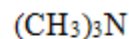
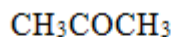
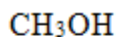


## Chapter 2: Acids and Bases

- Which of the following statements is a correct definition for a Brønsted-Lowry acid?
  - Proton acceptor
  - Electron pair donor
  - Electron pair acceptor
  - Proton donor
- Which of the following statements about a Brønsted-Lowry base is true?
  - The net charge may be zero, positive, or negative.
  - All Brønsted-Lowry bases contain a lone pair of electrons or a  $\pi$  bond.
  - All Brønsted-Lowry bases contain a proton.
  - The net charge may be zero or positive.
- Which of the following compounds is both a Brønsted-Lowry acid and base?



**I**

**II**

**III**

**IV**

- A) I, II   B) I, III   C) II, IV   D) I, IV
- Which of the following species cannot act as both a Brønsted-Lowry acid and base?
    - $\text{HCO}_3^-$
    - $\text{HSO}_4^-$
    - $\text{HO}^-$
    - $\text{H}_2\text{PO}_4^-$
  - Which of the following species is not a Brønsted-Lowry base?
    - $\text{BF}_3$
    - $\text{NH}_3$
    - $\text{H}_2\text{O}$
    - $\text{PO}_4^{3-}$
  - Which of the following statements about Brønsted-Lowry acids and bases is true?
    - Loss of a proton from a base forms its conjugate acid.
    - Loss of a proton from an acid forms its conjugate base.
    - Gain of a proton by an acid forms its conjugate base.
    - Brønsted-Lowry acid-base reactions always result in the transfer of a proton from a base to an acid.
  - Which of the following species is the conjugate base of methanol,  $\text{CH}_3\text{OH}$ ?
    - $\text{CH}_3\text{OH}_2^+$
    - $\text{CH}_3\text{O}^-$
    - $\text{CH}_3^-$
    - $\text{CH}_4$
  - Which of the following species is the conjugate base of the hydronium ion,  $\text{H}_3\text{O}^+$ ?
    - $\text{H}_3\text{O}$
    - $\text{H}_2\text{O}^-$
    - $\text{H}_2\text{O}$
    - $\text{HO}^-$
  - Which of the following species is the conjugate acid of ammonia,  $\text{NH}_3$ ?
    - $\text{H}_4\text{N}$
    - $\text{H}_3\text{N}^+$
    - $\text{H}_2\text{N}^-$
    - $\text{H}_4\text{N}^+$

10. Which is the conjugate acid in the following reaction?



A) I   B) II   C) III   D) IV

11. Which is the conjugate base in the following reaction?



A) I   B) II   C) III   D) IV

12. Which is the conjugate acid in the following reaction?



A) I   B) II   C) III   D) IV

13. Which is the conjugate base in the following reaction?



A) I   B) II   C) III   D) IV

14. Which of the following statements about acid strength is true?

- A) The stronger the acid, the further the equilibrium lies to the left.
- B) The stronger the acid, the smaller the  $K_a$ .
- C) The stronger the acid, the larger the  $pK_a$ .
- D) The stronger the acid, the smaller the  $pK_a$ .

15. Which of the following compounds is the strongest acid?

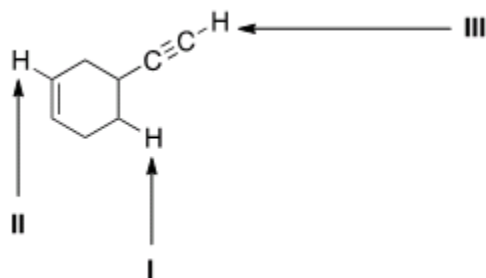


A) I   B) II   C) III   D) IV

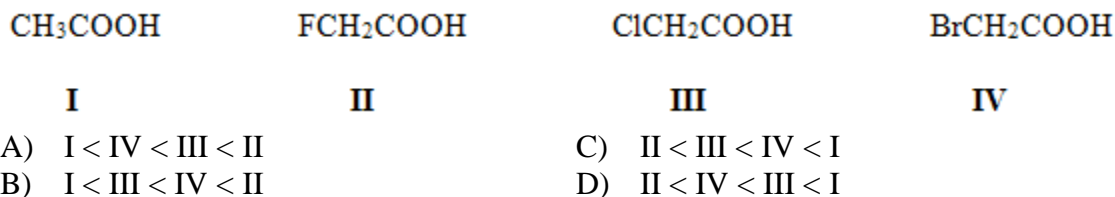
16. Which of the following compounds is the strongest acid?

