Key

SUPeR Chemistry
CH 223 Practice Exam

Do not begin until instructed to do so.

1. In which of the following does the reaction go farthest to completion?

   A) $K_c = 10^5$

   B) $K_c = 10^{-5}$

   C) $K_c = 1000$

   D) $K_c = 100$

   E) $K_c = 1$

2. For the reaction $2H_2S(g) \leftrightarrows 2H_2(g) + S_2(g)$, $K_c = 4500$ at a particular temperature. What will happen when 0.010 mole of H_2S, 1.0 mol of H_2 and 1.5 mol of S_2 are added to a 1.0 L container at that temperature?

   A) Nothing, the system is at equilibrium.

   B) More H_2S will be formed.

   C) More H_2 will be formed than S_2.

   D) More S_2 will be formed that H_2.

$$Q_c = \frac{[H_2]^2[S_2]}{[H_2S]^2} = \frac{(1.0)^2(1.5)}{(0.010)^2} = 1.5 \times 10^4$$

$Q_c > K_c$, rxn. shifts toward reactants

3. For the reaction system $N_2(g) + 3H_2(g) \leftrightarrows 2NH_3(g)$, $\Delta H = -92$ kJ. To shift the equilibrium and increase the yield of ammonia, we should

   1. increase the temperature
   2. decrease the temperature
   3. increase the pressure by decreasing the volume.
   4. decrease the pressure by increasing the volume.

   A) 1 only

   B) 2 only

   C) 1 and 3 only

   D) 2 and 3 only

   E) 1 and 4 only

4. A 1.00 L vessel initially contains 0.777 mol of SO_3 at 1100K. What is the value of K_c at this temperature if 0.520 mol of SO_3 remains at equilibrium?

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

(A) 0.0315 B) 0.0637 C) 0.129 D) 31.7 E) 7.75

$$K = \frac{[SO_2]^2[O_2]}{[SO_3]^2} = \frac{(0.257)^2(0.129)}{(0.520)^2} = 0.0315$$

$[SO_2] = 0.777 - 0.520 = 0.129$

$[O_2] = \frac{1}{2}(0.257) = 0.129$

5. Consider the following equilibrium reaction:

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

with $K = 1.6 \times 10^{-5}$. 1.00 mole of pure NOCl and 1.00 mol of pure Cl_2 are placed in a 1.00 L container. What is the equilibrium concentration of NO(g)?

A) 1.0 M B) 1.6×10^{-5}M C) 0.50 M D) 6.2×10^{-4}M (E) 4×10^{-3}M

	NOCl	NO	Cl_2
i	1.0	0	1.0
Δ	$-2x$	$+2x$	$+x$
f	$1.0-2x$	$2x$	$1.0+x$

$$1.6 \times 10^{-5} = \frac{(2x^2)(1.0+x)}{(1.0-2x)^2}$$

assume $x \ll 1$

$1.6 \times 10^{-5} = 4x^2$

$x = 2 \times 10^{-3}$

$[NO] = 2x = 4 \times 10^{-3}$

6. A mixture of 0.60 mol $Cl_{2(g)}$ and 0.40 mol $F_{2(g)}$ was allowed to come to equilibrium in a 1000–mL flask. If $2x$ represents the molar concentration of $ClF_{(g)}$ at equilibrium, which expression represents the equilibrium constant?

$$Cl_{2(g)} + F_{2(g)} \rightleftharpoons 2ClF_{(g)}$$

(A) $\frac{x^2}{(0.60-x)\cdot(0.40-x)}$

(B) $\frac{(2x)^2}{(0.60-x)\cdot(0.40-x)}$

(C) $\frac{2x}{(0.60-x)\cdot(0.40-x)}$

(D) $\frac{2x^2}{(0.60-x)\cdot(0.40-x)}$

7. Use the reactions

(1) $H_2(g) + O_2(g) \leftrightarrows H_2O_2(g)$ $K_p = 2.3 \times 10^6$ at 600 K

