

Essential Organic Chemistry, 3e (Bruice)

Chapter 2 Acids and Bases: Central to Understanding Organic Chemistry

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

- A) H₂O, HO⁻
- B) H₂O, H₃O⁺
- C) HSO₄⁻, H₂SO₄
- D) -OH, O²⁻
- E) NO₃⁻, NO₂⁻

Answer: E

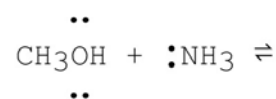
Diff: 1

Section: 2-1

Objective: G2, G3

LO: 2.1

2) What is the product of the following acid-base reaction?



- A) CH₃O⁻ + ⁺NH₄
- B) CH₂OH + ⁺NH₃
- C) CH₃OH₂⁺ + ⁻NH₂
- D) CH₃NH₂ + H₂O
- E) CH₄ + NH₂OH

Answer: A

Diff: 3

Section: 2-4

Objective: G2, G3

LO: 2.1

3) The conjugate acid of H₂O is _____.

- A) H₃O⁻
- B) H₃O
- C) H₃O⁺
- D) HO⁻
- E) H₂O⁺

Answer: C

Diff: 2

Section: 2-1

Objective: G2, G3

LO: 2.1

4) Which of the following is the strongest acid?

- A) H⁻
- B) HO⁻
- C) HSO₄⁻
- D) H₂O
- E) H₃O⁺

Answer: E

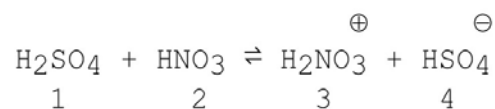
Diff: 2

Section: 2-1

Objective: G2, G3

LO: 2.1

5) Which two species act as bases in the acid-base reaction shown below?



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

Answer: C

Diff: 2

Section: 2-1

Objective: G2, G3

LO: 2.1

6) What is the conjugate acid of NH₃?

- A) +NH₃
- B) -NH
- C) +NH₄
- D) -NH₂
- E) +NH₂

Answer: C

Diff: 2

Section: 2-1

Objective: G2, G3

LO: 2.1

7) What is the conjugate acid of CH_3NH_2 ?

A) CH_3NH_3^+

B) CH_3NH^-

C) $^+\text{NH}_4$

D) $^-\text{NH}_2$

Answer: A

Diff: 2

Section: 2-1

Objective: G2, G3

LO: 2.1

8) What is the conjugate base of CH_3NH_2 ?

A) CH_3NH_3^+

B) CH_3NH^-

C) $^+\text{NH}_4$

D) $^-\text{NH}_2$

Answer: B

Diff: 2

Section: 2-1

Objective: G2, G3

LO: 2.1

9) What is the pH of a 0.1 M solution of HCl?

A) 6

B) -6

C) 1

D) -8

E) -1

Answer: C

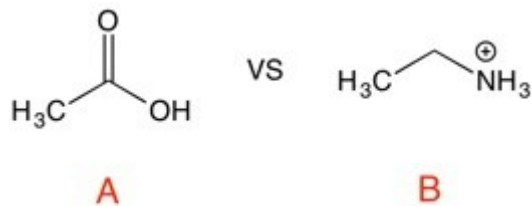
Diff: 2

Section: 2-2

Objective: G2, G3

LO: 2.2

10) Which is a stronger acid, A or B?



A) A

B) B

Answer: A

Diff: 2

Section: 2-3

Objective: G2, G3

LO: 2.3

11) Which is a stronger acid, A or B?



A) A

B) B

Answer: A

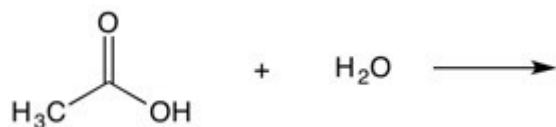
Diff: 2

Section: 2-3

Objective: G2, G3

LO: 2.3

12) Does water act as an acid or a base in the following reaction?



A) Acid

B) Base

C) Neither

D) Both

Answer: B

Diff: 2

Section: 2-4

Objective: G2, G3

LO: 2.5

13) Does methyl alcohol act as an acid or a base in the following reaction?



- A) Acid
- B) Base
- C) Neither
- D) Both

Answer: B

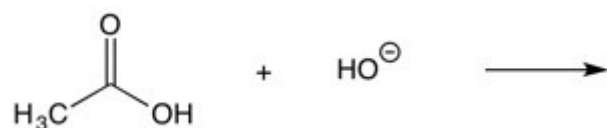
Diff: 2

Section: 2-4

Objective: G2, G3

LO: 2.5

14) Does acetic acid act as an acid or a base in the following reaction?



