1. According to the Lewis definition, a base is a(n):
A) Proton donor.
B) Electron pair donor.
C) Hydroxide ion donor.
D) Hydrogen ion donor.
E) Electron pair acceptor.
Ans: B

2. Which of the following is not both a Bronsted-Lowry acid and a Bronsted-Lowry base?
A) HSO_4^-
B) $H_2PO_4^-$
C) HCO_3^-
D) OH^-
E) SH^-
Ans: D

3. Which of the following is not a conjugate acid - conjugate base pair (in that order)?
A) H_3PO_4, $H_2PO_4^-$
B) HBF_4, BF_4^-
C) CH_3CH_2OH, $CH_3CH_2O^-$
D) H_3O^+, H_2O
E) HPO_4^{--}, $H_2PO_4^-$
Ans: E

4. The conjugate base of sulfuric acid is:
A) $H_3SO_4^+$
B) SO_3
C) HSO_4^-
D) H_2SO_3
E) HSO_3^-
Ans: C

5. Consider the equilibrium

$$PO_4^{---} + H_2O \rightleftharpoons HPO_4^{--} + OH^-$$

Which are the Bronsted-Lowry bases?

A) PO_4^{---} and HPO_4^{--}
B) PO_4^{---} and OH^-
C) PO_4^{---} and H_2O
D) H_2O and OH^-
E) H_2O and HPO_4^{--}

Ans: B

6. Which of these is <u>not</u> a true statement?

A) All Lewis bases are also Bronsted-Lowry bases.
B) All Lewis acids contain hydrogen.
C) All Bronsted-Lowry acids contain hydrogen.
D) All Lewis acids are electron deficient.
E) According to the Bronsted-Lowry theory, water is both an acid and a base.

Ans: B

7. For the equilibrium

$$CH_3NH_3^+ + H_2O \rightleftharpoons CH_3NH_2 + H_3O^+$$

the two substances which are both acids are:

A) H_2O and H_3O^+
B) $CH_3NH_3^+$ and H_2O
C) $CH_3NH_3^+$ and CH_3NH_2
D) $CH_3NH_3^+$ and H_3O^+
E) CH_3NH_2 and H_2O

Ans: D

8. Which of the following is <u>not</u> a Lewis base?

A) NH_3
B) H^-
C) BF_3
D) H_2O
E) H_3C^-

Ans: C

9. Which of the following is not a Bronsted-Lowry acid?
A) H_2O
B) $(CH_3)_3N$
C) NH_4^+
D) CH_3CO_2H
E) $HC{\equiv}CH$
Ans: B

10. Which combination of substances below does not constitute a Lewis acid-Lewis base reaction?
A) $PH_3 + H^+$
B) $Ag^+ + NH_3/H_2O$
C) $BF_3 + NH_3$
D) $CH_3CH_2OCH_2CH_3 + AlCl_3$
E) $OH^- + NH_3/H_2O$
Ans: E

11. Which of these is not a Lewis acid?
A) $AlCl_3$
B) H^+
C) BCl_3
D) SO_3
E) H_2S
Ans: E

12. This species is a carbon-based Lewis acid:
A) CH_4
B) $HCCl_3$
C) CH_3^+
D) $:CH_3^-$
E) $\cdot CH_3$
Ans: C

13. What is the conjugate base of ethanol?
A) $CH_3CH_2O^-$
B) $CH_3CH_2^-$
C) $CH_3CH_2OH_2^+$
D) CH_3CH_3
E) CH_3OCH_3
Ans: A

14. Which of the acids below would have the strongest conjugate base?
A) CH_3CH_2OH $pK_a = 18$
B) CH_3CO_2H $pK_a = 4.75$
C) $ClCH_2CO_2H$ $pK_a = 2.81$
D) Cl_2CHCO_2H $pK_a = 1.29$
E) Cl_3CCO_2H $pK_a = 0.66$
Ans: A