(2) $2H_2(g) + O_2(g) \leftrightarrows 2H_2O(g)$ $K_p = 1.8 \times 10^{37}$ at 600 K

to find K_p for

(3) $H_2O(g) + 1/2\ O_2(g) \leftrightarrows H_2O_2(g)$ at 600 K

reverse, divide by two

A) 4.4×10^{43}

B) 9.8×10^{24}

C) 1.2×10^{-4}

(D) 5.4×10^{-13}

E) 2.6×10^{-31}

$$K_3 = K_1 \cdot \left(\frac{1}{K_2}\right)^{1/2}$$

$$= (2.3 \times 10^6)\left(\frac{1}{1.8 \times 10^{37}}\right)^{1/2}$$

$$= 5.42 \times 10^{-13}$$

8. If $K = 0.145$ for $A_2 + 2B \leftrightarrows 2AB$, then for $AB \leftrightarrows B + 1/2\ A_2$, K would equal

A) 0.145

B) -0.145

C) 0.381

(D) 2.63

E) 6.90

$$K = \left(\frac{1}{0.145}\right)^{1/2} = 2.63$$

9. Exactly 1.0 mol of N_2O_4 is placed in an empty 1.0 L container and is allowed to reach equilibrium described by the equation

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

If at equilibrium the N_2O_4 is 20% dissociated, what is the value of the equilibrium constant for the reaction under these conditions?

A) 0.05

(B) 0.2

C) 0.5

D) 20

E) 400

$$K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(0.4)^2}{0.8} = 0.2$$

	N_2O_4	NO_2
i	1.0	0
Δ	-0.2	+2(0.2)
f	0.8	0.4

10. The best description of an aqueous solution of a strong acid is:

A) 5% ionization, pH > 7

B) 5% ionization, pH < 7

C) 100% ionization, pH > 7

D) 100% ionization, pH < 7

11. The pH of 3.6×10^{-5} M HNO_3 is

A) 5.2

B) 4.4

C) 4.7

$HNO_3 \rightarrow H^+ + NO_3^-$

$pH = -\log [H^+]$

$= -\log (3.6 \times 10^{-5})$

$= 4.4$

12. Which solution is the most basic?

A) pOH = 5.2

B) $[OH^-] = 2.5 \times 10^{-6}$ M

C) pH = 8.6

$pH = 8.8$

$pOH = 5.6, \quad pH = 8.4$

13. A 0.10 M solution of an acid HA has $[H_3O^+] = 10^{-5}$. What is K_a for the acid?

A) 10^{-10}

B) 10^{-5}

C) 10^{-9}

$K_a = \frac{x^2}{0.1 - x} = \frac{(10^{-5})^2}{0.1} = 10^{-9}$

assume $x \ll 1$

14. Which statement is FALSE?

A) a Lewis base donates electrons

B) $HOClO_3$ is a stronger oxyacid than $HOClO_2$

C) OH^- is the conjugate base of H_3O^+

15. If methyl amine CH_3NH_2 has $K_b = 4.4 \times 10^{-4}$ then K_a for $CH_3NH_3^+$ is:

(A) 2.3×10^{-11}

B) 3.8×10^{-9}

C) 4.4×10^{-10}

$$K_a \cdot K_b = K_w$$

$$K_a = \frac{1.0 \times 10^{-14}}{4.4 \times 10^{-4}} = 2.3 \times 10^{-11}$$

16. Which statement is FALSE?

A) 0.5 M H_2SO_3 ($K_{a1} = 10^{-2}$; $K_{a2} = 10^{-7}$) has $[H_2SO_3] > [HSO_3^-] > [SO_3^{2-}]$

(B) Ag^+ in the reaction $Ag^+ + 2\ NH_3 \rightarrow Ag(NH_3)_2^+$ is a Bronsted-Lowry acid