- A) Acid
- B) Base
- C) Neither
- D) Both

Answer: A

Diff: 2

Section: 2-4

Objective: G2, G3

LO: 2.5

15) Which are favored at equilibrium, reactants or products?



- A) Reactants
- B) Products
- C) Both
- D) Neither

Answer: A

Diff: 2

Section: 2-5

Objective: G2, G3

LO: 2.6

16) Which are favored at equilibrium, reactants or products?



A) Reactants

B) Products

C) Both

D) Neither

Answer: B

Diff: 2

Section: 2-5

Objective: G2, G3

LO: 2.6

17) Which of the following is the strongest acid?

A) CH_3OH

B) CH_3OH_2^+

C) $-\text{NH}_2$

D) CH_3NH_2

E) CH_3NH_3^+

Answer: B

Diff: 2

Section: 2-6

Objective: G2, G3

LO: 2.7

18) The $\text{p}K_a$ of CH_3COOH is 4.8 and the $\text{p}K_a$ of HCOOH is 3.8. Given this information, one knows that _____.

A) CH_3COOH completely ionizes in water

B) HCOOH is a weaker acid than CH_3COOH

C) HCOO^- is a weaker base than CH_3COO^-

D) CH_3COOH reacts with HO^- while HCOOH does not

E) HCOOH reacts with HO^- while CH_3COOH does not

Answer: C

Diff: 2

Section: 2-6

Objective: G2, G3

LO: 2.7

19) Which of the following is the strongest acid?

- A) HF
- B) H₂O
- C) NH₃
- D) CH₄
- E) CH₃OH

Answer: A

Diff: 2

Section: 2-6

Objective: G2, G3

LO: 2.7

20) Which of the following is the strongest acid?

- A) CH₃CH₂OH
- B) CH₃OCH₃
- C) CH₃NHCH₃
- D) CH₃C≡CH
- E) CH₃CH=CH₂

Answer: A

Diff: 2

Section: 2-6

Objective: G2, G3

LO: 2.7

21) Which of the following has the highest pK_a?

- A) CH₃NH₂
- B) CH₃OH
- C) CH₃COOH
- D) H₂O
- E) CH₃NH₃⁺

Answer: A

Diff: 2

Section: 2-6

Objective: G2, G3

LO: 2.7

22) Which of the following has the highest pK_a ?

- A) CH_3CH_3
- B) HCCH
- C) CH_2CH_2
- D) CH_3OH
- E) CH_3NH_2

Answer: A

Diff: 2

Section: 2-6

Objective: G2, G3

LO: 2.7

23) Which of the following carboxylic acids is the strongest acid?

- A) ICH_2COOH
- B) BrCH_2COOH
- C) CH_3COOH
- D) FCH_2COOH
- E) ClCH_2COOH

Answer: D

Diff: 2

Section: 2-7

Objective: G2, G3

LO: 2.8

24) The pK_a of CH_3COOH is 4.8. If the pH of an aqueous solution of CH_3COOH and CH_3COO^- is 4.8, then one knows _____.

- A) CH_3COOH 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) CH_3COOH is completely unionized

Answer: C

Diff: 2

Section: 2-10

Objective: G2, G3

LO: 2.11

25) When a small amount of $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$, ($\text{p}K_{\text{a}} \sim 4.8$) is added to a separatory funnel that contains ether and water with a $\text{pH} = 2.0$, it is found mainly in the _____ layer 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

Diff: 2

Section: 2-10

Objective: G2, G3

LO: 2.12

26) When a small amount of $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$ ($\text{p}K_{\text{a}} \sim 4.8$) is added to a separatory funnel that contains ether and water with a $\text{pH} = 12.0$, it is found mainly in the _____ layer 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

Diff: 2

Section: 2-10

Objective: G2, G3

LO: 2.12

27) HA is an acid with a $\text{p}K_{\text{a}} = 4.5$. Which of the following statements about an aqueous solution of HA is true?

- A) At $\text{pH} = 4.5$, the solution contains more H-A than A^-
- B) At $\text{pH} = 4.5$, the solution contains more A^- than H-A
- C) At $\text{pH} = 3.5$, the solution contains more A^- than HA
- D) At $\text{pH} = 6.5$, the solution contains much more HA than A^- .
- E) At $\text{pH} = 4.5$, the solution contains about the same amount of A^- and HA.

