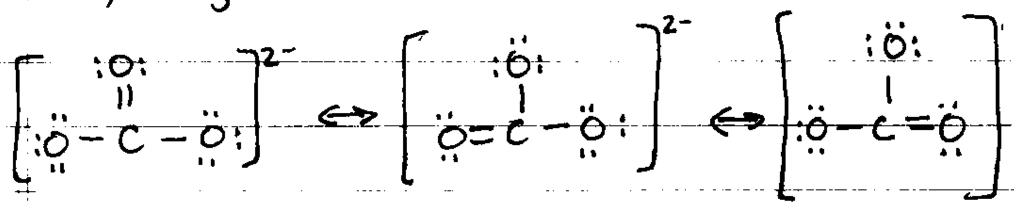
Comprehensive Problems

1.

a) CO_3^{2-} 24 ve^-



Must have 3 equivalent resonance structures.

F.C.'s: C: ∅

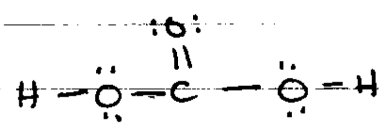
singly bonded O's: −1 each

doubly bonded O: ∅

b)

H^+ ions bond to singly bonded O atoms with −1 FC's.

H_2CO_3:



All F.C.'s = ∅

2.

$$H_2O_{(l)} + CO_{2}(g) \rightarrow H_2CO_3\,(aq)$$

ox. #   +1 −2   +4 −2   +1 +4 −2

Not an oxidation-reduction reaction. All oxidation numbers remain unchanged.

3. $\Delta G^\circ_{rxn} = \Sigma\left[n\Delta G_f^\circ(\text{products})\right] - \Sigma\left[n\Delta G_f^\circ(\text{reactants})\right]$

$\Delta G^\circ = \left[(1\,\text{mol}\,H_2CO_3)(-699.65\,\text{kJ/mol})\right] - \left[\binom{1\,\text{mol}}{H_2O}(-237.1\,\text{kJ/mol}) + \binom{1\,\text{mol}}{CO_2}(-394.4\,\text{kJ/mol})\right]$

$\Delta G^\circ_{rxn} = -699.65\,\text{kJ} - [-631.5\,\text{kJ}] = -68.2\,\text{kJ}$

$\Delta G^\circ_{rxn} < 0$. Yes spontaneous.

4. $H_2CO_{3\,(aq)} + H_2O_{(\ell)} \rightleftharpoons HCO_3^-{}_{(aq)} + H_3O^+{}_{(aq)}$ $Ka_1 = \dfrac{[HCO_3^-][H_3O^+]}{[H_2CO_3]}$

$HCO_3^-{}_{(aq)} + H_2O_{(\ell)} \rightleftharpoons CO_3^{2-}{}_{(aq)} + H_3O^+{}_{(aq)}$ $Ka_2 = \dfrac{[CO_3^{2-}][H_3O^+]}{[HCO_3^-]}$

5. $Ka_1 = 4.5 \times 10^{-7} M = \dfrac{[HCO_3^-][H_3O^+]}{[H_2CO_3]}$

a) $Ka_1 \ll 1$; therefore, the reactants dominate at equlibrium.

b.) $\Delta G° = -RT\ln K$

$\Delta G° = -(8.31451\,J/mol \cdot K)(298.15K)\ln(4.5 \times 10^{-7})$

$\Delta G° = (-2478.97\,J/mol)(-14.6140) = +3.6 \times 10^4\,J/mol = \boxed{36\,kJ/mol}$

6.
a. $pH = 7.40 = -\log[H_3O^+]$

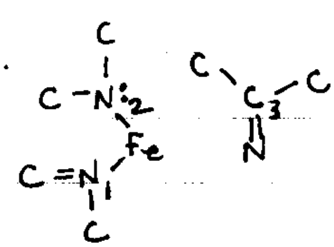
$[H_3O^+] = 10^{-pH} = 10^{-7.40} = 3.98 \times 10^{-8} = \boxed{4.0 \times 10^{-8} M}$

b. $H_2O_{(\ell)} + CO_{2(g)} \rightleftharpoons H_2CO_{3\,(aq)} \rightleftharpoons HCO_3^-{}_{(aq)} + H^+{}_{(aq)}$

c. As the concentration of CO_2 increases, the first equlibrium shifts to the right, producing more H_2CO_3. This causes the second equlibrium to also shift to the right, increasing the concentration of H^+ (or H_3O^+) and decreasing the pH.

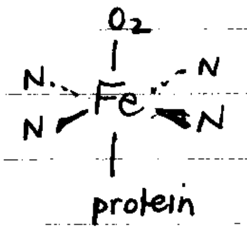
7. Fe^{2+}: $[Ar]\,3d^6$ [Ar] ⥮ ↿ ↿ ↿ ↿ (3d)

8.



a.	b
N_1: SN=3 → 120°	sp^2
N_2: SN=4 → <109.5°	sp^3
C_3: SN=3 → 120°	sp^2

9. octahedral ; 90° angles



10. $420\text{ nm} = \lambda$ $\quad E = \frac{hc}{\lambda} = \frac{(6.62607 \times 10^{-34}\text{ J}\cdot\text{s})(2.9979 \times 10^{8}\text{ m/s})}{4.20 \times 10^{-7}\text{ m}}$

$E = 4.73 \times 10^{-19}\text{ J}$

11. $4\text{ Hb} + 4\text{ O}_2 \rightleftharpoons 4\text{ Hb-O}_2$

In the lungs, P_{O_2} is high, causing the equlibrium to shift right and hemoglobin to bind O_2. As blood reaches the tissues where P_{O_2} is low, the equilibrium shifts back to the left and Hb releases its O_2.