15. Which of the following is a Lewis acid?
A) H_3O^+
B) BF_3
C) NF_3
D) OH^-
E) $N{\equiv}N$
Ans: B

16. Adding sodium hydride to ethanol would produce:
A) $CH_3CH_2OCH_2CH_3 + H_2$
B) $CH_3CH_2OCH_2CH_3 + NaOH$
C) $CH_3CH_2ONa + H_2$
D) $CH_3CH_2Na + NaOH$
E) $CH_3CH_3 + NaOH$
Ans: C

17. Which acid-base reaction would <u>not</u> take place as written?
A) $CH_3Li + CH_3CH_2OH \longrightarrow CH_4 + CH_3CH_2OLi$
B) $HC{\equiv}CH + NaOH \longrightarrow HC{\equiv}CNa + H_2O$
C) $HC{\equiv}CNa + H_2O \longrightarrow HC{\equiv}CH + NaOH$
D) $CH_3OH + NaH \longrightarrow CH_3ONa + H_2$
E) $CH_3CO_2H + CH_3ONa \longrightarrow CH_3CO_2Na + CH_3OH$
Ans: B

18. The amide ion, NH_2^-, is a base which can be used only in which of the solvents shown below:
A) CH_3OH
B) CH_3CH_2OH
C) H_2O
D) D_2O
E) Liquid NH_3
Ans: E

19. Acetic acid dissociates most completely in:
A) CCl_4
B) $Cl_2C{=}CCl_2$
C) H_2O
D) $(CH_3CH_2)_2O$
E) the gas phase.
Ans: C

20. For the reaction:

$$HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$$

which pair of substances both are bases?
A) H_2O and CN^-
B) H_3O^+ and H_2O
C) HCN and H_3O^+
D) HCN and CN^-
E) H_3O^+ and CN^-
Ans: A

21. What compounds are produced when sodium nitrate is added to a mixture of water and ethanol?
A) $HNO_3 + NaOH$
B) $HNO_3 + CH_3CH_2ONa$
C) $NaOH + CH_3CH_2ONa$
D) $CH_3CH_2OCH_2CH_3 + NaOH$
E) No reaction occurs.
Ans: E

22. Which reaction of these potential acids and bases does <u>not</u> occur to any appreciable degree due to an unfavorable equilibrium?
A) NaOH (aq) + $CH_3CH_2CH_2CO_2H$
B) CH_3CH_2ONa in ethanol + ethene
C) CH_3Li in hexane + ethyne
D) $NaNH_2$ in liq. NH_3 + ethanol
E) $NaC_2H_3O_2$ (aq) + HI
Ans: B

23. Which combination of reagents is the least effective in generating sodium ethoxide, CH_3CH_2ONa?

A) CH_3CH_2OH + NaH
B) CH_3CH_2OH + $NaNH_2$
C) CH_3CH_2OH + NaOH
D) CH_3CH_2OH + CH_3Li
E) CH_3CH_2OH + $HC{\equiv}CNa$

Ans: C

24. In the reaction, $Na^+NH_2^-$ + $CH_3OH \longrightarrow CH_3O^-Na^+ + NH_3$, the stronger base is:

A) $NaNH_2$
B) CH_3OH
C) CH_3ONa
D) NH_3
E) This is not an acid-base reaction.

Ans: A

25. Which sequence is the best one to use to prepare $CH_3C{\equiv}CD$?

A) $CH_3C{\equiv}CH \xrightarrow{NaH} \xrightarrow{D_2O}$
B) $CH_3C{\equiv}CH \xrightarrow{NaOH} \xrightarrow{D_2O}$
C) $CH_3C{\equiv}CH \xrightarrow{CH_3ONa} \xrightarrow{D_2O}$
D) $CH_3C{\equiv}CH \xrightarrow{DOH}$
E) None of these will be successful.

