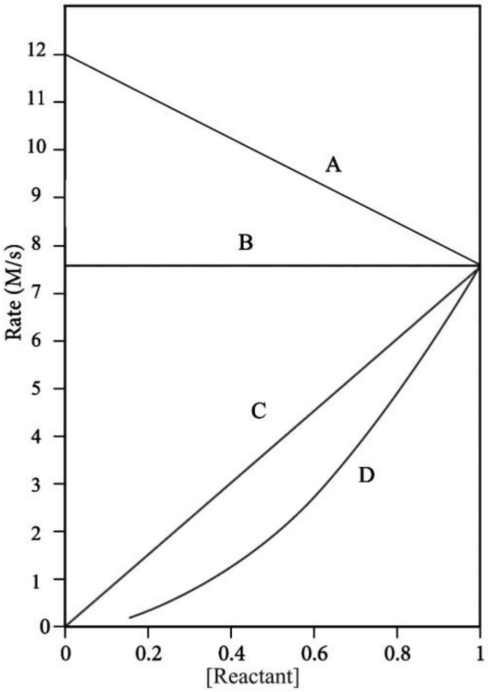
3. On the graph at right, which plot describes the reaction rate as a function of reactant concentration for a first-order reaction?



A. A

B. B

C. C

D. D

4. Given the following reaction and data set, determine the **order** of each reactant and the corresponding rate law:

$$CO(g) + NO_2(g) \rightarrow CO_2(g) + NO(g)$$

Trial	Initial [CO], M	Initial [NO_2], M	Initial Rate (M/s)
1	0.10	0.10	0.00511
2	0.10	0.40	0.0817
3	0.20	0.10	0.00502

A. rate = $k[CO]$

B. rate = $k[NO_2][CO]^2$

C. rate = $k[NO_2]^2[CO]$

D. rate = $k[NO_2]^2$

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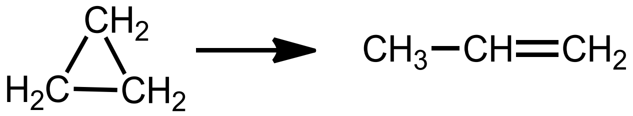
5. The half-life of the following first-order reaction at 720 K is 5.73 h.



How long does it take to consume 85.0% of the reactant, cyclopropane, at 720 K?

A. 941 min

B. 765 min

C. 89.3 min

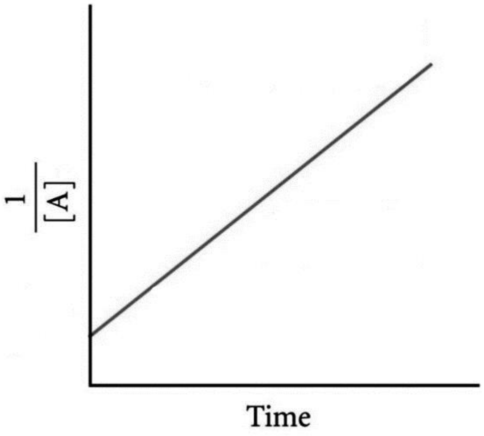
D. 13.0 min

6. Determine the **reaction order** and **rate constant** for the decomposition reaction

$$A \rightarrow B + C.$$

Plotting 1/[A] vs. *t* results in the graph at right with the equation

$$y = 0.412x + 250.$$



A.	zero order, 0.206 $M \cdot s^{-1}$	C.	first order, 0.206 s^{-1}
B.	zero order, 0.412 $M \cdot s^{-1}$	D.	second order, 0.412 $M^{-1} \cdot s^{-1}$

---

7. The rate constant for the first-order reaction,

$$KClO_3(aq) \rightarrow KCl(aq) + O_2(g),$$

is 1.37×10^{-3} s^{-1}. If the initial concentration of $KClO_3$ is 5.47 M, what is the concentration after 60.0 s?

