CHM 2046 **Practice Exam 1: Answer Key**

Important: Bubble in **A**, **B** or **C** as the test form code at the top right of your answer sheet.
Useful information is provided at the end.

VERSION A

1. The reaction A(aq) + 2 B(aq) ⇌ 2C(aq) + D(aq) has $K_c = 14$. At a particular moment in time, [A] = 0.4 M, [B] = 0.5 M, [C] = 1.1 M, and [D] = 1.4 M. Which of the following statements is true?

   a. Q < K and the reaction is proceeding to the right.
   b. Q < K and the reaction is proceeding to the left.
   c. Q > K and the reaction is proceeding to the left.
   d. Q > K and the reaction is proceeding to the right.
   e. The reaction is at equilibrium.

2. In the following reaction at 600 K, which has $K_c = 6.2 \times 10^3$ and $\Delta H^o = -254$ kJ, 1.0 mol of each substance is introduced into a 1.0 L vessel in the presence of a catalyst and allowed to reach equilibrium at 600 K.

   $$P_4S_6\,(g) + 2\,S_2\,(g) \rightleftharpoons P_4S_{10}\,(g)$$

   If the volume of the vessel is then doubled, what will happen?

   a. the concentrations will all decrease, and the reaction will then shift left-to-right.
   b. the concentrations will all increase, and the reaction will then shift right-to-left.
   c. the concentrations will all increase, and the reaction will then shift left-to-right.
   d. the concentrations will all decrease, but the reaction will then not shift.
   e. the concentrations will all decrease, and the reaction will then shift right-to-left.

3. Consider the reaction

   $$P_4O_6\,(g) + 2\,O_2\,(g) \rightleftharpoons 2\,P_2O_5\,(g)$$

   At a particular moment in time, p_{O_2} is found to be increasing. Which of the following statements is true?

   a. $Q_p < K_p$
   b. $Q_p > K_p$
   c. $Q_p = K_p$
   d. $Q_p < 0$
   e. cannot decide without knowing K_c

4. At a particular temperature,

   $$2\,NO_2\,(g) \rightleftharpoons N_2\,(g) + 2\,O_2\,(g) \qquad K_c = 2.5 \times 10^{-8}$$
   $$2\,NO_2\,(g) \rightleftharpoons 2\,NO\,(g) + O_2\,(g) \qquad K_c = 5.0 \times 10^{-5}$$

   Use the above information to calculate the K_c for the reaction below at that temperature.

   $$N_2\,(g) + O_2\,(g) \rightleftharpoons 2\,NO\,(g) \qquad K_c = ?$$

   a. 2.0×10^3
   b. 5.0×10^{-4}
   c. impossible to determine
   d. 1.3×10^{-12}
   e. 2.5×10^{-5}

5. What is K_c for the following reaction, whose $K_p = 8.2 \times 10^2$ at 500 K?

   $$SOBr_2\,(g) \rightleftharpoons SO\,(g) + Br_2\,(g)$$

   a. 20
   b. 0.050
   c. 3.4×10^4
   d. 8.2×10^2
   e. impossible to determine.

6. At a particular temperature, the p_{Ne} in the following reaction is 2.9×10^2 atm at equilibrium, and the moles of IF_3, I_2 and NeF_2 are equal. What is K_p?

$$2\ IF_3\ (s) + 3\ Ne\ (g) \rightleftharpoons I_2\ (s) + 3\ NeF_2\ (s)$$

a. 2.4×10^7
b. 4.1×10^{-8}
c. 3.4×10^{-3}
d. 2.9×10^2
e. cannot be determined without the temperature

7. Once the reaction $2\ A + 2\ B \rightleftharpoons C + D$ has reached equilibrium, which of the following statements must be true?
a. the forward rate constant is equal to the backward rate constant.
b. $K_c < 1$
c. $[A] = 2[C]$
d. $K_c < 1$
e. the backward reaction rate is equal to the forward reaction rate.

8. The reaction $2\ PH_3\ (g) \rightleftharpoons P_2\ (g) + 3\ H_2\ (g)$ has $K_c = 8.0$ at a particular temperature. At equilibrium, $[H_2] = 0.24$ M and $[P_2] = 0.20$ M. What is $[PH_3]$ at equilibrium?
a. 1.5×10^{-2} M
b. 3.5×10^{-4} M
c. 1.9×10^{-2} M
d. 2.4×10^{-4} M
e. cannot be determined without the temperature.

