Chemistry 12

Acid-Base Equilibrium Part I Practice Test

Name: Key

Date:

I. Multiple Choice.

D 1. Water will act as an acid with which of the following?

~~I.~~ H_2CO_3 + H_2O

amphiprotic ← II. HCO_3^- + H_2O ✓

III. CO_3^{2-} + H_2O ✓

- A. I only.
- B. III only.
- C. I and II only.
- [✓ D.] II and III only.

C 2. Which of the following describes the relationship between acid strength and K_a value for weak acids?

	Acid Strength	K_a
A.	decreases	increases
B.	decreases	remains constant
[✓ C.]	increases	increases
D.	increases	decreases

B 3. Which of the following are amphiprotic?

I. H_2O ✓

II. ~~NH_4^+~~

III. HCO_3^- ✓

- A. I and II only.
- [✓ B.] I and III only.
- C. II and III only.
- D. I, II and III.

A 4. What is the pOH of a 0.10M $Sr(OH)_2$ solution?

- [✓ A.] 0.70
- B. 1.00
- C. 13.00
- D. 13.30

5. Show your calculation for the question above:

$$\underset{0.10M}{Sr(OH)_2} \rightarrow \underset{0.10M}{Sr^{2+}} + \underset{0.20M}{2OH^-}$$

$$pOH = -\log(0.20M)$$

$$= 0.70$$

C 6. Which of the following 0.10M solutions will have the highest electrical conductivity?

strongest acid / highest K_a

- A. H_3PO_4
- B. H_2S
- [✓ C.] HIO_3
- D. CH_3COO^-

D 7. After the following pairs of substances react and reach equilibrium, which will favour reactants?

A.	HSO_4^-	+	$HCOO^-$
B.	HPO_4^{2-}	+	HSO_3^-
C.	HIO_3	+	CN^-
[✓ D.]	SO_4^{2-}	+	HNO_2

8. Briefly explain your answer to the question above:

$$SO_4^{2-} + \underset{\underline{\underline{A}}}{HNO_2} \rightleftharpoons \underset{\underline{\underline{A}}}{HSO_4^-} + NO_2^-$$

↑ stronger

←

D ________ 9. Consider the following:

stronger

$SO_4^{2-} + \underline{HNO_2} \leftrightharpoons \underline{HSO_4^-} + NO_2^-$

←

Equilibrium would favour:

A. the products since HSO_4- is a weaker acid than HNO_2 .
B. the reactants since HSO_4- is a weaker acid than HNO_2 .
C. the products since HSO_4- is a stronger acid than HNO_2 .
[✓ D.] the reactants since HSO_4- is a stronger acid than HNO_2

B _____ 10. The concentration, K_a and pH values of four acids are given in the following table:

Acid	~~Concentration~~	K_a	~~pH~~
HA	~~3.0 M~~	2.0×10^{-5}	~~2.1~~
HB	~~0.7 M~~	4.0×10^{-5}	~~2.3~~
HC	~~4.0 M~~	1.0×10^{-5}	~~2.2~~
HD	1.5 M	1.3×10^{-5}	2.4

Based on this data, the **strongest** acid is:

A. HA
[✓ B.] HB
C. HC
D. HD

↓ highest Ka

A ________ 11. Which of the following K_a values represents the acid with the strongest conjugate base?

[✓ A.] 4.2×10^{-12}
B. 9.5×10^{-9}
C. 2.0×10^{-5}
D. 7.8×10^{-3}

12. Briefly explain your answer to the question above:

strongest conjugate base
= highest K_b
= lowest K_a

A ________ 13. The K_b for the dihydrogen phosphate ion $H_2PO_4^-$ is:

[✓ A.] 1.3×10^{-12}
B. 6.3×10^{-8}
C. 1.6×10^{-7}
D. 7.1×10^{-3}

$$K_b = \frac{K_w}{K_a(H_3PO_4)} = \frac{1.0 \times 10^{-14}}{7.5 \times 10^{-3}}$$

D ________ 14. Calculate the pH of 0.01 M NaOH.

