

**TEST BANK**



ESSENTIAL  
ORGANIC  
CHEMISTRY

*Second Edition*

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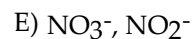
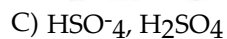


PAULA YURKANIS BRUCE

*Essential Organic Chemistry, 2e (Bruice)*

**Chapter 2 Acids and Bases**

1) Which of the following is not a conjugate acid-base pair?



Answer: E

Section: 2.1

2) Which is defined as a species that accepts a proton?

A) Arrhenius acid

B) Lewis acid

C) Lewis base

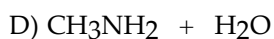
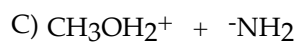
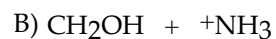
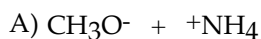
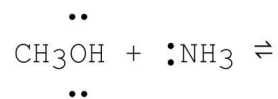
D) Bronsted-Lowry acid

E) Bronsted-Lowry base

Answer: E

Section: 2.1

3) What is the product formed from the following acid-base reaction?



Answer: A

Section: 2.1

4)

The conjugate acid of  $\text{H}_2\text{O}$  is \_\_\_\_\_.

- A)  $\text{H}_2\text{O}:$
- B)  $\text{H}_3\text{O}$
- C)  $\text{H}_3\text{O}^{\oplus}$
- D)  $-\text{:OH}$
- E)  $\text{H}_2\text{O}^{\oplus}$

Answer: C  
Section: 2.1

5) Which of the following ions is the strongest acid?

- A)  $\text{:H}^{\ominus}$
- B)  $\text{HO}^{\ominus}$
- C)  $\text{HSO}_4^{\ominus}$
- D)  $\text{H}_2\text{O}$
- E)  $\text{H}_3\text{O}^{\oplus}$

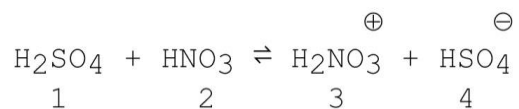
Answer: E  
Section: 2.1

6) The conjugate base of  $\text{NH}_3$  is \_\_\_\_\_.

- A)  $+\text{NH}_2$
- B)  $-\text{NH}_2$
- C)  $+\text{NH}_4$
- D)  $-\text{NH}_4$
- E)  $-\text{NH}_3$

Answer: B  
Section: 2.1

7) Which species act as bases in the following reaction?



- A) 1 and 2
- B) 3 and 4
- C) 2 and 4
- D) 1 and 3
- E) 2 and 3

Answer: C

Section: 2.1

8) What is the conjugate acid of  $\text{NH}_3$ ?

- A)  $+\text{NH}_3$
- B)  $-\text{NH}$
- C)  $+\text{NH}_4$
- D)  $-\text{NH}_2$
- E)  $+\text{NH}_2$

Answer: C

Section: 2.1

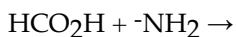
9) Give the conjugate acid and the conjugate base for  $\text{HSO}_4^-$ .

Answer: conjugate acid:  $\text{H}_2\text{SO}_4$

conjugate base:  $\text{SO}_4^{2-}$

Section: 2.1

10) Write a completed equation for the acid-base pair shown below.



Answer:  $\text{HCO}_2\text{H} + \text{-NH}_2 \rightarrow \text{HCO}_2^- + \text{NH}_3$

Section: 2.1

11) What is the conjugate acid of  $\text{CH}_3\text{NH}_2$ ?

- A)  $\text{CH}_3\text{NH}_3^+$
- B)  $\text{CH}_3\text{NH}^-$
- C)  $\text{NH}_4^+$
- D)  $\text{NH}_2^-$

Answer: A

Section: 2.1

12) What is the conjugate base of  $\text{CH}_3\text{NH}_2$ ?

- A)  $\text{CH}_3\text{NH}_3^+$
- B)  $\text{CH}_3\text{NH}^-$
- C)  $\text{NH}_4^+$
- D)  $\text{NH}_2^-$

Answer: B

Section: 2.1

13) What is the pH of a 0.1 M solution of HCl? (Note:  $\text{p}K_a$  for HCl is -6.)

- A) 6
- B) -6
- C) 1
- D) -8
- E) -1

Answer: C

Section: 2.2

14) If the pH of a solution of HCl is 4.1, then what is the  $\text{H}_3\text{O}^+$  concentration?

