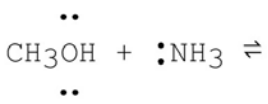
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Essential Organic Chemistry, 3e **(Bruice)**
Chapter 2 Acids and Bases: Central to Understanding Organic Chemistry

1) Which of the following is <u>not</u> a conjugate acid-base pair?
A) H_2O, HO^-
B) H_2O, H_3O^+
C) HSO_4^-, H_2SO_4
D) ^-OH, O^{2-}
E) NO_3^-, NO_2^-
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) CH_3O^- + $^+NH_4$
B) CH_2OH + $^+NH_3$
C) $CH_3OH_2^+$ + $^-NH_2$
D) CH_3NH_2 + H_2O
E) CH_4 + NH_2OH
Answer: A
Diff: 3
Section: 2-4
Objective: G2, G3
LO: 2.1

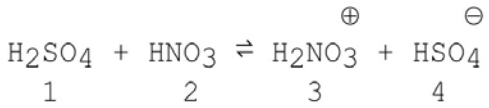
3) The conjugate acid of H_2O is _____.
A) H_3O^-
B) H_3O
C) H_3O^+
D) HO^-
E) H_2O^+
Answer: C
Diff: 2
Section: 2-1
Objective: G2, G3
LO: 2.1

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4) Which of the following is the strongest acid?
A) H^-
B) HO^-
C) HSO_4^-
D) H_2O
E) H_3O^+
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 NH_3?
A) $^+NH_3$
B) ^-NH
C) $^+NH_4$
D) $^-NH_2$
E) $^+NH_2$
Answer: C
Diff: 2
Section: 2-1
Objective: G2, G3
LO: 2.1

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7) What is the conjugate acid of CH_3NH_2?

A) $CH_3NH_3^+$

B) CH_3NH^-

C) $^+NH_4$

D) $^-NH_2$

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) $^+NH_4$

D) $^-NH_2$

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

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



A B

A) A
B) B
Answer: A
Diff: 2
Section: 2-3
Objective: G2, G3
LO: 2.3

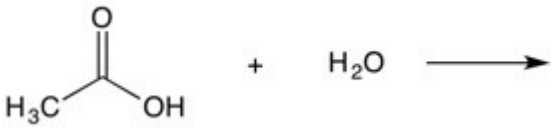
11) Which is a stronger acid, A or B?



A 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

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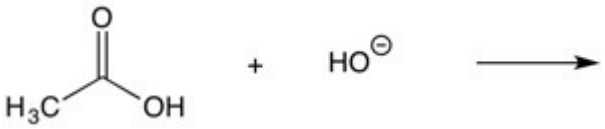
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13) Does methyl alcohol act as an acid or a base in the following reaction?



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

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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) $-NH_2$
D) CH_3NH_2
E) $CH_3NH_3^+$
Answer: B
Diff: 2
Section: 2-6
Objective: G2, G3
LO: 2.7

18) The pK_a of CH_3COOH is 4.8 and the pK_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

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19) Which of the following is the strongest acid?
A) HF
B) H_2O
C) NH_3
D) CH_4
E) CH_3OH
Answer: A
Diff: 2
Section: 2-6
Objective: G2, G3
LO: 2.7

20) Which of the following is the strongest acid?
A) CH_3CH_2OH
B) CH_3OCH_3
C) CH_3NHCH_3
D) $CH_3C{\equiv}CH$
E) $CH_3CH{=}CH_2$
Answer: A
Diff: 2
Section: 2-6
Objective: G2, G3
LO: 2.7

21) Which of the following has the highest pK_a?
A) CH_3NH_2
B) CH_3OH
C) CH_3COOH
D) H_2O
E) $CH_3NH_3^+$
Answer: A
Diff: 2
Section: 2-6
Objective: G2, G3
LO: 2.7

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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) $[CH_3COOH] > [CH_3COO^-]$
C) $[CH_3COOH] = [CH_3COO^-]$
D) $[CH_3COOH] < [CH_3COO^-]$
E) CH_3COOH is completely unionized
Answer: C
Diff: 2
Section: 2-10
Objective: G2, G3
LO: 2.11

