

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 $2\text{H}_2\text{S}(\text{g}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{S}_2(\text{g})$, $K_c = 4500$ 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 than H_2 .

$$Q_c = \frac{[\text{H}_2]^2 [\text{S}_2]}{[\text{H}_2\text{S}]^2} = \frac{(1.0)^2 (1.5)}{(0.010)^2} = 1.5 \times 10^4$$

$Q_c > K_c$, rxn. shifts toward reactants

3. For the reaction system $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$, $\Delta H = -92 \text{ kJ}$. 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?



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

$$K = \frac{[\text{SO}_2]^2 [\text{O}_2]}{[\text{SO}_3]^2} = \frac{(0.257)^2 (0.129)}{(0.520)^2} = 0.0315$$

$$[\text{SO}_2] = 0.777 - 0.520 = 0.129$$

$$[\text{O}_2] = \frac{1}{2} (0.257) = 0.129$$

5. Consider the following equilibrium reaction:



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 $\text{NO}(\text{g})$?

- 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

	<u>NOCl</u>	<u>NO</u>	<u>Cl₂</u>	
i	1.0	0	1.0	
Δ	- 2x	+ 2x	+ x	
f	1.0 - 2x	2x	1.0 + x	

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

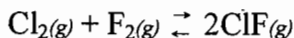
assume $x \ll 1$

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

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

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

6. A mixture of 0.60 mol $\text{Cl}_2(\text{g})$ and 0.40 mol $\text{F}_2(\text{g})$ was allowed to come to equilibrium in a 1000-mL flask. If $2x$ represents the molar concentration of $\text{ClF}(\text{g})$ at equilibrium, which expression represents the equilibrium constant?



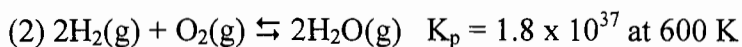
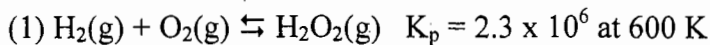
(A) $\frac{x^2}{(0.60 - x) \cdot (0.40 - x)}$

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

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

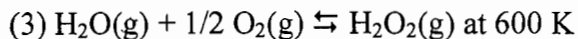
(D) $\frac{2x^2}{(0.60 - x) \cdot (0.40 - x)}$

7. Use the reactions



reverse, divide by two

to find K_p for



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 $\text{A}_2 + 2\text{B} \rightleftharpoons 2\text{AB}$, then for $\text{AB} \rightleftharpoons \text{B} + 1/2 \text{A}_2$, K would equal

A) 0.145

B) -0.145

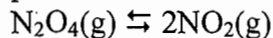
C) 0.381

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



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

$$K = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{(0.4)^2}{0.8} = 0.2$$

L	N_2O_4	NO_2	
	1.0	0	
Δ	-0.2	+2(0.2)	↗
P	0.8	0.4	

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

- A) 5% ionization, $\text{pH} > 7$
- B) 5% ionization, $\text{pH} < 7$
- C) 100% ionization, $\text{pH} > 7$
- D) 100% ionization, $\text{pH} < 7$

11. The pH of $3.6 \times 10^{-5} \text{ M HNO}_3$ is

- A) 5.2
- B) 4.4
- C) 4.7

$$\begin{aligned} \text{HNO}_3 &\rightarrow \text{H}^+ + \text{NO}_3^- \\ \text{pH} &= -\log[\text{H}^+] \\ &= -\log(3.6 \times 10^{-5}) \\ &= 4.4 \end{aligned}$$

12. Which solution is the most basic?

A) $\text{pOH} = 5.2$

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

C) $\text{pH} = 8.6$

$\text{pH} = 8.8$

$\text{pOH} = 5.6, \text{pH} = 8.4$

13. A 0.10 M solution of an acid HA has $[\text{H}_3\text{O}^+] = 10^{-5}$. 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}

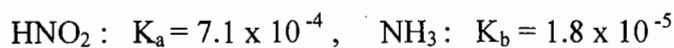
$$K_a \cdot K_b = K_w$$

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

16. Which statement is FALSE?

- A) 0.5 M H_2SO_3 ($K_{a1} = 10^{-2}$; $K_{a2} = 10^{-7}$) has $[\text{H}_2\text{SO}_3] > [\text{HSO}_3^-] > [\text{SO}_3^{2-}]$
 (B) Ag^+ in the reaction $\text{Ag}^+ + 2 \text{NH}_3 \rightarrow \text{Ag}(\text{NH}_3)_2^+$ is a Bronsted-Lowry acid
 C) pure water at 25°C has $[\text{H}_3\text{O}^+] = 1.0 \times 10^{-7} \text{ M}$