A. 1.0×10^{-12}
B. 1.0×10^{-2}
C. 2.0
[✓ D.] 12.0

$pOH = -\log(0.01)$
$= 2.0$

$pH = 12.0$

A ________15. Consider the following data:

Chemical species	Ka Value
H_3AsO_4	5.0×10^{-5}
$H_2AsO_4^-$	8.0×10^{-8}
$HAsO_4^{2-}$	6.0×10^{-10}

The K_b value for $H_2AsO_4^-$ is:

[✓ A.] 2.0×10^{-10}
B. 8.0×10^{-8}
C. 1.2×10^{-7}
D. 1.7×10^{-5}

16. Explain your answer to the question above:

$$K_b = \frac{K_w}{K_a(H_3AsO_4)} = \frac{1.0 \times 10^{-14}}{5.0 \times 10^{-5}}$$

17. Consider a Bronsted-Lowry acid-base equation where HNO_2 is a reactant and $H_2PO_4^-$ is a product.

a) Complete the following equation:

$$\underset{SA}{HNO_2} + \underset{SB}{\underline{HPO_4^{2-}}} \leftrightharpoons \underset{WA}{H_2PO_4^-} + \underset{WB}{\underline{NO_2^-}}$$

b) Identify the weaker base in equilibrium in the above equation.

NO_2^-

II. Problems:

1. Define the term amphiprotic. List 2 amphiprotic substances and write a chemical equation describing how it behaves in water.

Amphiprotic = a chemical species that can act as an acid or a base

(Multiple possible answers)

ex: Acid $HPO_4^{2-} + H_2O \rightleftharpoons PO_4^{3-} + H_3O$

Base $HPO_4^{2-} + H_2O \rightleftharpoons H_2PO_4^{-} + OH^{-}$

2. Calculate the $[H_3O^+]$ and [OH-] in a saturated solution of magnesium hydroxide.

$$Mg(OH)_2 \rightarrow \underset{s}{Mg^{2+}} + \underset{2s}{2OH^-}$$

$$K_{sp} = 5.6 \times 10^{-12} = 4s^3$$

$$s = \sqrt[3]{\frac{5.6 \times 10^{-12}}{4}}$$

$$= 1.12 \times 10^{-4}$$

$$[OH^-] = 2s = 2(1.12 \times 10^{-4})$$

$$= \boxed{2.24 \times 10^{-4} M}$$

$$[H_3O^+] = \frac{K_w}{[OH^-]} = \frac{1.0 \times 10^{-14}}{2.24 \times 10^{-4}} = \boxed{4.5 \times 10^{-11} M}$$

↱ amphiprotic!

3. Determine the pH of a 0.75M solution of HSO_3^-.

$\boxed{K_a = 1.0\times10^{-7}} \rightarrow K_b = \frac{K_w}{K_a(H_2SO_3)} = \cancel{\frac{1.0\times10^{-14}}{1.5\times10^{-2}}} = 6.7\times10^{-13}$

	HSO_3^-	+	H_2O	$\rightleftharpoons$	SO_3^{2-}	+	H_3O^+
I	0.75M				0M		0M
C	$-x$				$+x$		$+x$
E	$0.75-x$				x		x

$K_a = 1.0\times10^{-7} = \frac{x^2}{0.75-x}$

assume $0.75-x \cong 0.75$

$x = \sqrt{(0.75)(1.0\times10^{-7})}$

$= 2.7\times10^{-4}\,M = [H_3O^+]$

$[H_3O^+]_i$ ↰

$pH = -\log(2.7\times10^{-4})$

$= \boxed{3.56}$

4. What mass of HCl must be dissolved in 1.50 L of a NaOH solution having a pH of 11.176 to produce a solution with a pH of 10.750? (Assume no volume change)

↳ $[OH^-]_f$

$pOH = 14 - 10.750$

$[OH^-]_f = 10^{-3.25}$

$= 5.62\times10^{-4}\,M$

↳ $[OH^-]_i$

$pOH = 14 - 11.176$

$[OH^-]_i = 10^{-2.824}$

$= 1.50\times10^{-3}\,M$

$$[OH^-]_f = [OH^-]_i - [H_3O^+]_i$$

$$[H_3O^+]_i = [OH^-]_i - [OH^-]_f$$

$$1.50\times10^{-3} - 5.62\times10^{-4}$$

$$= 9.38\times10^{-4}\,M = [HCl]$$

$$1.50L \times \frac{9.38\times10^{-4}\,mol}{1L} \times \frac{36.5g}{1mol} = \boxed{0.0514g}$$