9. $$2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ SO_3\ (g)$$

1.000 atm of SO_2 and 1.000 atm of O_2 were placed in a container, and the reaction allowed to reach equilibrium. At equilibrium, $p_{O2} = 0.612$ atm. What is K_p?

a. 19.6
b. 4.39
c. 9.80
d. 11.4
e. impossible to determine

10. A 3.6×10^{-3} M solution of one of the following acids has pOH = 11.56. Identify the acid.

HF, HNO_2, HI, HClO, HCN

a. HF
b. HI
c. HNO_2
d. $HClO_3$
e. HCN

11. Consider the reaction $2\ KClO_3\ (s) \rightleftharpoons KCl\ (s) + 3\ O_2\ (g)$ at 500 K.
At equilibrium, $p_{O2} = 0.20$ atm. What is K_c?

a. 8.0×10^{-3}
b. 550
c. 1.2×10^{-7}
d. 125
e. impossible to determine.

12. $$CO\ (g) + H_2O\ (g) \rightleftharpoons CO_2\ (g) + H_2\ (g)$$

2.00 M CO and 1.00 M H_2O were placed in a flask and allowed to reach equilibrium at a particular temperature where $K_c = 1.56$. What is the [CO] at equilibrium?
a. 0.27 M
b. 0.73 M
c. 1.27 M
d. 1.73 M
e. none of the other answers

13. $2\ CO_2\ (g) \rightleftharpoons 2CO\ (g) + O_2\ (g)$

2.000 atm of CO_2 are added to a vessel and heated to 100 K. At equilibrium, the p_{CO} was found to be double the p_{O2}. What is the K_c for this reaction at 500K?

a. 2.00
b. 5.3×10^{-2}
c. 2.1×10^{3}
d. 6.8×10^{-4}
e. impossible to determine

14. The reaction A ⇌ B has an equilibrium constant K = 1.0×10^{4} at a certain temperature. Which of the following is true at equilibrium?

a. $[A] = (1.0 \times 10^{-4})[B]$
b. The reaction lies far to the left-hand side.
c. The forward rate constant = the backward rate constant.
d. [A] = [B]
e. The K for 2B ⇌ 2A is 2.0×10^{4}.

15. In the following reaction at 600 K, which has $K_c = 6.2 \times 10^{3}$ and ΔH^o = -254 kJ, 1.0 mol of each substance is introduced into a 1.0 L vessel in the presence of a catalyst and allowed to reach equilibrium at 600 K.

$$P_4S_6\ (g) + 2\ S_2\ (g) \rightleftharpoons P_4S_{10}\ (g)$$

If nitrogen gas, $N_2(g)$, is now added to the vessel, what will happen?

a. $[S_2]$ will decrease and $[P_4S_{10}]$ will increase.
b. the equilibrium concentrations will stay the same.
c. $[S_2]$ will increase and $[P_4S_{10}]$ will decrease.
d. all concentrations will increase.
e. the value of K_c will increase

16. In the following reaction at 600 K, which has $K_c = 6.2 \times 10^{3}$ and ΔH^o = -254 kJ, 1.0 mol of each substance is introduced into a 1.0 L vessel in the presence of a catalyst and allowed to reach equilibrium at 600 K.

$$P_4S_6\ (g) + 2\ S_2\ (g) \rightleftharpoons P_4S_{10}\ (g)$$

If more S_2 is now added to the flask, what will happen?

a. the reaction shifts from right-to-left, and K_c stays unchanged.
b. the reaction shifts from right-to-left, and K_c decreases.
c. the reaction shifts from left-to-right, and K_c decreases.
d. the reaction shifts from left-to-right, and K_c stays unchanged.
e. the reaction shifts from left-to-right, and K_c increases.

17. Which of the following is an Arrhenius base?

a. NH_3
b. CH_3COOH
c. H_3O^+ (aq)
d. F^-
e. KOH

18. What is Q_c for the following reaction? $2\ CH_4\ (g) \rightleftharpoons C_2H_2\ (g) + 3\ H_2\ (g)$

a. $Q_c = \dfrac{[H_2]^3[C_2H_2]}{[CH_4]^2}$

b. $Q_c = \dfrac{[C_2H_2][H_2]}{[CH_4]}$

c. $Q_c = \dfrac{3[H_2][C_2H_2]}{2[CH_4]}$

d. $Q_c = \dfrac{[C_2H_2] + [H_2]^3}{[CH_4]^2}$

e. $Q_c = \dfrac{[C_2H_2][H_2]^3}{[CH_4]}$

19. Which of the following is <u>not</u> a conjugate acid/base pair?

a. H_2SO_4 / HSO_4^-
b. F^- / HF
c. Cl^- / HCN
d. HNO_2 / NO_2^-
e. HPO_3^- / H_2PO_3

20. Some HCl (g) is dissolved in pure water to give a final concentration of 4.0×10^{-12} M. What is the pH of this solution of HCl (aq) to one decimal place?

a. 11.4
b. 1.4
c. 4.0
d. 8.2
e. 7.0

21. Which of the following is <u>not</u> a Bronsted base? NH_3, F^-, OH^-, CH_3COO^-.
a. OH^-
b. F^-
c. NH_3
d. CH_3COO^-
e. they are all Bronsted bases.