Ans: A

26. Adding sodium hydride, NaH, to water produces:

A) H_2 and NaOH(aq)
B) $H^-(aq)$ + $Na^+(aq)$
C) $H_3O^+(aq)$ + $Na^+(aq)$
D) $H_3O^-(aq)$ + $Na^+(aq)$
E) $Na_2O + H_2$

Ans: A

27. Which reaction will yield CH_3CH_2-D?
A) $CH_3CH_3 + D_2O$
B) $CH_3CH_2Li + D_2O$
C) $CH_3CH_2OLi + D_2O$
D) $CH_3CH_2OH + D_2O$
E) More than one of these
Ans: B

28. A product of the reaction, $CH_3CH_2Li + D_2O \longrightarrow$ is
A) CH_3CH_2OD
B) $CH_3CH_2CH_2CH_3$
C) $CH_2=CH_2$
D) CH_3CH_2D
E) $CH_3CH_2OCH_2CH_3$
Ans: D

29. The compounds ethane, ethene, and ethyne exhibit this order of <u>increasing</u> acidity:
A) Ethyne < ethene < ethane
B) Ethene < ethyne < ethane
C) Ethane < ethyne < ethene
D) Ethane < ethene < ethyne
E) Ethene < ethane < ethyne
Ans: D

30. Which is an incorrect statement?
A) RSH compounds are stronger acids than ROH compounds.
B) PH_3 is a weaker base than NH_3.
C) NH_2^- is a stronger base than OH^-.
D) OH^- is a stronger base than OR^-.
E) H^- is a stronger base than OR^-.
Ans: D

31. The correct sequence of the ions shown, in order of <u>increasing</u> basicity, is:
A) $CH_3CH_2:^- < CH_2=CH:^- < HC\equiv C:^-$
B) $CH_3CH_2:^- < HC\equiv C:^- < CH_2=CH:^-$
C) $HC\equiv C:^- < CH_3CH_2:^- < CH_2=CH:^-$
D) $CH_2=CH:^- < HC\equiv C:^- < CH_3CH_2:^-$
E) $HC\equiv C:^- < CH_2=CH:^- < CH_3CH_2:^-$
Ans: E

32. Which is a protic solvent?
A) CCl_4
B) $HCCl_3$
C) CH_3OH
D) $CH_3(CH_2)_4CH_3$
E) $CH_3CH_2OCH_2CH_3$
Ans: C

33. If a 0.01 M solution of a weak acid has a pH of 4.0, the pK_a of the acid is:
A) 10.0
B) 8.0
C) 6.0
D) 4.0
E) 2.0
Ans: C

34. Which one of the following is a true statement?
A) The stronger the acid, the larger is its pK_a.
B) The conjugate base of a strong acid is a strong base.
C) Acid-base reactions always favor the formation of the stronger acid and the stronger base.
D) Strong acids can have negative pK_a values.
E) Hydrogen need not be present in the molecular formula of a Bronsted-Lowry acid.
Ans: D

35. The basic species are arranged in decreasing order of basicity in the sequence:
A) $F^- > OCH_3^- > NH_2^- > CH_3CH_2^-$
B) $OCH_3^- > CH_3CH_2^- > NH_2^- > F^-$
C) $CH_3CH_2^- > NH_2^- > OCH_3^- > F^-$
D) $NH_2^- > CH_3CH_2^- > F^- > OCH_3^-$
E) $NH_2^- > OCH_3^- > CH_3CH_2^- > F^-$
Ans: C

36. A particular acid has $K_a = 2.0 \times 10^{-5}$ (in aqueous solution). The evaluation of which of these expressions gives the value for pK_a?
A) $10^{-14}/2.0 \times 10^{-5}$
B) $10^{-14}(2.0 \times 10^{-5})$
C) $5 - \log 2.0$
D) $-5 + \log 2.0$
E) $2.0 \times 10^{-5}/10^{-14}$
Ans: C

37. As a consequence of the "leveling effect," the strongest acid which can exist in appreciable concentration in aqueous solution is:
A) H_3O^+
B) H_2SO_4
C) $HClO_4$
D) HCl
E) HNO_3
Ans: A

38. Based on the position of the central atom in the periodic chart, we predict that the strongest acid of the following is:
A) H_2O
B) H_2S
C) H_2Se
D) H_2Te
Ans: D

