12.10 The catalyst only affects the rate, not the position of the equilibrium

12.12 At equilibrium, $Q = K$. K_{eq} is the equilibrium constant which is constant for a given temperature. Q can be any value at all when the system isn't at equilibrium.

12.13 heterogeneous: (a), (c), (e), (f)
homogeneous: (b), (d),

12.18 (a) $K = \dfrac{P_{NO}^4 P_{H_2O}^6}{P_{NH_3}^4 P_{O_2}^5}$ (b) $K = \dfrac{P_{N_2}[H^+]^2}{[Cu^{2+}][NH_2OH]^2}$

neither $H_2O_{(\ell)}$ or $Cu_{(s)}$ appear in the equilibrium equation because they are in their "standard state".

12.23 $H_3O^+_{(aq)} + OH^-_{(aq)} \rightleftharpoons H_2O_{(\ell)} + H_2O_{(\ell)}$

$$K' = \frac{1}{[H_3O^+][OH^-]} = \frac{1}{K} = \frac{1}{1.0\times10^{-14}} = 1.0\times10^{14}$$

12.25 $CH_3COOH + OH^- \rightleftharpoons CH_3COO^- + H_2O \quad K_1 = 1.8\times10^9$

$+ \quad H_2O + H_2O \rightleftharpoons H_3O^+ + OH^- \quad K_2 = 1.0\times10^{-14}$

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+ \quad K_3 =$

$$K_3 = K_1 K_2 = \frac{[CH_3COO^-]}{[CH_3COOH][OH^-]} \times [OH^-][H_3O^+] = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$$

$$= 1.8\times10^9 \times 1.0\times10^{-14} = 1.41\times10^{-3}$$