# 1022_1st Exam_1030319

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

1) Hydrogen iodide decomposes at 800 K via a second-order process to produce hydrogen and iodine according to the following chemical equation.

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

At 800 K it takes 142 seconds for the initial concentration of HI to decrease from $6.75 \times 10^{-2}$ M to $3.50 \times 10^{-2}$ M. What is the rate constant for the reaction at this temperature?

A) $5.12 \times 10^{-4}$ $M^{-1}s^{-1}$
B) $9.69 \times 10^{-2}$ $M^{-1}s^{-1}$
C) 10.3 $M^{-1}s^{-1}$
D) $1.95 \times 10^{3}$ $M^{-1}s^{-1}$

Answer: B

2) Cyclohexane ($C_6H_{12}$) undergoes a molecular rearrangement in the presence of $AlCl_3$ to form methylcyclopentane (MCP) according to the equation:

$$C_6H_{12} \rightleftharpoons MCP$$

If $K_c$ = 0.143 at 25°C for this reaction, predict the direction in which the system will shift if the initial concentrations of $C_6H_{12}$ and MCP are 0.0400 M and 0.0200 M, respectively. The system

A) will shift right.
B) is already at equilibrium.
C) is not at equilibrium and will remain in an unequilibrated state.
D) will shift left.

Answer: D

3) Consider the following reaction at equilibrium. What effect will adding 1 mole of Ar to the reaction mixture have on the system?

$$2\ H_2S(g) + 3\ O_2(g) \rightleftharpoons 2\ H_2O(g) + 2\ SO_2(g)$$

A) The reaction will shift to the left in the direction of reactants.
B) No effect will be observed.
C) The equilibrium constant will increase.
D) The reaction will shift to the right in the direction of products.
E) The equilibrium constant will decrease.

Answer: B

4) A reaction is found to have an activation energy of 38.0 kJ/mol. If the rate constant for this reaction is $1.60 \times 10^{2}$ $M^{-1}s^{-1}$ at 249 K, what is the rate constant at 436 K?

A) $7.94 \times 10^{4}$ $M^{-1}s^{-1}$
B) $2.38 \times 10^{5}$ $M^{-1}s^{-1}$
C) $1.26 \times 10^{3}$ $M^{-1}s^{-1}$
D) $3.80 \times 10^{4}$ $M^{-1}s^{-1}$
E) $4.20 \times 10^{5}$ $M^{-1}s^{-1}$

Answer: E

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 M, $[PBr_3]_{eq}$ = 0.23 M, $[Br_2]_{eq}$ = 3.3 M.

$$PBr_5(g) \rightleftharpoons PBr_3(g) + Br_2(g)$$

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

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

The reaction is first order and has a rate constant of $4.82 \times 10^{-3}\ s^{-1}$ 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) $2.0 \times 10^3$ 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:

$$C_6H_{12} \rightleftharpoons CH_3C_5H_9$$

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 M, $[CH_3C_5H_9]$ = 0.041 M
B) $[C_6H_{12}]$ = 0.241 M, $[CH_3C_5H_9]$ = 0.034 M
C) $[C_6H_{12}]$ = 0.253 M, $[CH_3C_5H_9]$ = 0.022 M
D) $[C_6H_{12}]$ = 0.159 M, $[CH_3C_5H_9]$ = 0.116 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) $\infty$
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 $1.35 \times 10^2\ s^{-1}$ at 25.0°C. What is the magnitude of k at 75.0°C if $E_a$ = 85.6 kJ/mol?

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

Answer: A

14) Consider the following reaction:

$$CH_4(g) + 2\ H_2S(g) \rightleftharpoons CS_2(g) + 4\ H_2(g)$$

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: $P(CO)_{eq} = 6.8 \times 10^{-11}$ atm, $P(O_2)_{eq} = 1.3 \times 10^{-3}$ atm, $P(CO_2)_{eq}$ = 0.041 atm.

$$2\ CO(g) + O_2(g) \rightleftharpoons 2\ CO_2(g)$$

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

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 $\Delta n$ for the following equation in relating $K_c$ to $K_p$?

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\ H_2(g)$$

A) 2 B) -2 C) -1 D) 0 E) -3

Answer: A

18) Express the equilibrium constant for the following reaction.

$$4PCl_5(g) \rightleftharpoons 4PCl_3(g) + 4Cl_2(g)$$

A) $K = \frac{[PCl_5]^4}{[PCl_3]^4[Cl_2]^4}$

B) $K = \frac{[PCl_3]^2[Cl_2]^2}{[PCl_5]^2}$

C) $K = \frac{[PCl_3][Cl]^2}{[PCl_5]}$

D) $K = \frac{[PCl_5]^{1/2}}{[PCl_3]^{1/2}[Cl_2]^{1/2}}$

E) $K = \frac{[PCl_3]^4[Cl_2]^4}{[PCl_5]^4}$

Answer: E

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

$$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g) \qquad \text{Rate} = k[NO][O_3]$$

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 >> 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:

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g) \qquad K_c = 0.33$$

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 $1.49 \times 10^8$ at 100.0°C:

$$CO(g) + Cl_2(g) \rightarrow COCl_2(g)$$

In an equilibrium mixture of the three gases, $P_{CO} = P_{Cl_2} = 2.22 \times 10^{-4}$ atm. The partial pressure of the product, phosgene ($COCl_2$), is _____ atm.