A.	5.39 M	C.	3.77 M
B.	5.04 M	D.	7.49×10^{-3} M

---

8. Which statement regarding the Arrhenius equation is **false**?

A. The frequency factor, *A*, is the number of times that reactants approach the activation barrier per unit time.

B. The exponential factor, $e^{-Ea/RT}$, is the fraction of molecular approaches that are successful in overcoming the activation barrier, E_a, to form products.

C. The exponential factor, $e^{-Ea/RT}$, decreases with increasing temperature.

D. The exponential factor, $e^{-Ea/RT}$, decreases with increasing activation energy, E_a.

---

9. Consider the reaction

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$$

The activation energy is 145 kJ/mol. Calculate the rate constant at 520. °C, given that the rate constant at 430. °C is 2.57 $M^{-1} \cdot s^{-1}$.

A. 1.08 $M^{-1} \cdot s^{-1}$

C. 8.69 $M^{-1} \cdot s^{-1}$

B. 2.01 $M^{-1} \cdot s^{-1}$

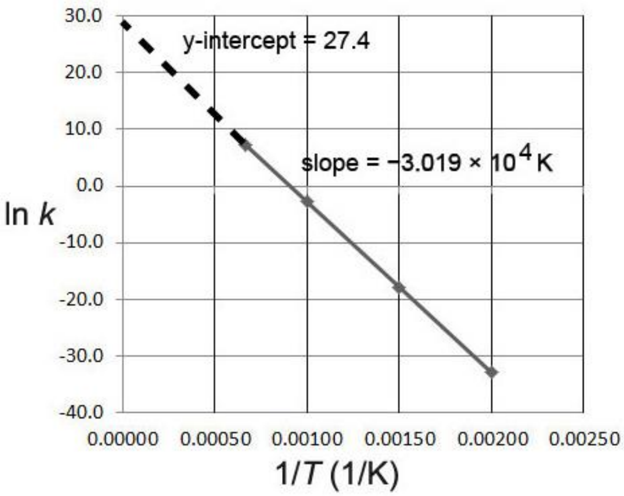
D. 42.9 $M^{-1} \cdot s^{-1}$

---

10. Consider the reaction

$$N_2O(g) \rightarrow N_2(g) + O(g).$$

The plot of ln k vs. 1/T at right gives a slope of -3.019×10^4 K and a y-intercept of 27.4. Determine the activation energy (E_a) and frequency factor (A) for the reaction.



A. $E_a = 5.02 \times 10^5$ J/mol; $A = 9.54 \times 10^{10}$ s^{-1}

B. $E_a = 3.02 \times 10^5$ J/mol; $A = 9.54 \times 10^{11}$ s^{-1}

C. $E_a = 3.02 \times 10^5$ J/mol; $A = 7.93 \times 10^{11}$ s^{-1}

D. $E_a = 2.51 \times 10^5$ J/mol; $A = 7.93 \times 10^{11}$ s^{-1}

---

11. Consider the reaction mechanism:

(1) $NO_2(g) + Cl_2(g) \rightarrow ClNO_2(g) + Cl(g)$

(2) $NO_2(g) + Cl(g) \rightarrow ClNO_2(g)$

Identify the reaction intermediate.

A. $NO_2(g)$
C. $ClNO_2(g)$
B. $Cl_2(g)$
D. $Cl(g)$

---

12. Consider the following reaction mechanism:

(1) $2\ NO(g) \rightleftharpoons N_2O_2(g)$ fast

(2) $N_2O_2(g) + H_2(g) \rightarrow N_2O(g) + H_2O(g)$ slow

(3) $N_2O(g) + H_2(g) \rightarrow N_2(g) + H_2O(g)$ fast

What is the rate law for this overall reaction?