39. An acid, HA, has the following thermodynamic values for its dissociation in water at 27º C: $\Delta H = -8.0$ kJ mol^{-1};
$\Delta S = -70$ kJ $K^{-1}mol^{-1}$.
The ΔG for the process is:
A) +29 kJ mol^{-1}
B) +13 kJ mol^{-1}
C) -6.1 kJ mol^{-1}
D) -13 kJ mol^{-1}
E) -29 kJ mol^{-1}
Ans: B

40. Which of these bases is the strongest one which can be used (and retains its basic character) in aqueous solution?
A) OCH_3^-
B) F^-
C) OH^-
D) $C_2H_3O_2^-$
E) HSO_4^-
Ans: C

41. The acidity constant, K_a, differs from the equilibrium constant, K_{eq}, for the dissociation of the same acid in water at the same temperature and concentration in what way?
A) K_a can be determined experimentally with less accuracy than K_{eq}.
B) The two terms are identical numerically.
C) K_a is used for strong acids only; K_{eq} for weak acids.
D) K_a is the reciprocal of K_{eq}.
E) $K_{eq} = K_a/[H_2O]$.
Ans: E

42. Which of the following is an untrue statement?
A) The % dissociation of a weak acid increases with increasing dilution of the acid solution.
B) The stronger an acid, the weaker its conjugate base.
C) The larger the value of K_a for an acid, the smaller the value of its pK_a.
D) Comparison of the acidity of strong acids in solution requires the use of a solvent less basic than water.
E) The stronger the acid, the more positive the value of ΔG^o for the dissociation.
Ans: E

43. When proton transfer reactions reach equilibrium, there have been formed:
A) the weaker acid and the weaker base.
B) the weaker acid and the stronger base.
C) the stronger acid and the weaker base.
D) the stronger acid and the stronger base.
E) All proton transfers go to completion; they are not equilibrium processes.
Ans: A

44. For the simple hydrides, MH_n, pK_a values decrease in the order:
A) $CH_4 > NH_3 > H_2O > H_2S > HBr$
B) $HBr > H_2S > H_2O > NH_3 > CH_4$
C) $HBr > H_2O > NH_3 > H_2S > CH_4$
D) $NH_3 > H_2S > CH_4 > H_2O > HBr$
E) $H_2S > H_2O > HBr > NH_3 > CH_4$
Ans: A

45. The compound aniline, $C_6H_5NH_2$, has weakly basic properties in aqueous solution. In this other solvent, aniline would behave as a strong base.
A) CH_3OH
B) CH_3CH_2OH
C) CF_3CO_2H
D) Liquid NH_3
E) $CH_3(CH_2)_4CH_3$
Ans: C

46. Which of the following organic compounds is the strongest acid?
A) C_6H_{12} $pK_a = 52$
B) CH_3CH_3 $pK_a = 50$
C) CH_3CH_2OH $pK_a = 18$
D) CH_3CO_2H $pK_a = 5$
E) CF_3CO_2H $pK_a = 0$
Ans: E

47. Which is the strongest acid?
A) CH_3CH_2OH
B) CH_3CO_2H
C) $HC{\equiv}CH$
D) $CH_2{=}CH_2$
E) CH_3CH_3
Ans: B

48. Which of the following correctly lists the compounds in order of <u>decreasing</u> acidity?
A) $H_2O > HC{\equiv}CH > NH_3 > CH_3CH_3$
B) $HC{\equiv}CH > H_2O > NH_3 > CH_3CH_3$
C) $CH_3CH_3 > HC{\equiv}CH > NH_3 > H_2O$
D) $CH_3CH_3 > HC{\equiv}CH > H_2O > NH_3$
E) $H_2O > NH_3 > HC{\equiv}CH > CH_3CH_3$
Ans: A

49. Select the strongest base.
A) OH^-
B) $RC{\equiv}C^-$
C) NH_2^-
D) $CH_2{=}CH^-$
E) $CH_3CH_2^-$
Ans: E

50. A group of acids arranged in order of decreasing acidity is:
$HNO_3 > CH_3COOH > C_6H_5OH > H_2O > HC{\equiv}CH$
What is the arrangement of the conjugate bases of these compounds in decreasing order of basicity?