Answer: E

Diff: 3

Section: 2-10

Objective: G2, G3

LO: 2.11

28) A buffer is used to maintain the pH of human blood at ~ 7.4 . Which acid/base pair buffers the blood?

A) $\text{H}_2\text{O} / \text{HO}^-$

B) $\text{H}_3\text{O}^+ / \text{H}_2\text{O}$

C) $\text{H}_2\text{CO}_3 / \text{HCO}_3^-$

D) $\text{NH}_4^+ / \text{NH}_3$

E) HCl / Cl^-

Answer: C

Diff: 2

Section: 2-11

Objective: G2, G3

LO: 2.14

29) What is the conjugate acid and the conjugate base of HSO_4^- ?

Answer: conjugate acid: H_2SO_4

conjugate base: SO_4^{2-}

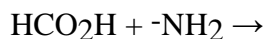
Diff: 3

Section: 2-1

Objective: G2, G3

LO: 2.1

30) Write the products of the following acid-base reaction:



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

Diff: 3

Section: 2-3

Objective: G2, G3

LO: 2.1

31) If H_2O 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, HO^- or F^- ? Explain.

Answer: HO^- is a stronger base than F^- because HF is a stronger acid than H_2O , and the stronger the acid the weaker its conjugate base.

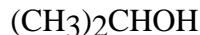
Diff: 3

Section: 2-2

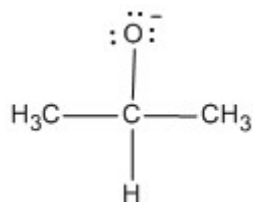
Objective: G2, G3

LO: 2.2

32) Draw the conjugate base of the following compound:



Answer:



Diff: 2

Section: 2-3

Objective: G2, G3

LO: 2.4

33) Rank NH₃, HF, and H₂O in order of increasing acidity and explain your rationale.

Answer: NH₃ < H₂O < HF

Because N, F, and O are about the same size, we know that the strongest acid has its H attached to the most electronegative atom. Of the three atoms, F is the most electronegative and N is the least electronegative. Therefore, NH₃ is the weakest acid and HF is the strongest acid.

Diff: 3

Section: 2-6

Objective: G2, G3

LO: 2.7

34) Explain why NF₃ is a weaker base than NH₃.

Answer: Fluorine has an electron withdrawing effect that reduces the availability of the pair of electrons on nitrogen. Thus the basicity of :NF₃ is less than that of :NH₃.

Diff: 3

Section: 2-7

Objective: G2, G3

LO: 2.8

35) Is CH₃CHBrCO₂⁻ or CH₃CHFCO₂⁻ the stronger base? Explain your choice.

Answer: CH₃CHBrCO₂⁻ is the stronger base. F is better at withdrawing electrons inductively than Br because F is more electronegative. This greater electron withdrawal stabilizes CH₃CHFCO₂⁻ relative to CH₃CHBrCO₂⁻, which makes the latter a stronger base.

Diff: 3

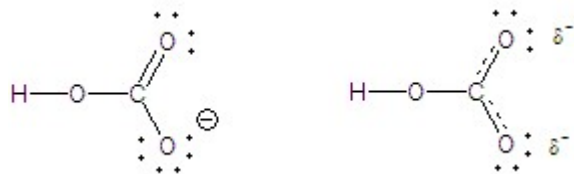
Section: 2-7

Objective: G2, G3

LO: 2.8

36) Draw a resonance contributor and the resonance hybrid for HOCO_2^- .

Answer: resonance contributor: resonance hybrid:



Diff: 3

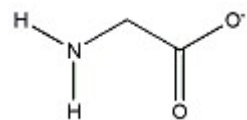
Section: 2-8

Objective: G2, G3

LO: 2.9

37) The amino acid ($\text{H}_3\text{N}^+\text{CH}_2\text{CO}_2\text{H}$) has two acidic H's, one with a $\text{p}K_a = 2.34$ and the other with a $\text{p}K_a = 9.60$. Draw the structure of the amino acid that predominates at $\text{pH} = 12$.

Answer:



Diff: 2

Section: 2-10

Objective: G2, G3

LO: 2.11

38) $\text{HC}\equiv\text{N}$ has a $\text{p}K_a = 9.1$. What form of the compound, $\text{HC}\equiv\text{N}$ or $\text{HC}\equiv\text{N}^-$, predominates in a solution with $\text{pH} = 7.0$

Answer: HCN

Diff: 1

Section: 2-10

Objective: G2, G3

LO: 2.11