Ionization constants for Questions 17-20



17. The pH of 0.440 M HNO_2 is

- A) 3.51
 (B) 1.75
 C) 4.38
 D) 2.49

$$\text{HNO}_2 \rightleftharpoons \text{H}^+ + \text{NO}_2^-$$

$$K_a = \frac{[\text{H}^+][\text{NO}_2^-]}{[\text{HNO}_2]}$$

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

~~0.440 - x~~

assume $x \ll 1$

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

$$x = [\text{H}^+] = 0.0176$$

$$\text{pH} = -\log 0.0176 = 1.75$$

18. The degree of ionization in 0.010 M NH_3 is

- A) 1.8%
 B) 0.9%
 C) 3.7%
 (D) 4.2%

$$\text{NH}_3 \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$$

$$K_b = 1.8 \times 10^{-5}$$

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

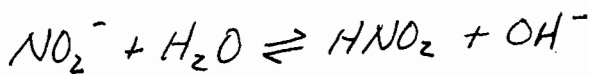
assume $x \ll 1$

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

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

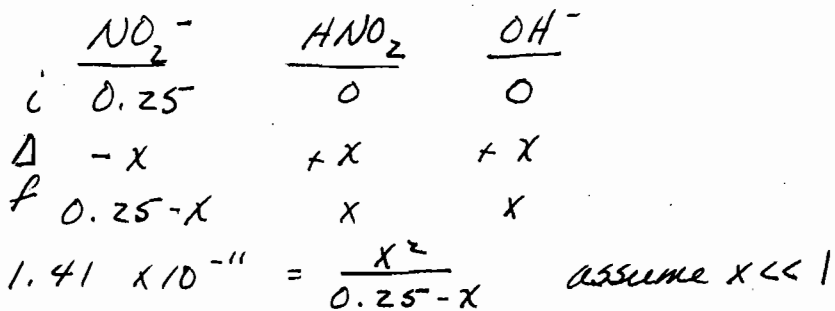
$$\% \text{ diss.} = \frac{4.24 \times 10^{-4}}{0.010} \times 100 = 4.24$$

dissociates in water
 Na^+ = spectator \downarrow



19. The pH of 0.25 M NaNO_2 is

- A) 8.1
- B) 8.2
- C) 8.3**
- D) 8.4



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

$$\text{pOH} = 5.73 \quad \text{pH} = 8.27$$

20. At pH = 6.15 the quotient $[\text{NO}_2^-] / [\text{HNO}_2]$ in a solution containing HNO_2 is:

- A) 10^4
- B) 10^3**
- C) 10^2
- D) 10

$$7.1 \times 10^{-4} = \frac{[\text{H}^+][\text{NO}_2^-]}{[\text{HNO}_2]} = K_a$$

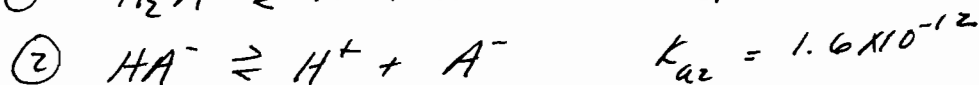
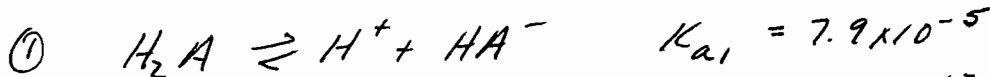
$$[\text{H}^+] = \log^{-1}(-6.15) = 7.08 \times 10^{-7}$$

$$\frac{K_a}{[\text{H}^+]} = \frac{[\text{NO}_2^-]}{[\text{HNO}_2]} = \frac{7.1 \times 10^{-4}}{7.08 \times 10^{-7}} = 1.00 \times 10^3$$

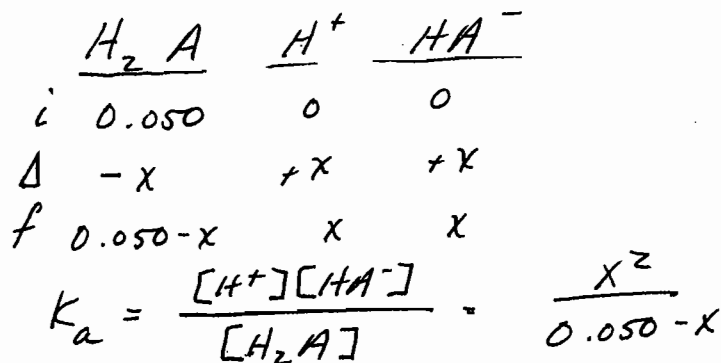
21. Calculate the pH of a 0.05 M solution of the diprotic acid, H_2A , which has

$$K_{a1} = 7.9 \times 10^{-5} \text{ and } K_{a2} = 1.6 \times 10^{-12}$$

- A) 1.3
- B) 2.7**
- C) 3.1
- D) 5.4
- E) 6.5



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



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

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

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