1. Which substance has the **greatest** ideal van't Hoff factor?

A. $AlPO_4$

B. C_6H_{14}

C. $(NH_4)_2SO_4$

D. $Fe(C_2H_3O_2)_3$

2. A solution is prepared at 25 °C from 25.0 g of lauric acid (nonvolatile, 200.3 g/mol) in 50.0 g of H_2O. What is the **vapor pressure** of the solution? The vapor pressure of pure water at 25 °C is 23.8 torr.

A. 1.04 torr

B. 1.08 torr

C. 22.8 torr

D. 24.9 torr

3. Calculate the freezing point of a solution prepared by dissolving 0.250 g $CHCl_3$ in 15.00 g CCl_4.

Normal freezing point, $CHCl_3$ = −6.36 °C
Normal freezing point, CCl_4 = −22.9 °C
K_f ($CHCl_3$) = 4.70 °C/*m*
K_f (CCl_4) = 29.9 °C/*m*

A. 4.25 °C

B. −1.81 °C

C. −18.5 °C

D. −27.1 °C

4. What is the **molarity** of a Na_2SO_4 solution with an osmotic pressure of 1.20 atm at 18.5 °C?

A. 0.0271 M
C. 0.0167 M
B. 0.00223 M
D. 0.0693 M

5. Which aqueous solution has the **highest** boiling point? Assume ideal van't Hoff factors.

A. 0.25 *m* NaCl
C. 0.20 *m* $CaBr_2$
B. 0.10 *m* $AlCl_3$
D. 0.25 *m* glucose (non-electrolyte)

6. The rate of a reaction can be defined as

A. the change in mass over concentration.
B. the change in concentration over time.
C. the change in time over mass.
D. the change in speed over time.

7. Nitrogen dioxide forms according to the reaction

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

What is the **rate of the reaction** if the concentration of NO_2 goes from zero to 0.500 M in 30 seconds?

A. 8.3×10^{-3} M/s
C. 3.2×10^{-2} M/s
B. 1.6×10^{-2} M/s
D. 0.60 M/s

8. For the reaction

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$$

the concentration of $NH_3(g)$ dropped at a rate of 0.032 M/s during the first 10 seconds. What is the rate of change of $H_2O(g)$ during this same time interval?

A. 0.050 M/s
C. 0.048 M/s
B. 0.026 M/s
D. 0.036 M/s

9. Select the **false** statement concerning the following reaction and its corresponding rate law.

$$2\ H_2(g) + 2\ NO(g) \rightarrow N_2(g) + 2\ H_2O(g) \qquad \text{rate} = k[H_2][NO]^2$$

A. The reaction is second order in NO.

B. The reaction is third order overall.

C. Doubling the concentration of NO will quadruple the rate of the reaction.

D. The given rate law must be incorrect; it must be second order in H_2.

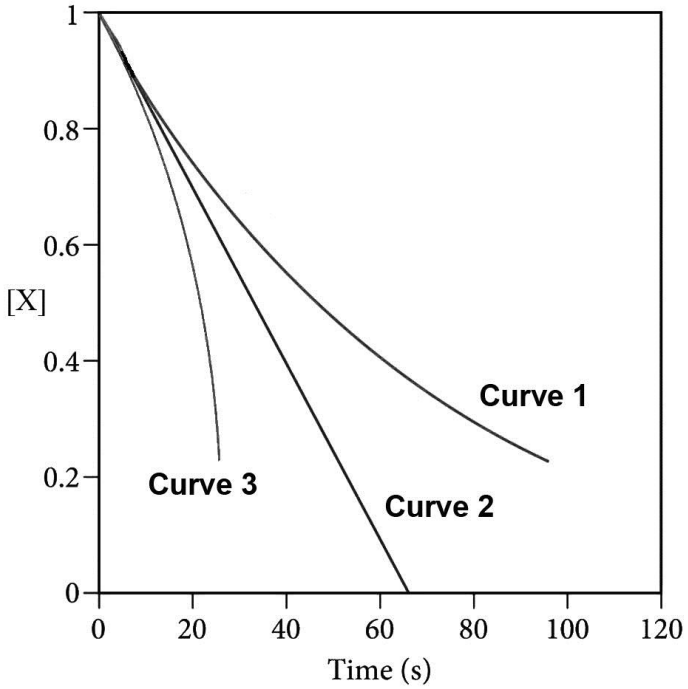
10. What is the order of the reaction for the uncatalyzed decomposition of N_2O_4 given the following experimental data?

