

5) Which of the following statements is TRUE?

- A) The addition of a homogeneous catalyst does not change the activation energy of a given reaction.
- B) The rate constant does not depend on the activation energy for a reaction where the products are lower in energy than the reactants.
- C) A catalyst raises the activation energy of a reaction.
- D) Rate constants are temperature dependent.
- E) None of the above are true.

Answer: D

6) Determine the value of K_C for the following reaction if the equilibrium concentrations are as follows: $[PBr_5]_{eq} = 0.56 \text{ M}$, $[PBr_3]_{eq} = 0.23 \text{ M}$, $[Br_2]_{eq} = 3.3 \text{ M}$.



- A) 1.4 B) 0.74 C) 0.93 D) 0.76 E) 1.1

Answer: A

7) The decomposition of N_2O_5 in solution in carbon tetrachloride proceeds via the reaction



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 M B) $2.0 \times 10^3 \text{ M}$ C) 0.028 M D) 0.060 M E) 12 M

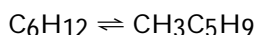
Answer: C

8) Identify the rate-determining step.

- A) the slowest step
- B) always the last step
- C) always the second step
- D) the faster step
- E) the fast step

Answer: A

9) Cyclohexane, C_6H_{12} , undergoes a molecular rearrangement in the presence of $AlCl_3$ to form methylcyclopentane, $CH_3C_5H_9$, according to the equation:



If $K_C = 0.143$ at 25°C for this reaction, find the equilibrium concentrations of C_6H_{12} and $CH_3C_5H_9$ if the initial concentrations are 0.200 M and 0.075 M, respectively.

- A) $[C_6H_{12}] = 0.041 \text{ M}$, $[CH_3C_5H_9] = 0.041 \text{ M}$ B) $[C_6H_{12}] = 0.241 \text{ M}$, $[CH_3C_5H_9] = 0.034 \text{ M}$
C) $[C_6H_{12}] = 0.253 \text{ M}$, $[CH_3C_5H_9] = 0.022 \text{ M}$ D) $[C_6H_{12}] = 0.159 \text{ M}$, $[CH_3C_5H_9] = 0.116 \text{ M}$

Answer: B

- 10) In a reaction mixture containing reactants and products, each at a concentration of 1M, what is the value of Q?
- A) 0
 - B) 1
 - C) ∞
 - D) -1
 - E) It cannot be determined without concentrations.

Answer: B

- 11) Given the following rate law, how does the rate of reaction change if the concentration of X is doubled?
- $$\text{Rate} = k [X][Y]^2$$

- A) The rate of reaction will increase by a factor of 3.
- B) The rate of reaction will increase by a factor of 5.
- C) The rate of reaction will increase by a factor of 2.
- D) The rate of reaction will decrease by a factor of 2.
- E) The rate of reaction will remain unchanged.

Answer: C

- 12) Carbon-14 has a half-life of 5720 years and this is a first order reaction. If a piece of wood has converted 75% of the carbon-14, then how old is it?
- A) 1430 years
 - B) 2375 years
 - C) 11440 years
 - D) 4290 years
 - E) 4750 years

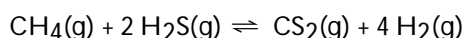
Answer: C

- 13) 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) $1.92 \times 10^4 \text{ s}^{-1}$
- B) $3.47 \times 10^4 \text{ s}^{-1}$
- C) $3.85 \times 10^6 \text{ s}^{-1}$
- D) 670 s^{-1}
- E) $1.36 \times 10^2 \text{ s}^{-1}$

Answer: A

- 14) Consider the following reaction:

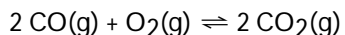


A reaction mixture initially contains 0.50 M CH_4 and 0.75 M H_2S . If the equilibrium concentration of H_2 is 0.44 M, find the equilibrium constant (K_C) for the reaction.

- A) 0.038
- B) 2.9
- C) 0.23
- D) 0.34
- E) 10.

Answer: A

- 15) Determine the value of K_P for the following reaction if the equilibrium concentrations are as follows: $P(\text{CO})_{\text{eq}} = 6.8 \times 10^{-11} \text{ atm}$, $P(\text{O}_2)_{\text{eq}} = 1.3 \times 10^{-3} \text{ atm}$, $P(\text{CO}_2)_{\text{eq}} = 0.041 \text{ atm}$.