$$2\ H_2(g) + 2\ NO(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

A. rate = $k\,[NO]^2[H_2]$
C. rate = $k[N_2O_2][H_2]$
B. rate = $k[NO]^2$
D. rate = $k[N_2O][H_2]^2$

---

13. Select the **false** statement.

A. A catalyst works by raising the activation energy.

B. An enzyme is a biological catalyst.

C. A catalyst increases the rate of a chemical reaction but is not consumed by the reaction.

D. A homogeneous catalyst exists in the same phase as the reactants.

---

14. Which statement is always **true** about the concentrations of the reactants and products at equilibrium?

A. The concentrations of the reactants and products are equal.

B. The reactant concentration decreases and the product concentration increases.

C. The concentrations of the reactants and products are constant.

D. None of the above is true.

15. If $K >> 1$, then

A. products are favored.

B. reactants are favored.

C. reactant and product concentration are about equal.

D. the ratio of products to reactants cannot be estimated.

---

16. Given the reactions

$NO(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{1}{2}O_2(g)$ $K_{c1} = 1.0 \times 10^{15}$

$2\ NOBr(g) \rightleftharpoons N_2(g) + O_2(g) + Br_2(g)$ $K_{c2} = 5.0 \times 10^{26}$

calculate K_{c3} for the reaction

$2\ NO(g) + Br_2(g) \rightleftharpoons 2\ NOBr(g)$ $K_{c3} = ?$

A. 4.0×10^{-12} C. 1.0×10^{9}

B. 2.0×10^{3} D. 5.0×10^{38}

---

17. For the reaction

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

$K_c = 5.9 \times 10^{8}$ at 25 °C. Calculate K_p at 25 °C.

A. 9.8×10^{4} C. 9.9×10^{5}

B. 1.6×10^{5} D. 1.6×10^{7}

---

18. Which of the following is the equilibrium constant expression for this reaction?

$$NH_4SH(s) \rightleftharpoons H_2S(g) + NH_3(g)$$

A. $K_c = \frac{[H_2S][NH_3]}{[NH_4SH]}$

B. $K_c = \frac{[NH_4SH]}{[H_2S][NH_3]}$

C. $K_c = [H_2S][NH_3]$

D. $K_c = \frac{1}{[NH_4SH]}$

---

19. For the reaction

$$2\ A(aq) + B(aq) \rightleftharpoons 3\ C(aq) + 2\ D(aq),$$

[A] = 1.7 M, [B] = 6.4 M, [C] = 5.8 M, and [D] = 2.1 M at equilibrium.

What is the value of K_c?

A. 47

B. 1.1

C. 0.89

D. 2.1×10^{-2}

---

20. Iron(II) reacts with cyanide to form a complex ion according to the equation:

$$Fe^{2+}(aq) + 6\ CN^{-}(aq) \rightleftharpoons [Fe(CN)_6]^{4-}(aq) \qquad K_c = 1.5 \times 10^{35} \text{ at 298 K}$$

Solutions of Fe^{2+} and CN^{-} are mixed such that $Q_c = 1.5 \times 10^{20}$.Which statement is **true**?

A. The reaction is at equilibrium.

B. The reaction is not at equilibrium and will shift toward products to reach equilibrium.

C. The reaction is not at equilibrium and will shift toward reactants to reach equilibrium.

D. The reaction is not at equilibrium and cannot reach equilibrium under these conditions.

---

21. Consider this reaction and its equilibrium constant at 20 °C.

$$N_2O_4(g) \rightleftharpoons 2\ NO_2(g) \qquad K_c = 1.35 \times 10^{-3}$$

A reaction mixture contains $[NO_2] = 0.0014$ M and $[N_2O_4] = 0.035$ M. Calculate Q_c and determine the direction of the reaction at 20 °C.

A. $Q_c = 5.6 \times 10^{-5}$; the reaction will proceed toward reactants.

B. $Q_c = 5.6 \times 10^{-5}$; the reaction will proceed toward products.

C. $Q_c = 3.9 \times 10^{-2}$; the reaction will proceed toward reactants.

D. $Q_c = 4.0 \times 10^{-2}$; the reaction will proceed toward products.

---

22. A sealed flask is charged with pure $BrF_5(g)$ and the system is allowed to reach equilibrium at 500 K. At equilibrium, the concentration of BrF_5 is 0.096 M. What is the equilibrium concentration of F_2?

$$BrF_5(g) \rightleftharpoons BrF_3(g) + F_2(g) \qquad K_c = 1.2 \times 10^{-36} \text{ at 500 K}$$

A. 1.5×10^{-37} M

B. 3.4×10^{-19} M

C. 5.8×10^{-10} M

D. 0.45 M

---

23. Consider the reaction

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g) \qquad K_p = 1.1 \times 10^{-6} \text{ at 298 K}$$

If the initial pressure of SO_2 is 0.84 atm and the initial pressure of O_2 is 0.54 atm, what is the equilibrium pressure of SO_3?