- A)  $\text{CH}_3\text{OH}$    B)  $\text{BrCH}_2\text{OH}$    C)  $\text{CH}_3\text{NH}_2$    D)  $\text{CH}_3\text{Cl}$

17. Which of the following compounds is the weakest acid?  
A) HF B) HCl C) HBr D) HI
18. Which of the following compounds is the weakest acid?  
A)  $\text{H}_2\text{S}$  B)  $\text{PH}_3$  C) HCl D)  $\text{SiH}_4$
19. Which of the following species is the strongest base?  
A)  $\text{HO}^-$  B)  $\text{H}_2\text{N}^-$  C)  $\text{CH}_3\text{COO}^-$  D)  $\text{Cl}^-$
20. Which of the following ranks the compounds in order of increasing basicity, putting the least basic first?  
A)  $\text{CH}_3\text{NH}_2 < \text{CH}_3\text{OH} < \text{CH}_4$  C)  $\text{CH}_4 < \text{CH}_3\text{NH}_2 < \text{CH}_3\text{OH}$   
B)  $\text{CH}_3\text{OH} < \text{CH}_3\text{NH}_2 < \text{CH}_4$  D)  $\text{CH}_4 < \text{CH}_3\text{OH} < \text{CH}_3\text{NH}_2$
21. Consider the following molecule with protons labeled, I-III. Rank these protons in order of decreasing acidity, putting the most acidic first.



- A)  $\text{I} > \text{II} > \text{III}$  B)  $\text{I} > \text{III} > \text{II}$  C)  $\text{III} > \text{II} > \text{I}$  D)  $\text{III} > \text{I} > \text{II}$
22. Rank the following compounds in order of increasing acidity, putting the least acidic first.
- |                          |                            |                                   |                                     |
|--------------------------|----------------------------|-----------------------------------|-------------------------------------|
| $\text{CH}_3\text{COOH}$ | $\text{ClCH}_2\text{COOH}$ | $\text{CH}_3\text{CH}_2\text{OH}$ | $\text{ClCH}_2\text{CH}_2\text{OH}$ |
| <b>I</b>                 | <b>II</b>                  | <b>III</b>                        | <b>IV</b>                           |
- A)  $\text{III} < \text{I} < \text{IV} < \text{II}$  C)  $\text{II} < \text{I} < \text{IV} < \text{III}$   
B)  $\text{III} < \text{IV} < \text{I} < \text{II}$  D)  $\text{III} < \text{I} < \text{II} < \text{IV}$
23. Rank the following compounds in order of increasing acidity, putting the least acidic first.



24. Rank the following compounds in order of decreasing acidity, putting the most acidic first.

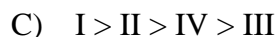


I

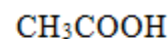
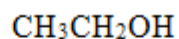
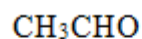
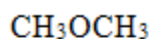
II

III

IV



25. Rank the following compounds in order of decreasing acidity, putting the most acidic first.

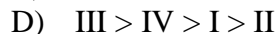
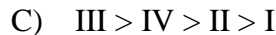
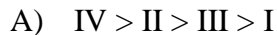


I

II

III

IV



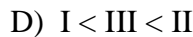
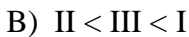
26. Rank the following conjugate bases in order of increasing basicity, putting the least basic first.



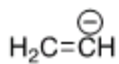
I

II

III



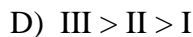
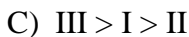
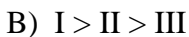
27. Rank the following conjugate bases in order of decreasing basicity, putting the most basic first.



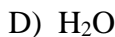
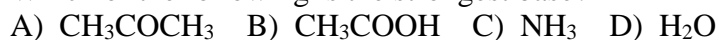
I

II

III



28. Which of the following is the strongest base?



29. What is the direction of equilibrium when acetylene ( $\text{C}_2\text{H}_2$ ) reacts with  $\text{H}_2\text{N}^-$  in an acid-base reaction?



A) Left B) Right C) Neither D) Cannot be determined

30. What is the direction of equilibrium when acetylene ( $\text{C}_2\text{H}_2$ ) reacts with ethoxide ( $\text{CH}_3\text{CH}_2\text{O}^-$ ) in an acid-base reaction?



A) Left B) Right C) Neither D) Cannot be determined

31. Which of the following statements explain why  $\text{H}_2\text{O}$  is a stronger acid than  $\text{CH}_4$ ?

A)  $\text{H}_2\text{O}$  can form hydrogen bonds while  $\text{CH}_4$  cannot.  
 B)  $\text{H}_2\text{O}$  forms a less stable conjugate base,  $\text{HO}^-$ .  
 C)  $\text{CH}_4$  forms a more stable conjugate base,  $\text{CH}_3^-$ .  
 D)  $\text{H}_2\text{O}$  forms a more stable conjugate base,  $\text{HO}^-$ .

32. Which of the following statements explain why  $\text{HBr}$  is a stronger acid than  $\text{HF}$ ?

A)  $\text{Br}^-$  is more stable than  $\text{F}^-$  because  $\text{Br}^-$  is larger than  $\text{F}^-$ .  
 B)  $\text{Br}^-$  is less stable than  $\text{F}^-$  because  $\text{Br}^-$  is larger than  $\text{F}^-$ .  
 C)  $\text{Br}^-$  is more stable than  $\text{F}^-$  because  $\text{Br}^-$  is less electronegative than  $\text{F}^-$ .  
 D)  $\text{Br}^-$  is less stable than  $\text{F}^-$  because  $\text{Br}^-$  is less electronegative than  $\text{F}^-$ .