- A) 3.6×10^{-21}
- B) 2.8×10^{20}
- C) 4.6×10^{11}
- D) 2.2×10^{-12}
- E) 3.6×10^{-15}

Answer: B

16) What are the units of k in a second order reaction?

A) $M^{-1}s^{-1}$

B) M

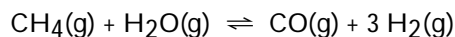
C) $\frac{1}{M}$

D) $\frac{M}{s}$

E) $\frac{M^2}{s}$

Answer: A

17) What is Δn for the following equation in relating K_c to K_p ?



A) 2

B) -2

C) -1

D) 0

E) -3

Answer: A

18) Express the equilibrium constant for the following reaction.



A) $K = \frac{[\text{PCl}_5]^4}{[\text{PCl}_3]^4[\text{Cl}_2]^4}$

B) $K = \frac{[\text{PCl}_3]^2[\text{Cl}_2]^2}{[\text{PCl}_5]^2}$

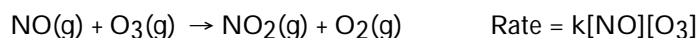
C) $K = \frac{[\text{PCl}_3][\text{Cl}_2]^2}{[\text{PCl}_5]}$

D) $K = \frac{[\text{PCl}_5]^{1/2}}{[\text{PCl}_3]^{1/2}[\text{Cl}_2]^{1/2}}$

E) $K = \frac{[\text{PCl}_3]^4[\text{Cl}_2]^4}{[\text{PCl}_5]^4}$

Answer: E

19) What is the overall order of the following reaction, given the rate law?



A) 3rd order

B) 0th order

C) 1st order

D) $1\frac{1}{2}$ order

E) 2nd order

Answer: E

20) Identify an homogeneous catalyst.

A) H_2SO_4 with concentrated HCl

B) N_2 and H_2 catalyzed by Fe

C) Pt with methane

D) Pd in H_2 gas

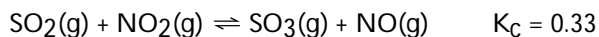
E) SO_2 over vanadium (V) oxide

Answer: A

- 21) Give the direction of the reaction, if $K \gg 1$.
- A) The forward reaction is favored.
 - B) If the temperature is raised, then the reverse reaction is favored.
 - C) If the temperature is raised, then the forward reaction is favored.
 - D) Neither direction is favored.
 - E) The reverse reaction is favored.

Answer: A

- 22) Consider the following reaction and its equilibrium constant:

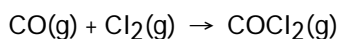


A reaction mixture contains 0.41 M SO_2 , 0.14 M NO_2 , 0.12 M SO_3 and 0.14 M NO . Which of the following statements is TRUE concerning this system?

- A) The reaction quotient will decrease.
- B) The equilibrium constant will decrease.
- C) The reaction will shift in the direction of products.
- D) The reaction will shift in the direction of reactants.
- E) The system is at equilibrium.

Answer: C

- 23) The K_p for the reaction below is 1.49×10^8 at 100.0°C :

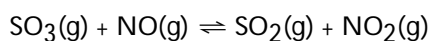


In an equilibrium mixture of the three gases, $P_{\text{CO}} = P_{\text{Cl}_2} = 2.22 \times 10^{-4}$ atm. The partial pressure of the product, phosgene (COCl_2), is _____ atm.

- A) 6.67×10^{11}
- B) 7.34
- C) 3.02×10^{15}
- D) 3.31×10^{-16}
- E) 3.31×10^4

Answer: B

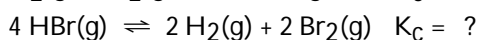
- 24) What is Δn for the following equation in relating K_c to K_p ?



- A) -1
- B) 2
- C) 0
- D) -2
- E) 1

Answer: C

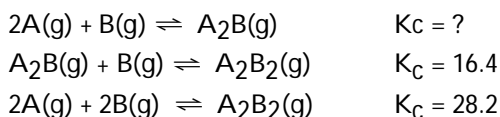
- 25) The equilibrium constant is given for one of the reactions below. Determine the value of the missing equilibrium constant.