A. 1.5×10^{3} atm

B. 3.6×10^{-4} atm

C. 6.5×10^{-4} atm

D. 4.5×10^{-7} atm

24. Given the reaction

$$CO(g) + 2\ H_2(g) \rightleftharpoons CH_3OH(g),$$

which change will cause the **greatest** shift in the equilibrium toward the **products**?

A. doubling the volume of the container

B. doubling P_{H2}

C. doubling P_{CO}

D. halving P_{CO}

---

25. Consider the following **endothermic** reaction at 298 K:

$$6\ H_2O(g) + 6\ CO_2(g) \rightarrow C_6H_{12}O_6(aq) + 6\ O_2(g)$$

When the temperature is increased at constant pressure, what will happen to the system?

A. The equilibrium constant and the concentrations of reactants and products will all remain unchanged.

B. The concentrations of products will increase and the equilibrium constant will decrease.

C. The concentrations of reactants will increase and the equilibrium constant will increase.

D. The concentrations of products will increase and the equilibrium constant will increase.

---

26. Given the reactions

(1) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

(2) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$,

which statement is **false**?

A. NaOH is both an Arrhenius base and a Brønsted-Lowry base.

B. HCl is an Arrhenius acid in reaction (1) and a Brønsted-Lowry acid in reaction (2).

C. NH_3 is both an Arrhenius base and a Brønsted-Lowry base.

D. NH_3 is a Brønsted-Lowry, but not an Arrhenius, base.

---

27. Which of the following is **not** an acid?

A. HCl

B. H_2SO_4

C. NH_4^+

D. NaCl

28. Which list correctly classifies the acids?

A. Strong: $HClO_4$, HNO_3
Weak: HF, $HC_2H_3O_2$

B. Strong: HCl, HNO_2
Weak: HCN, H_2SO_4

C. Strong: HI, HClO
Weak: H_3PO_4, $HClO_4$

D. Strong: HNO_3, H_2SO_3
Weak: H_2CO_3, HBr

---

29. Select the **strongest** of these acids.

A. HF, $K_a = 3.5 \times 10^{-4}$

B. HNO_2, $K_a = 4.6 \times 10^{-4}$

C. HC_6H_5O, $K_a = 1.3 \times 10^{-10}$

D. HCN, $K_a = 4.9 \times 10^{-10}$

---

30. Consider the weak acid dissociation

$$HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$$

The rate laws for acid dissociation (forward reaction) and formation (reverse reaction) are

$$rate_{\mathrm{diss}} = k_{\mathrm{diss}}[\mathrm{HCN}]$$
$$rate_{\mathrm{form}} = k_{\mathrm{form}}[\mathrm{H_3O^+}][\mathrm{CN^-}]$$

If one exists, determine the relationship between the rate constants and K_a.

A. $K_a = k_{\mathrm{diss}} \cdot k_{\mathrm{form}}$

B. $K_a = \dfrac{k_{\mathrm{diss}}}{k_{\mathrm{form}}}$

C. $K_a = \dfrac{k_{\mathrm{form}}}{k_{\mathrm{diss}}}$

D. There is no relationship between the rate constants and K_a.

CHE 107 Exam 2 Spring 2015 Key

1. A
2. C
3. C
4. D
5. A
6. D
7. B
8. C
9. D
10. D
11. D
12. A
13. A
14. C
15. A
16. B
17. C
18. C
19. A
20. B
21. B
22. B
23. C
24. B
25. D
26. C
27. D
28. A
29. B
30. B