- A) -0.6128
- B)  $6.1 \times 10^{-1}$
- C)  $7.9 \times 10^{-5}$
- D)  $1.3 \times 10^{-10}$
- E)  $8.0 \times 10^9$

Answer: C

Section: 2.2

15) Which statement is correct about acid-base chemistry?

- A) the larger the  $K_a$ , the stronger the acid
- B) a small  $\text{p}K_a$  correspond to a large  $K_a$
- C) the smaller the  $\text{p}K_a$ , the stronger the acid
- D) A only
- E) all of the above

Answer: E

Section: 2.2

16) If  $\text{H}_2\text{O}$  has a  $\text{p}K_a$  value of 15.7 and HF has a  $\text{p}K_a$  value of 3.2, which is a stronger base,  $\text{HO}^-$  or  $\text{F}^-$ ? Explain.

Answer:  $\text{HO}^-$  is a stronger base than  $\text{F}^-$  because HF is a stronger acid than  $\text{H}_2\text{O}$ , and the stronger the acid, the weaker its conjugate base.

Section: 2.2

17) How is the position of equilibrium determined in an acid-base reaction?

Answer: Compare the  $\text{p}K_a$  value of the acid on the left side of the reaction arrow to the  $\text{p}K_a$  value of the acid on the right side of the reaction arrow. The equilibrium favors reaction of the strong acid and formation of the weak acid. "Strong reacts to give weak".

Section: 2.2

- 18) The  $pK_a$  of  $\text{CH}_3\text{COOH}$  is 4.8 and the  $pK_a$  of  $\text{HCOOH}$  is 3.8. Given this information, one knows that \_\_\_\_\_.
- A)  $\text{CH}_3\text{COOH}$  completely ionizes in water
  - B)  $\text{HCOOH}$  is a weaker acid than  $\text{CH}_3\text{COOH}$
  - C)  $\text{HCOO}^-$  is a weaker base than  $\text{CH}_3\text{COO}^-$
  - D)  $\text{CH}_3\text{COOH}$  reacts with  $\text{HO}^-$  while  $\text{HCOOH}$  does not
  - E)  $\text{HCOOH}$  reacts with  $\text{HO}^-$  while  $\text{CH}_3\text{COOH}$  does not

Answer: C

Section: 2.2

- 19) What is the typical pH of rain?
- A) 1.0
  - B) 4.0
  - C) 5.5
  - D) 7.0
  - E) 7.5

Answer: C

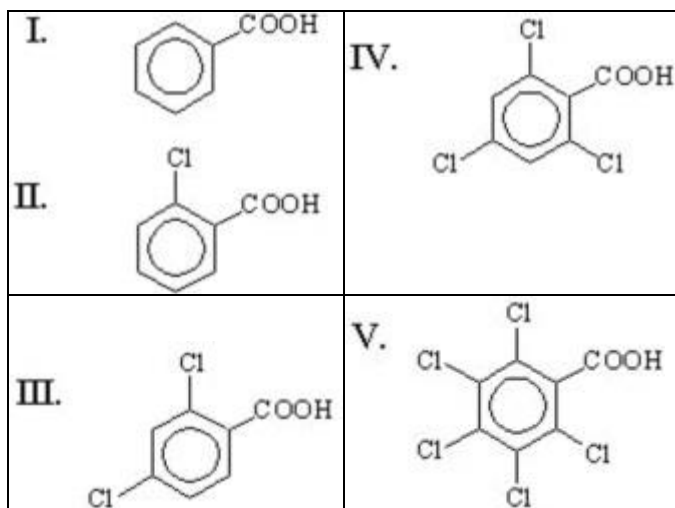
Section: 2.2

- 20) Which of the following is the strongest acid?
- A)  $\text{CH}_3\text{OH}$
  - B)  $\text{CH}_3\text{OH}_2^+$
  - C)  $\text{H}_2\text{N}^-$
  - D)  $\text{CH}_3\text{NH}_2$
  - E)  $\text{CH}_3\text{NH}_3^+$

Answer: B

Section: 2.3

21) Which of the following is the strongest acid?



- A) I
- B) II
- C) III
- D) IV
- E) V

Answer: E

Section: 2.3 and 2.6

22) Which of the following statements is correct?