C) pure water at 25°C has $[H_3O^+] = 1.0 \times 10^{-7}$ M

Ionization constants for Questions 17-20

HNO_2 : $K_a = 7.1 \times 10^{-4}$, NH_3 : $K_b = 1.8 \times 10^{-5}$

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17. The pH of 0.440 M HNO_2 is

A) 3.51

(B) 1.75

C) 4.38

D) 2.49

$$HNO_2 \rightleftharpoons H^+ + NO_2^-$$

$$K_a = \frac{[H^+][NO_2^-]}{[HNO_2]}$$

$$7.1 \times 10^{-4} = \frac{x^2}{0.440 - x}$$

assume $x << 1$

$$x^2 = 3.12 \times 10^{-4}$$

$$x = [H^+] = 0.0176$$

$$pH = -\log 0.0176 = 1.75$$

18. The degree of ionization in 0.010 M NH_3 is

A) 1.8%

B) 0.9%

C) 3.7%

(D) 4.2%

$$NH_3 \rightleftharpoons NH_4^+ + OH^- \qquad K_b = 1.8 \times 10^{-5}$$

$$1.8 \times 10^{-5} = \frac{x^2}{0.010 - x}$$

assume $x << 1$

$$x^2 = 1.8 \times 10^{-7}$$

$$x = 4.24 \times 10^{-4}$$

$$\% \text{ diss.} = \frac{4.24 \times 10^{-4}}{0.010} \times 100 = 4.24$$

dissociates in water
Na^+ = spectator ✓

$NO_2^- + H_2O \rightleftharpoons HNO_2 + OH^-$

19. The pH of 0.25 M $NaNO_2$ is

A) 8.1
B) 8.2
(C) 8.3
D) 8.4

	NO_2^-	HNO_2	OH^-
i	0.25	0	0
Δ	$-x$	$+x$	$+x$
f	$0.25-x$	x	x

$1.41 \times 10^{-11} = \frac{x^2}{0.25-x}$ assume $x \ll 1$

$x = 1.88 \times 10^{-6} = [OH^-]$

$pOH = 5.73$ $pH = 8.27$

20. At pH = 6.15 the quotient $[NO_2^-] / [HNO_2]$ in a solution containing HNO_2 is:

A) 10^4
(B) 10^3
C) 10^2
D) 10

$7.1 \times 10^{-4} = \frac{[H^+][NO_2^-]}{[HNO_2]} = K_a$

$[H^+] = \log^{-1}(-6.15) = 7.08 \times 10^{-7}$

$\frac{K_a}{[H^+]} = \frac{[NO_2^-]}{[HNO_2]} = \frac{7.1 \times 10^{-4}}{7.08 \times 10^{-7}} = 1.00 \times 10^3$

21. Calculate the pH of a 0.05 M solution of the diprotic acid, H_2A, which has $K_{a1} = 7.9 \times 10^{-5}$ and $K_{a2} = 1.6 \times 10^{-12}$.

A) 1.3
(B) 2.7
C) 3.1
D) 5.4
E) 6.5

① $H_2A \rightleftharpoons H^+ + HA^-$ $K_{a1} = 7.9 \times 10^{-5}$

② $HA^- \rightleftharpoons H^+ + A^-$ $K_{a2} = 1.6 \times 10^{-12}$

- Because $K_{a1} \gg K_{a2}$, assume all H^+ comes from step ①.

	H_2A	H^+	HA^-
i	0.050	0	0
Δ	$-x$	$+x$	$+x$
f	$0.050-x$	x	x

$K_a = \frac{[H^+][HA^-]}{[H_2A]} = \frac{x^2}{0.050-x}$

- Because K_{a1} small, assume $x \ll 1$

$7.9 \times 10^{-5} = \frac{x^2}{0.050}$

$x = 1.99 \times 10^{-3} = [H^+]$, $pH = 2.7$