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

Answer: B

24) What is $\Delta n$ for the following equation in relating $K_c$ to $K_p$?

$$SO_3(g) + NO(g) \rightleftharpoons SO_2(g) + NO_2(g)$$

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.

$$H_2(g) + Br_2(g) \rightleftharpoons 2\ HBr(g) \qquad K_c = 3.8 \times 10^4$$
$$4\ HBr(g) \rightleftharpoons 2\ H_2(g) + 2\ Br_2(g) \qquad K_c = \ ?$$

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

Answer: B

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

$2A(g) + B(g) \rightleftharpoons A_2B(g)$ Kc = ?
$A_2B(g) + B(g) \rightleftharpoons A_2B_2(g)$ $K_c = 16.4$
$2A(g) + 2B(g) \rightleftharpoons A_2B_2(g)$ $K_c = 28.2$

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 $1.35 \times 10^2\ s^{-1}$ at 25.0°C. What is the magnitude of k at 95.0°C if $E_a$ = 55.5 kJ/mol?

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

Answer: C

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

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

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) $[PCl_5]$ = 3.96 M, $[PCl_3]$ = 3.83 M, and $[Cl_2]$ = 3.83 M
B) $[PCl_5]$ = 0.00765 M, $[PCl_3]$ = 0.117 M, and $[Cl_2]$ = 0.117 M
C) $[PCl_5]$ = 1.80 M, $[PCl_3]$ = 1.80 M, and $[Cl_2]$ = 1.80 M
D) $[PCl_5]$ = 0.0625 M, $[PCl_3]$ = 0.335 M, and $[Cl_2]$ = 0.335 M

Answer: B

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

A) $SO_3(g) + NO(g) \rightleftharpoons SO_2(g) + NO_2(g)$
B) $2\ N_2(g) + O_2(g) \rightleftharpoons 2\ N_2O(g)$
C) $4\ NH_3(g) + 3\ O_2(g) \rightleftharpoons 2\ N_2(g) + 6\ H_2O(g)$
D) $2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$
E) None of the above reactions have $K_c = K_p$.

Answer: A

30) Express the equilibrium constant for the following reaction.

$$NaClO_3(s) \rightleftharpoons NaClO(s) + O_2(g)$$

A) $K = \dfrac{[NaClO]^2[O_2]^2}{[NaClO_3]^2}$

B) $K = [O_2]^{-1}$

C) $K = [O_2]$

D) $K = \dfrac{[NaClO][O_2]}{[NaClO_3]}$

E) $K = \dfrac{[NaClO_3]}{[NaClO][O_2]}$

Answer: C

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

$2NO_2 + Cl_2 \rightarrow 2NO_2Cl$ (overall reaction)

Mechanism

$NO_2 + Cl_2 \rightarrow NO_2Cl + Cl$ slow

$NO_2 + Cl \rightarrow NO_2Cl$ fast

A) Rate = $k[NO_2][Cl]$

B) Rate = $k[NO_2Cl][Cl]^2$

C) Rate = $k[NO_2Cl]^2$

D) Rate = $k[NO_2][Cl_2]$

E) Rate = $k[NO_2]^2[Cl_2]^2$

Answer: D

32) Given the following balanced equation, determine the rate of reaction with respect to [NOCl].

$$2\ NO(g) + Cl_2(g) \rightarrow 2\ NOCl(g)$$

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

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

C) Rate = $-\dfrac{2\,\Delta[NOCl]}{\Delta t}$

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

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:

$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$.

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:

$2\ H_2O(g) + 2\ SO_2(g) \rightleftharpoons 2\ H_2S(g) + 3\ O_2(g)$

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 $1.3 \times 10^{-6}$.

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.

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

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 $\Delta n$ for the following equation in relating $K_c$ to $K_p$?

$4\ NH_3(g) + 3\ O_2(g) \rightleftharpoons 2\ N_2(g) + 6\ H_2O(g)$

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 $[O_2]$.

$$2\ O_3(g) \rightarrow 3\ O_2(g)$$

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

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

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

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

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.

$2\ NO_2(g) \rightarrow 2\ NO(g) + O_2(g)$.

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