- A) The stronger the acid, the weaker its conjugate base.
- B) The stronger the acid, the stronger its conjugate base.
- C) The stronger the base, the stronger its conjugate base.
- D) The stronger the acid, the weaker its conjugate acid.
- E) The stronger the acid, the stronger its conjugate acid.

Answer: A

Section: 2.3

23) Which of the following is the strongest acid?

- A) HI
- B) H<sub>2</sub>O
- C) :NH<sub>3</sub>
- D) CH<sub>4</sub>
- E) CH<sub>3</sub>OH

Answer: A

Section: 2.3

24) Which of the following is the strongest acid?

- A)  $\text{CH}_3\text{CH}_2\text{OH}$
- B)  $\text{CH}_3\text{OCH}_3$
- C)  $\text{CH}_3\text{NHCH}_3$
- D)  $\text{CH}_3\text{CCH}_3$
- E)  $\text{CH}_3\text{CHCH}_2$

Answer: A

Section: 2.3

25) Which statement is incorrect?

- A) A protonated compound has gained a proton.
- B) A protonated compound has gained an electron.
- C) A protonated acids are very strong acids.
- D) An amine can behave as an acid or a base.
- E) Alcohols are much weaker acids than carboxylic acids.

Answer: B

Section: 2.3

26) The  $\text{p}K_a$  of  $\text{CH}_3\text{COOH}$  is 4.8. If the pH of an aqueous solution of  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COO}^-$  is 4.8, then one knows \_\_\_\_\_.

- A)  $\text{CH}_3\text{COOH}$  is completely ionized
- B)  $[\text{CH}_3\text{COOH}] > [\text{CH}_3\text{COO}^-]$
- C)  $[\text{CH}_3\text{COOH}] = [\text{CH}_3\text{COO}^-]$
- D)  $[\text{CH}_3\text{COOH}] < [\text{CH}_3\text{COO}^-]$
- E)  $\text{CH}_3\text{COOH}$  is completely unionized

Answer: C

Section: 2.4

27) Explain why  $\text{CH}_3\text{CH}_2\text{OH}$  ( $\text{p}K_a = 15.9$ ) predominates in a solution of pH 4.5.

Answer: The pH of the solution is more acidic than the  $\text{p}K_a$  of the OH group (15.9). A compound will mainly exist in its acidic form (with its proton) in solutions that are more acidic than the  $\text{p}K_a$  value of the group that undergoes dissociation (pH is less than  $\text{p}K_a$ ).

Section: 2.4

28) When a small amount of hexanoic acid [ $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$ ,  $\text{p}K_a \sim 4.8$ ], is added to a separatory funnel which contains the organic solvent diethyl ether and water with a pH of 2.0, it is found mainly in the \_\_\_\_\_ phase as \_\_\_\_\_.

- A) ether;  $\text{CH}_3(\text{CH}_2)_4\text{CO}_2^-$
- B) water;  $\text{CH}_3(\text{CH}_2)_4\text{CO}_2^-$
- C) ether;  $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$
- D) water;  $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$
- E) none of the above

Answer: C

Section: 2.4



- 29) When a small amount of hexanoic acid [ $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$ ,  $\text{p}K_a \sim 4.8$ ], is added to a separatory funnel which contains the organic solvent diethyl ether and water with a pH of 12.0, it is found mainly in the \_\_\_\_\_ phase as \_\_\_\_\_.
- A) ether;  $\text{CH}_3(\text{CH}_2)_4\text{CO}_2^-$
  - B) water;  $\text{CH}_3(\text{CH}_2)_4\text{CO}_2^-$
  - C) ether;  $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$
  - D) water;  $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$
  - E) none of the above

Answer: B

Section: 2.4

- 30) To determine the position of equilibrium for an acid-base reaction, the equilibrium favors \_\_\_\_\_.
- A) reaction of the weaker acid and formation of the stronger acid
  - B) shift of the reaction toward the compound with the lowest  $K_a$
  - C) shift of the reaction toward the side of the reaction with the largest  $\text{p}K_a$
  - D) reaction of the stronger acid and formation of the weaker acid
  - E) None of the statements are true.

Answer: D

Section: 2.5

- 31) Explain why  $:\text{NF}_3$  is a weaker base than  $:\text{NH}_3$ .

Answer: Fluorine has an electron withdrawing effect that reduces the availability of the pair of electrons on nitrogen. Thus the basicity of  $:\text{NF}_3$  is less than that of  $:\text{NH}_3$ .