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

N_2O_4(M)	Initial rate (M/s)
0.100	3.0×10^{-2}
0.300	9.1×10^{-2}
0.500	1.5×10^{-1}

A. 0
C. 2
B. 1
D. 3

11. Which statement below best describes the graph of [X] vs. time for a **first-order reaction** where X → products?



A. The rate of the reaction decreases over time as shown by Curve 1 because the concentration of reactant decreases.

B. The rate of the reaction is constant as shown by Curve 2 because the rate is independent of the concentration of the reactant.

C. The rate of the reaction decreases over time as shown by Curve 3 because the concentration of the reactant decreases.

D. The rate of the reaction is smallest at time zero.

12. For the reaction

$$SO_2Cl_2(g) \rightarrow SO_2(g) + Cl_2(g)$$

a plot of $\ln[SO_2Cl_2]$ versus time yields a straight line with slope = $-2.90 \times 10^{-4}\ s^{-1}$.

If the initial concentration of SO_2Cl_2 is 0.150 M, what is the concentration at 20.0 minutes?

A. 0.145 M

B. 0.0225 M

C. 0.106 M

D. 0.977 M

13. A plot of $\frac{1}{[A]}$ versus time for a certain reaction produces a straight line with slope equal to 0.269 $M^{-1}s^{-1}$. Which of the following is **true**?

A. The reaction is second order. The rate constant is 0.269 $M^{-1}s^{-1}$.

B. The reaction is first order. The rate constant is 0.269 s^{-1}.

C. The reaction is second order. The activation energy is 0.269 kJ/mol.

D. The reaction is first order. The activation energy is 0.269 kJ/mol.

14. What is the **rate constant** for the second-order decay of a substance whose initial concentration is 0.400 M with an initial half-life of 39 minutes.

A. 1.7 $M^{-1}min^{-1}$

B. $5.1 \times 10^{-3}\ M^{-1}min^{-1}$

C. $1.9 \times 10^{-1}\ M^{-1}min^{-1}$

D. $6.4 \times 10^{-2}\ M^{-1}min^{-1}$

15. A plot of ln k versus (1/T) yields a straight line with a slope of -1.35×10^6 K. What information can we calculate from the given slope?

A. frequency factor, A

B. rate constant, k

C. order of the reaction, n

D. activation energy, E_a

16. Consider the reaction between nitrogen dioxide and carbon monoxide.

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

The activation energy is 145 kJ/mol. At 622 °C , the rate constant is 567 $M^{-1}s^{-1}$. Determine the rate constant at 430 °C.

A. 2.77 $M^{-1}s^{-1}$

B. 2.11×10^{-3} $M^{-1}s^{-1}$

C. 1.21×10^5 $M^{-1}s^{-1}$

D. 321 $M^{-1}s^{-1}$

17. Identify the intermediate(s) in the proposed mechanism.

$$HNO_2 + H^+ \rightleftharpoons H_2O + NO^+ \quad \text{(fast)}$$

$$NH_4^+ \rightleftharpoons NH_3 + H^+ \quad \text{(fast)}$$

$$NO^+ + NH_3 \rightarrow NH_3NO^+ \quad \text{(slow)}$$

$$NH_3NO^+ \rightarrow H_2O + H^+ + N_2 \quad \text{(fast)}$$

A. NH_3NO^+ only

B. NO^+ and H^+

C. NH_3 only

D. NO^+, NH_3 and NH_3NO^+

18. A proposed mechanism for the reaction $2\ NO + Cl_2 \rightleftharpoons 2\ NOCl$ is:

Step 1: $NO + Cl_2 \rightleftharpoons NOCl_2$ (fast)

Step 2: $NOCl_2 + NO \rightarrow 2\ NOCl$ (slow)

What is the rate law for the overall reaction?