- A) 1.6×10^3
- B) 6.9×10^{-10}
- C) 5.1×10^{-3}
- D) 1.9×10^4
- E) 2.6×10^{-5}

Answer: B

26) The equilibrium constant is given for two of the reactions below. Determine the value of the missing equilibrium constant.



- A) 462 B) 0.00216 C) 1.72 D) 11.8 E) 0.582

Answer: C

27) 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 $E_a = 55.5 \text{ kJ/mol}$?

- A) 576 s^{-1}
B) $2.85 \times 10^4 \text{ s}^{-1}$
C) $9.56 \times 10^3 \text{ s}^{-1}$
D) $4.33 \times 10^{87} \text{ s}^{-1}$
E) $1.36 \times 10^2 \text{ s}^{-1}$

Answer: C

28) Phosphorus pentachloride decomposes to phosphorus trichloride at high temperatures according to the equation:



At 250° 0.125 M PCl_5 is added to the flask. If $K_c = 1.80$, what are the equilibrium concentrations of each gas?

- A) $[\text{PCl}_5] = 3.96 \text{ M}$, $[\text{PCl}_3] = 3.83 \text{ M}$, and $[\text{Cl}_2] = 3.83 \text{ M}$
B) $[\text{PCl}_5] = 0.00765 \text{ M}$, $[\text{PCl}_3] = 0.117 \text{ M}$, and $[\text{Cl}_2] = 0.117 \text{ M}$
C) $[\text{PCl}_5] = 1.80 \text{ M}$, $[\text{PCl}_3] = 1.80 \text{ M}$, and $[\text{Cl}_2] = 1.80 \text{ M}$
D) $[\text{PCl}_5] = 0.0625 \text{ M}$, $[\text{PCl}_3] = 0.335 \text{ M}$, and $[\text{Cl}_2] = 0.335 \text{ M}$

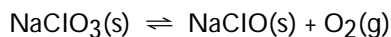
Answer: B

29) In which of the following reactions will $K_c = K_p$?

- A) $\text{SO}_3(g) + \text{NO}(g) \rightleftharpoons \text{SO}_2(g) + \text{NO}_2(g)$
B) $2 \text{N}_2(g) + \text{O}_2(g) \rightleftharpoons 2 \text{N}_2\text{O}(g)$
C) $4 \text{NH}_3(g) + 3 \text{O}_2(g) \rightleftharpoons 2 \text{N}_2(g) + 6 \text{H}_2\text{O}(g)$
D) $2 \text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2 \text{SO}_3(g)$
E) None of the above reactions have $K_c = K_p$.

Answer: A

30) Express the equilibrium constant for the following reaction.



A) $K = \frac{[\text{NaClO}]^2[\text{O}_2]^2}{[\text{NaClO}_3]^2}$

B) $K = [\text{O}_2]^{-1}$

C) $K = [\text{O}_2]$

D) $K = \frac{[\text{NaClO}][\text{O}_2]}{[\text{NaClO}_3]}$

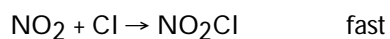
E) $K = \frac{[\text{NaClO}_3]}{[\text{NaClO}][\text{O}_2]}$

Answer: C

31) Given the following proposed mechanism, predict the rate law for the overall reaction.



Mechanism



A) Rate = $k[\text{NO}_2][\text{Cl}]$

B) Rate = $k[\text{NO}_2\text{Cl}][\text{Cl}]^2$

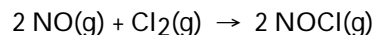
C) Rate = $k[\text{NO}_2\text{Cl}]^2$

D) Rate = $k[\text{NO}_2][\text{Cl}_2]$

E) Rate = $k[\text{NO}_2]^2[\text{Cl}_2]^2$

Answer: D

32) Given the following balanced equation, determine the rate of reaction with respect to $[\text{NOCl}]$.



A) Rate = $+\frac{1}{2} \frac{\Delta[\text{NOCl}]}{\Delta t}$

B) Rate = $-\frac{1}{2} \frac{\Delta[\text{NOCl}]}{\Delta t}$

C) Rate = $-\frac{2 \Delta[\text{NOCl}]}{\Delta t}$

D) Rate = $-\frac{1}{2} \frac{\Delta[\text{NO}]}{\Delta t}$

E) It is not possible to determine without more information.