22. In the following reaction at 600 K, which has $K_c = 6.2 \times 10^3$ and $\Delta H^o = -254$ kJ, 1.0 mol of each substance is introduced into a 1.0 L vessel in the presence of a catalyst and allowed to reach equilibrium at 600 K.

$$P_4S_6\ (g) + 2\ S_2\ (g) \rightleftharpoons P_4S_{10}\ (g)$$

If the temperature is now lowered, what will happen to the equilibrium concentrations?

a. $[P_4S_6]$ will decrease and $[P_4S_{10}]$ will increase.
b. the concentrations will stay the same.
c. $[S_2]$ will increase and $[P_4S_{10}]$ will decrease.
d. all concentrations will increase.
e. $[P_4S_6]$ will increase and $[P_4S_{10}]$ will decrease.

23. Which of the following is not a strong acid: HI, HNO_3, HBr, HSO_4^-
a. HI
b. HBr
c. HNO_3
d. HSO_4^-
e. they are all strong acids

24. Which of the statements is true about the equilibrium below?

$$HCOOH\ (aq) + CN^-\ (aq) \rightleftharpoons HCOO^-\ (aq) + HCN\ (aq)$$

a. $HCOO^-$ is the stronger base, and $K_c < 1$
b. CN^- is the stronger base, and $K_c > 1$
c. CN^- is the weaker base, and $K_c > 1$.
d. HCOOH is the stronger acid, and $K_c < 1$.
e. HCN is the stronger acid, and $K_c < 1$.

25. $K_c = 0.10$ for the reaction below at a particular temperature.

$$2\ SeO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ SeO_3\ (g)$$

What is K_c for the following reaction at the same temperature?

$$4\ SeO_3\ (g) \rightleftharpoons 4\ SeO_2\ (g) + 2\ O_2\ (g)$$

a. 3.2
b. 100
c. 0.01
d. 20
e. 0.02

26. K_c for the reaction $Al(s) + Cl_2(g) \rightleftharpoons AlCl_3(s)$ is given by
   a. $K_c = 1 / [Cl_2]$
   b. $K_c = [AlCl_3] / [Al][Cl_2]$
   c. $K_c = [Cl_2]$
   d. $K_c = 1 / [Al][Cl_2]$
   e. none of the other answers

27. A 2.4×10^{-2} M solution of NaOH has a volume of 0.10 L. If 0.20 L of pure water is added, what is the $[OH^-]$ in the final solution?
   a. 1.2×10^{-2} M
   b. 2.4×10^{-2} M
   c. 0.8×10^{-2} M
   d. 3.6×10^{-2} M
   e. cannot be determined without K_c

28. In the reaction below, the H_2O (l) is acting as a what?

$$NH_3(g) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

   a. Bronsted acid
   b. Bronsted base
   c. both a Bronsted acid and a Bronsted base
   d. neither a Bronsted acid nor a Bronsted base
   e. cannot be determined

29. The reaction $H_3O^+(aq) + OH^-(aq) \rightarrow 2\ H_2O(l)$ is what kind of reaction?
   a. self-ionization of water
   b. weak acid dissociation
   c. weak base dissociation
   d. neutralization
   e. auto-ionization of water

30. Consider the reaction $I_2(g) \rightleftharpoons 2I(g)$ at 500 K. The initial $[I_2] = 0.45$ M and initial $[I] = 0$. What is [I] at equilibrium? $K_c = 5.6 \times 10^{-12}$ at 500K.
   a. 2.5×10^{-5} M
   b. 6.4×10^{-6} M
   c. 1.6×10^{-6} M
   d. 5.0×10^{-4} M
   e. impossible to determine

Version Check

31. This question will not be graded. Bubble in your answer as question 31 so that we can check your exam version, if we think something is wrong,
   a. Version A
   b. Version B
   c. Version C

Useful Information

Acid K_a values

HIO_3	1.6×10^{-1}
$HClO_2$	1.12×10^{-2}
HNO_2	7.1×10^{-4}
HF	6.8×10^{-4}
HCOOH	1.8×10^{-4}
C_6H_5COOH	6.3×10^{-5}
CH_3COOH	1.8×10^{-5}
CH_3CH_2COOH	1.3×10^{-5}
HClO	2.9×10^{-8}
HBrO	2.3×10^{-9}
HCN	6.2×10^{-10}
HIO	2.3×10^{-11}

$K_p = K_c (RT)^{\Delta n}$
$R = 0.082$ L.atm/mol.K