A. rate = $k[NO]^2[Cl_2]$

B. rate = $k[NO][Cl_2]$

C. rate = $k[NOCl_2][NO]^2$

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

19. Which statement is **false** concerning a catalyst?

A. A catalyst is a reactant in an elementary step of a mechanism but is not consumed in the overall reaction.

B. An enzyme is a biological catalyst.

C. A catalyst decreases the rate constant of a reaction.

D. A catalyst lowers the activation energy of the overall reaction.

20. A _____ catalyst is in the _____ phase as the reactants and a/an _____ is a biological catalyst.

A. homogeneous, same, heterogeneous

B. heterogeneous, same, enzyme

C. homogeneous, same, enzyme

D. heterogeneous, different, homogeneous

21. Which of the following statements is **false** about dynamic equilibrium?

A. The concentration of reactants is equal to the concentration of products.

B. Both the forward and the reverse reactions continue.

C. The rate of the forward reaction is equal to the rate of the reverse reaction.

D. The concentrations of reactants and products remain constant.

22. Consider the reaction:

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g) \qquad K_p = 0.120 \text{ at a fixed temperature.}$$

The reaction chamber is charged with 1.0 atm SO_3. Select the **true** statement. [HINT: It is not necessary to solve explicitly for equilibrium pressures.]

A. At equilibrium, $1/2\ P(SO_3) = P(O_2)$.

B. At equilibrium, $P(SO_2) = P(SO_3)$.

C. At equilibrium, $P(SO_3) > P(SO_2)$.

D. At equilibrium, $P(SO_2) = 2\ P(O_2)$.

23. Given

$$NO(g) + \tfrac{1}{2}\ Br_2(g) \rightleftharpoons NOBr(g) \qquad K_1 = 5.3$$

What is the equilibrium constant for the following reaction?

$$2\ NOBr(g) \rightleftharpoons 2\ NO(g) + Br_2(g) \qquad K_2 = ?$$

A. $K_2 = (K_1)^{-2}$

B. $K_2 = -2 \times K_1$

C. $K_2 = \sqrt{K_1}$

D. $K_2 = 2 \div K_1$

24. What is the expression of K_c for the reaction below?

$$P_4(s) + 6\ Cl_2(g) \rightleftharpoons 4\ PCl_3(l)$$

A. $K_c = \dfrac{[PCl_3]^4}{[P_4][Cl_2]^6}$

B. $K_c = \dfrac{[PCl_3]^4}{[P_4]}$

C. $K_c = \dfrac{1}{[Cl_2]^6}$

D. $K_c = \dfrac{[PCl_3]^4}{[Cl_2]^6}$

25. Consider the reaction

$$A(g) \rightleftharpoons 2\ B(g).$$

Initially 0.250 M of compound A is placed in the reaction chamber at 250 °C. At equilibrium, it is determined that the concentration of B is 0.110 M. Calculate K_c at this temperature.

A. 0.0877

B. 0.0481

C. 0.552

D. 0.0621

26. Which statement is true?

A. For $Q < K$, the concentrations of products will decrease to reach equilibrium.

B. For $Q < K$, the concentrations of reactants will decrease while the concentrations of products will stay the same.

C. For $Q > K$, the reaction will proceed to the left to reach equilibrium.

D. For $Q > K$, the concentrations of reactants will increase while the concentrations of products will stay the same.

27. The equilibrium partial pressures of O_2 and SO_2 are 0.120 atm and 0.0245 atm, respectively, at 350 °C for the reaction

$$O_2(g) + 2\ SO_2(g) \rightleftharpoons 2\ SO_3(g) \qquad K_p = 5.60 \times 10^4 \text{ at } 350\ °C.$$

What is the partial pressure of $SO_3(g)$ at equilibrium?

A. 1.04 atm
C. 0.270 atm
B. 15.8 atm
D. 2.01 atm

28. Consider the reaction

$$2\ H_2S\ (g) \rightleftharpoons 2\ H_2(g) + S_2(g) \qquad K_p = 2.4 \times 10^{-4} \text{ at } 1073\ K.$$

If a reaction vessel initially contains only 1.20×10^3 torr H_2S, what is the equilibrium pressure of H_2?

A. 32.5 torr
C. 80.7 torr
B. 620 torr
D. 149 torr

29. Which changes will cause the **<u>amount of reactant</u>** to increase?

$$2\ KClO_3(s) \rightleftharpoons 2\ KCl(s) + 3\ O_2(g)$$

I. Removal of KCl

II. Addition of O_2

III. Removal of O_2

A. I only

B. I and III

C. II only

D. III only

30. Photosynthesis can be represented by

$$6\ CO_2(g) + 6\ H_2O(l) \rightleftharpoons C_6H_{12}O_6(s) + 6\ O_2(g) \qquad \Delta H° = 2{,}801\ kJ/mol$$

Which change results in a shift in equilibrium towards products?

A. H_2O is added.

B. $C_6H_{12}O_6$ is removed.

C. The pressure of CO_2 is increased.

D. The temperature is lowered.

Answer Key:

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