MULTIPLE CHOICE: (5 pts each)

1. According to the Lewis definition, a base is a(n):
   (a) proton donor     (b) hydrogen ion donor     (c) electron pair donor
   (d) electron pair acceptor    (e) hydroxide ion donor     (f) none of these

2. The conjugate base of sulfuric acid is:
   (a) H$_3$SO$_4^+$   (b) SO$_3$     (c) H$_2$SO$_3$     (d) HSO$_4^-$     (e) HSO$_3^-$

3. Which of the following is NOT a Brønsted acid?
   (a) H$_2$O        (b) Me$_3$N: (c) NH$_4^+$     (d) CH$_3$CO$_2$H     (e) ethyne

4. Which of the following is NOT a Lewis base?
   (a) :NH$_3$   (b) H$^-$   (c) BF$_3$   (d) H$_2$O   (e) H$_3$C$^-$

5. The compounds ethane, ethene and ethyne exhibit this order of increasing acidity:
   (a) ethyne < ethene < ethane     (d) ethane < ethene < ethyne
   (b) ethene < ethyne < ethane     (e) ethene < ethyne < ethane
   (c) ethane < ethyne < ethene     (f) none of these

6. Which of the following is a TRUE statement?
   (a) The stronger the acid, the larger its pK$_a$ value.
   (b) Strong acids can have negative pK$_a$ values.
   (c) Acid-base reactions always favor the formation of the stronger acid and the stronger base.
   (d) The conjugate base of a strong acid is a strong base.
   (e) Hydrogen need not be present in the molecular formula of a Brønsted acid.

7. Based on the position of the central atom in the periodic table, which of the following would you predict to be the strongest acid?
   (a) H$_2$O        (b) H$_2$S     (c) H$_2$Se     (d) H$_2$Te

8. This species is a carbon-based Lewis acid:
   (a) CH$_4$   (b) HCCl$_3$   (c) CH$_3^+$     (d) :CH$_3^-$     (e) ·CH$_3$

9. Which of the following acids would have the strongest conjugate base?
(a) CH$_3$CH$_2$OH, pK$_a$ = 18
(b) CH$_3$CO$_2$H, pK$_a$ = 4.75
(c) ClCH$_2$CO$_2$H pK$_a$ = 2.81
(d) Cl$_2$CHCO$_2$H pK$_a$ = 1.29
(e) Cl$_3$CCO$_2$H pK$_a$ = 0.66

10. Which of the following is the strongest base?
   (a) OH$^-$ (b) NH$_2^-$ (c) CH$_2$=CH$^-$ (d) CH$_3$CH$_2^-$

SHORT ANSWER:

11. Describe what is meant by the terms reaction and mechanism. (10 pts)

12. Use curved arrows to show the mechanism of the reaction of hydroxide ion with benzoic acid. (10 pts)

(d) Use curved arrows to show the mechanism of the following reaction. (10 pts)
(e) Use curved arrows to show the mechanism of the following reaction. Which reactant is the nucleophile and which is the electrophile (label on the lines provided)? (11 pts)

(f) Name three factors that can affect reaction equilibrium. (9 pts)

**Bonus (+2 pts): What thermodynamic expression do we use to show the relationship between the free energy of a reaction and reaction equilibrium?