Answer: A

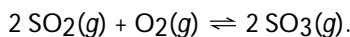
33) Determine the rate law and the value of k for the following reaction using the data provided.

$S_2O_8^{2-}(aq) + 3 I^-(aq) \rightarrow 2 SO_4^{2-}(g) + I_3^-(aq)$	$[S_2O_8^{2-}]_i$ (M)	$[I^-]_i$ (M)	Initial Rate ($M^{-1}s^{-1}$)
	0.30	0.42	4.54
	0.44	0.42	6.65
	0.44	0.21	3.33

- A) Rate = $36 M^{-1}s^{-1} [S_2O_8^{2-}][I^-]$
 B) Rate = $120 M^{-2}s^{-1} [S_2O_8^{2-}]^2[I^-]$
 C) Rate = $23 M^{-1/2}s^{-1} [S_2O_8^{2-}][I^-]^{1/2}$
 D) Rate = $86 M^{-2}s^{-1} [S_2O_8^{2-}][I^-]^2$
 E) Rate = $195 M^{-3}s^{-1} [S_2O_8^{2-}]^2[I^-]^2$

Answer: A

34) The equilibrium constant is equal to 5.00 at 1300 K for the reaction:

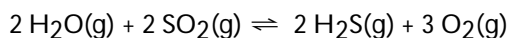


If initial concentrations are $[SO_2] = 6.00 M$, $[O_2] = 0.45 M$, and $[SO_3] = 9.00 M$, the system is

- A) not at equilibrium and will remain in an unequilibrated state.
 B) not at equilibrium and will shift to the left to achieve an equilibrium state.
 C) at equilibrium.
 D) not at equilibrium and will shift to the right to achieve an equilibrium state.

Answer: C

35) Consider the following reaction:

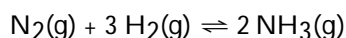


A reaction mixture initially contains 2.8 M H_2O and 2.6 M SO_2 . Determine the equilibrium concentration of H_2S if K_C for the reaction at this temperature is 1.3×10^{-6} .

- A) 0.058 M B) 0.028 M C) 0.12 M D) $3.1 \times 10^{-3} M$ E) 0.045 M

Answer: C

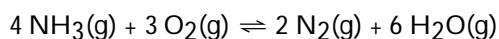
36) Calculate the value of $[N_2]_{eq}$ if $[H_2]_{eq} = 2.0 M$, $[NH_3]_{eq} = 0.5 M$, and $K_C = 2$.



- A) 0.016 M B) 0.031 M C) 62.5 M D) 0.062 M E) 0.40 M

Answer: A

37) What is Δn for the following equation in relating K_C to K_P ?



- A) 3 B) 2 C) -2 D) 1 E) -1

Answer: D

38) The first-order decay of radon has a half-life of 3.823 days. How many grams of radon remain after 7.22 days if the sample initially weighs 250.0 grams?

A) 54.8 g

B) 4.21 g

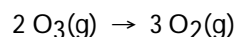
C) 183 g

D) 76.3 g

E) 67.5 g

Answer: E

39) Given the following balanced equation, determine the rate of reaction with respect to $[O_2]$.



A) Rate = $+\frac{2 \Delta[O_2]}{\Delta t}$

B) Rate = $-\frac{2 \Delta[O_2]}{3 \Delta t}$

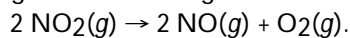
C) Rate = $-\frac{3 \Delta[O_2]}{\Delta t}$

D) Rate = $+\frac{1 \Delta[O_2]}{3 \Delta t}$

E) It is not possible to determine without more information.

Answer: D

40) Nitrogen dioxide decomposes at 300°C via a second-order process to produce nitrogen monoxide and oxygen according to the following chemical equation.



A sample of $NO_2(g)$ is initially placed in a 2.50-L reaction vessel at 300°C. If the half-life and the rate constant at 300°C are 11 seconds and $0.54 M^{-1} s^{-1}$, respectively, how many moles of NO_2 were in the original sample?

A) 5.9 mol

B) 0.42 mol

C) 0.17 mol

D) 15 mol

Answer: B