A) $NO_3^- > CH_3COO^- > C_6H_5O^- > OH^- > HC{\equiv}C^-$
B) $CH_3COO^- > C_6H_5O^- > NO_3^- > OH^- > HC{\equiv}C^-$
C) $C_6H_5O^- > NO_3^- > HC{\equiv}C^- > OH^- > CH_3COO^-$
D) $HC{\equiv}C^- > OH^- > C_6H_5O^- > CH_3COO^- > NO_3^-$
E) No prediction of relative base strength is possible.
Ans: D

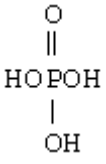
51. What prediction can be made of the relative strengths of the conjugate bases of: H_2S, HCl, SiH_4, PH_3?

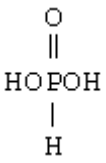
A) $PH_2^- > SiH_3^- > HS^- > Cl^-$
B) $SiH_3^- > PH_2^- > HS^- > Cl^-$
C) $Cl^- > HS^- > PH_2^- > SiH_3^-$
D) $HS^- > Cl^- > SiH_3^- > PH_2^-$
E) $Cl^- > PH_2^- > SiH_3^- > HS^-$
Ans: B

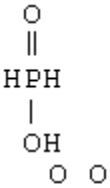
52. Which of these species is not amphoteric?

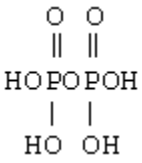
A) $HC{\equiv}C^-$
B) HS^-
C) NH_3
D) CH_3^-
E) HPO_4^{--}
Ans: D

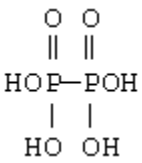
53. Which of these phosphorus-based acids is dibasic?

A)


B)


C)


D)


E)


Ans: B

54. Why cannot one determine the relative acid strengths of $HClO_4$ and HNO_3 using aqueous solutions of these acids?

A) The acids are insufficiently soluble for the measurements.
B) A more basic solvent than H_2O must be used.
C) H_2O is too basic a solvent for the distinction to be made.
D) These oxidizing acids cause redox reactions to occur.
E) Actually, the acid strengths can be determined using aqueous solutions.

Ans: C

55. Which of these is <u>not</u> a diprotic acid?

A) H_2S
B) H_2SO_4
C) H_2O
D) $(COOH)_2$
E) $H_2PO_4^-$

Ans: C

56. Which set contains non-equivalent members?
A) Enthalpy and heat content
B) Endothermic reaction and +ΔH
C) Exothermic reaction and -ΔH
D) Kinetic energy and energy of motion
E) High energy and high stability
Ans: E

57. Addition reactions are characteristic of compounds with _____.
Ans: multiple bonds

58. The four basic types of reactions are: _____.
Ans: substitution, addition, elimination, rearrangement

59. The process of bond-breaking where each fragment takes away one of the electrons from the bond is called _____.
Ans: homolysis

60. Heterolytic bond-breaking produces _____.
Ans: charged fragments/ions

61. According to Bronsted-Lowry theory, an acid is a substance that can _____.
Ans: donate a proton

62. According to Lewis theory, a base is a substance that can _____.
Ans: donate a lone pair of electrons

63. The molecule or ion that is formed when an acid loses its proton is called the _____.
Ans: conjugate base

64. Reagents that seek to react with a proton or some other electron-deficient center are called _____.
Ans: nucleophiles

65. A substance that can donate a lone pair of electrons is a _____ according to _____ theory.
Ans: base; Lewis

66. When drawing mechanisms, chemists generally use curved arrows. The curved arrow begins with _____ and points toward _____.
Ans: a lone pair or covalent bond; a site of electron deficiency

67. Why do water-insoluble carboxylic acids dissolve in aqueous sodium hydroxide?
Ans: Because they are converted to water-soluble salts.

68. Bond polarization that takes place through space and through the bonds of the molecule is called the _____.
Ans: inductive effect

69. What are the two fundamental types of energy?
Ans: potential energy and kinetic energy

70. Define a protic solvent.
Ans: one that has a hydrogen atom attached to a strongly electronegative element such as oxygen