Section: 2.6

- 32) Consider the set of compounds,  $\text{NH}_3$ ,  $\text{HF}$ , and  $\text{H}_2\text{O}$ . Rank these compounds in order of increasing acidity and discuss your rationale.

Answer:  $\text{NH}_3 < \text{H}_2\text{O} < \text{HF}$

When determining relative acidity, it is often useful to look at the relative basicity of the conjugate bases. The stronger the acid, the weaker (more stable, less reactive) the conjugate base. In this case, one would look at the relative basicity of  $\text{F}^-$ ,  $\text{OH}^-$ , and  $\text{NH}_2^-$ . The relative strengths of these species can be gauged based on the electronegativity of the charged atom in each base. Since fluorine is the most electronegative,  $\text{F}^-$  is the most stable, least reactive base in the group. This means that its conjugate acid,  $\text{HF}$ , is the strongest.

Section: 2.6

- 33) Would you predict trifluoromethanesulfonic acid,  $\text{CF}_3\text{SO}_3\text{H}$ , to be a stronger or weaker acid than methanesulfonic acid,  $\text{CH}_3\text{SO}_3\text{H}$ ? Explain your reasoning.

Answer: Trifluoromethanesulfonic acid is a stronger acid. Compare the strengths of the conjugate bases and remember that the weaker the base, the stronger the conjugate acid. In the case of the trifluoro derivative, the presence of the highly electronegative fluorine atoms serves to delocalize the negative charge to a greater extent. This additional delocalization makes trifluoromethanesulfonate anion a weaker base. Also the electron withdrawing effect of the  $\text{CF}_3$  allows the proton to be more easily pulled off of the  $\text{CF}_3\text{SO}_3\text{H}$  molecule.

Section: 2.6

- 34) The stronger the acid \_\_\_\_\_.
- A) the less stable its conjugate base
  - B) the larger the pK<sub>a</sub>
  - C) the weaker its conjugate base
  - D) the larger the pH
  - E) the higher the concentration of hydroxide ions

Answer: C

Section: 2.6

- 35) The stability of a base is determined by which of the following?
- A) pH
  - B) size
  - C) electronegativity
  - D) B and C
  - E) C only

Answer: D

Section: 2.6

- 36) What form will predominate in a solution of pH = 5.5?
- A) HCN (pK<sub>a</sub> = 9.1)
  - B) CH<sub>3</sub>COOH (pK<sub>a</sub> = 4.76)
  - C) CH<sub>3</sub>CH<sub>2</sub>NH<sub>3</sub><sup>+</sup> (pK<sub>a</sub> = 11.0)
  - D) <sup>+</sup>NH<sub>4</sub> (pK<sub>a</sub> = 9.4)

Answer: B

Section: 2.7

- 37) Which of the following is the definition of a buffer solution?
- A) solution composed of a weak acid and a weak base
  - B) solution composed of a weak acid and its conjugate base
  - C) solution that can maintain a nearly constant pH even with addition of small amounts of acid or base
  - D) solution containing <sup>-</sup>OH ions at a pH greater than 7
  - E) B and C

Answer: E

Section: 2.8

- 38) Which blood buffer controls the pH of blood?
- A) HSO<sub>3</sub><sup>-</sup>/SO<sub>3</sub><sup>2-</sup>
  - B) H<sub>3</sub>O<sup>+</sup>/H<sub>2</sub>O
  - C) H<sub>2</sub>CO<sub>3</sub>/HCO<sub>3</sub><sup>-</sup>
  - D) NH<sub>4</sub><sup>+</sup>/NH<sub>3</sub>
  - E) HSO<sub>4</sub><sup>-</sup>/SO<sub>4</sub><sup>2-</sup>

Answer: C

Section: 2.8

39) Which of the following are Lewis bases?

A)  $\text{NF}_3$

B)  $\text{BF}_3$

C)  $\text{CH}_3\text{OCH}_3$

D) A and B

E) A and C

Answer: E

Section: 2.9

40) Explain why  $\text{AlCl}_3$  is a Lewis acid.

Answer: A Lewis acid is an electron pair acceptor. Aluminum in  $\text{AlCl}_3$  has an empty p orbital that can accommodate the pair of electrons provided by a Lewis base.

Section: 2.9