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25) When a small amount of $CH_3(CH_2)_4CO_2H$, (pK_a ~4.8) is added to a separatory funnel that contains ether and water with a pH = 2.0, it is found mainly in the _____ layer as _____.
A) ether; $CH_3(CH_2)_4CO_2^-$
B) water; $CH_3(CH_2)_4CO_2^-$
C) ether; $CH_3(CH_2)_4CO_2H$
D) water; $CH_3(CH_2)_4CO_2H$
E) none of the above
Answer: C
Diff: 2
Section: 2-10
Objective: G2, G3
LO: 2.12

26) When a small amount of $CH_3(CH_2)_4CO_2H$ (pK_a~4.8) is added to a separatory funnel that contains ether and water with a pH = 12.0, it is found mainly in the _____ layer as _____.
A) ether; $CH_3(CH_2)_4CO_2^-$
B) water; $CH_3(CH_2)_4CO_2^-$
C) ether; $CH_3(CH_2)_4CO_2H$
D) water; $CH_3(CH_2)_4CO_2H$
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 pK_a = 4.5. Which of the following statements about an aqueous solution of HA is true?
A) At pH = 4.5, the solution contains more H-A than A^-
B) At pH = 4.5, the solution contains more A^- than H-A
C) At pH = 3.5, the solution contains more A^- than HA
D) At pH = 6.5, the solution contains much more HA than A^-.
E) At 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

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

A) H_2O / HO^-

B) H_3O^+ / H_2O

C) H_2CO_3 / HCO_3^-

D) NH_4^+ / 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:

$$HCO_2H + {}^-NH_2 \rightarrow$$

Answer: $HCO_2H + {}^-NH_2 \rightarrow HCO_2^- + NH_3$
Diff: 3
Section: 2-3
Objective: G2, G3
LO: 2.1

31) If H_2O has a pK_a value of 15.7 and HF has a pK_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

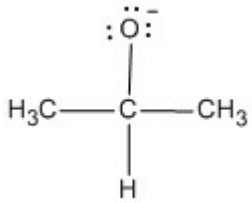
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32) Draw the conjugate base of the following compound:

$(CH_3)_2CHOH$

Answer:



Diff: 2
Section: 2-3
Objective: G2, G3
LO: 2.4

33) Rank NH_3, HF, and H_2O in order of increasing acidity and explain your rationale.
Answer: $NH_3 < H_2O <$ 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, NH_3 is the weakest acid and HF is the strongest acid.
Diff: 3
Section: 2-6
Objective: G2, G3
LO: 2.7

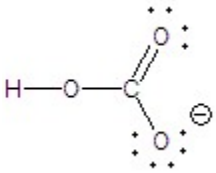
34) Explain why NF_3 is a weaker base than NH_3.
Answer: Fluorine has an electron withdrawing effect that reduces the availability of the pair of electrons on nitrogen. Thus the basicity of **:** NF_3 is less than that of **:** NH_3.
Diff: 3
Section: 2-7
Objective: G2, G3
LO: 2.8

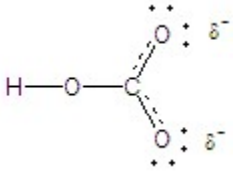
35) Is $CH_3CHBrCO_2^-$ or $CH_3CHFCO_2^-$ the stronger base? Explain your choice.
Answer: $CH_3CHBrCO_2^-$ is the stronger base. F is better at withdrawing electrons inductively than Br because F is more electronegative. This greater electron withdrawal stabilizes $CH_3CHFCO_2^-$ relative to $CH_3CHBrCO_2^-$, which makes the latter a stronger base.
Diff: 3
Section: 2-7
Objective: G2, G3
LO: 2.8

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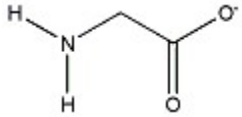
36) Draw a resonance contributor and the resonance hybrid for $HOCO_2^-$.
Answer: resonance contributor: resonance hybrid:





Diff: 3
Section: 2-8
Objective: G2, G3
LO: 2.9

37) The amino acid ($H_3N^+CH_2CO_2H$) has two acidic H's, one with a pK_a = 2.34 and the other with a pK_a = 9.60. Draw the structure of the amino acid that predominates at pH =12.
Answer:



Diff: 2
Section: 2-10
Objective: G2, G3
LO: 2.11

38) HC≡N has a pK_a = 9.1. What form of the compound, HC≡N or $HC\equiv N^-$, predominates in a solution with pH = 7.0
Answer: HCN
Diff: 1
Section: 2-10
Objective: G2, G3
LO: 2.11

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