33. Which of the following compounds has the lowest  $\text{pK}_a$ ?

A)  $\text{H}_2\text{O}$  B)  $\text{H}_2\text{S}$  C)  $\text{NH}_3$  D)  $\text{CH}_4$

34. Which of the following concepts can be used to explain the difference in acidity between acetic acid ( $\text{CH}_3\text{COOH}$ ) and ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ )?

A) Hybridization B) Electronegativity C) Resonance D) Size

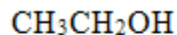
35. Which of the following concepts can be used to explain the difference in acidity between acetylene ( $\text{C}_2\text{H}_2$ ) and ethylene ( $\text{C}_2\text{H}_4$ )?

A) Size B) Resonance C) Inductive effect D) Hybridization

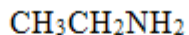
36. Which of the following concepts can be used to explain the difference in acidity between ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) and 2-fluoroethanol ( $\text{FCH}_2\text{CH}_2\text{OH}$ )?

A) Size B) Inductive effect C) Resonance D) Hybridization

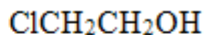
37. Rank the following compounds in order of decreasing acidity, putting the most acidic first.



**I**



**II**



**III**

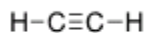
- A) I > II > III   B) III > II > I   C) II > III > I   D) III > I > II
38. Which of the following statements about Lewis acids is true?
- A) Lewis acids are proton donors.  
 B) Lewis acids are proton acceptors.  
 C) Lewis acids are electron pair donors.  
 D) Lewis acids are electron pair acceptors.
39. Which of the following statements about Lewis bases is true?
- A) Lewis bases are electron pair acceptors.  
 B) Lewis bases are electron pair donors.  
 C) Lewis bases are proton donors.  
 D) Lewis bases are proton acceptors.
40. Which of the following is a Lewis acid but not a Brønsted-Lowry acid?
- A)  $\text{CH}_3\text{OH}$    B)  $\text{H}_2\text{O}$    C)  $\text{CH}_3\text{COOH}$    D)  $\text{BF}_3$
41. Which of the following species can be both Lewis acid and Lewis base?



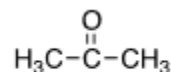
**I**



**II**

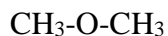


**III**

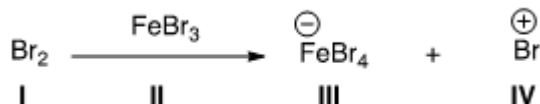


**IV**

- A) I, III, IV   B) I, II, IV   C) II, III, IV   D) I, II, III
42. What is the correct classification of the following compound?

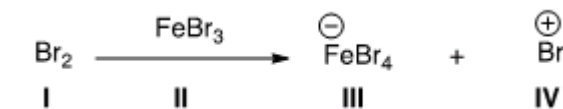


- A) Brønsted-Lowry acid and Lewis acid.   C) Brønsted-Lowry base.  
 B) Brønsted-Lowry base and Lewis base.   D) Lewis base.
43. Identify the Lewis acid in the following reaction.



- A) I   B) II   C) III   D) IV

44. Identify the Lewis base in the following reaction.



- A) I    B) II    C) III    D) IV

45. Which of the following compounds is *not* a Lewis acid?

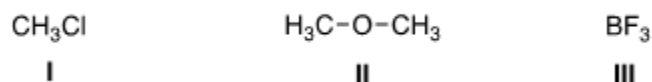
- A)  $\text{AlCl}_3$     B)  $\text{HCl}$     C)  $\text{H}_2\text{O}$     D)  $\text{CBr}_4$

46. What is the role of methylchloride ( $\text{CH}_3\text{Cl}$ ) in the following reaction?



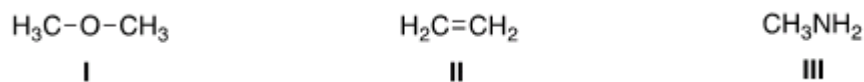
- A) Lewis acid  
B) Lewis base  
C) Brønsted-Lowry acid  
D) Brønsted-Lowry base

47. What is the electrophilic site in the following compounds?



- A) I = Carbon; II = carbon; III = boron.      C) I = Carbon; II = oxygen; III = boron.  
B) I = Chlorine; II = carbon; III = boron.      D) I = Carbon; II = carbon; III = fluorine.

48. What is the nucleophilic site in the following compounds?



- A) I = Hydrogen; II =  $\pi$  electrons in bond; III = nitrogen.  
 B) I = Oxygen; II = carbon; III = nitrogen.  
 C) I = Hydrogen; II = carbon; III = carbon.  
 D) I = Oxygen; II =  $\pi$  electrons in bond; III = nitrogen.

## Answer Key

1. D
2. B
3. B
4. C
5. A
6. B
7. B
8. C
9. D
10. C
11. D
12. D
13. C
14. D
15. D
16. B
17. A
18. D
19. B
20. D
21. C
22. B
23. A
24. D
25. B
26. A
27. C
28. C
29. B
30. A
31. D
32. A
33. B
34. C
35. D
36. B
37. D
38. D
39. B
40. D
41. A
42. B
43. B
44. A



- 45. D
- 46. B
- 47. A
- 48. D