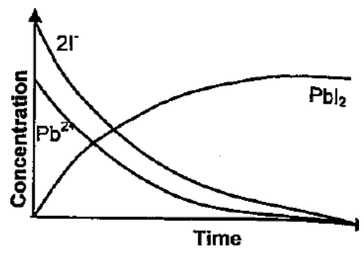
Equilibrium 2009 Class Answers

1. a) $Pb^{2+}(aq) + 2I^-(aq) \leftrightarrow PbI_2(s)$

b) See the graph.

c) The amount of the precipitate formed, its colour or intensity of the colour, or any other observable changes have ceased.

d) This could only be shown using tagged radioactive isotope mixed with normal iodine. It could be shown that the proportion of the radioactive isotopic iodine continues changing during the equilibrium even though the amounts remain constant.



2. a) N_2, H_2, and NH_3 are present at equilibrium.

b) Final concentrations: $[N_2] = 1.60$ mol L^{-1}, $[H_2] = 1.00$ mol L^{-1}, $[NH_3] = 0.40$ mol L^{-1}

c) Concentrations after 3 minutes: $[N_2] = 1.60$ mol L^{-1}, $[H_2] = 1.05$ mol L^{-1}, $[NH_3] = 0.30$ mol L^{-1}

d) About 2 minutes after the reaction commences.

e) At the seventh minute after the reaction commences.

f) Same as given for b) above.

4. a) Adding a solution of NaOH would increase the concentration of OH^- ions which would shift the equilibrium position to the right, so more CrO_4^{2-} ions would be produced.

b) Adding a solution of HCl would decrease the concentration of OH^- ions (since the H^+ ions from HCl would react with the OH^- ions present). This would shift the equilibrium position towards the left, so more $Cr_2O_7^{2-}$ would be present.

c) Adding water would not produce reactants or products: it will only dilute the system.

6. a) In an open container, the pale green powder will decompose completely to form black copper oxide, while all the CO_2 gas will escape.

b) In a closed container, the reaction will not go to completion. A mixture of green copper carbonate and black copper oxide will be formed with a colourless gas over the mixture, which is CO_2.

7. a) A decrease in pressure will shift the equilibrium to the left, forming more of the reactants from the products.

b) A decrease in pressure has no effect because the number of gaseous moles are equal on both sides.

c) A decrease in pressure will shift the equilibrium to the right (towards more number of gaseous moles), forming more products from the reactants.

d) A decrease in pressure will shift the equilibrium to the right (towards more number of gaseous moles), forming more products.

8. a) Raising the temperature will shift the equilibrium to the left, forming more reactants as this is an exothermic reaction.

b) Raising the temperature will shift the equilibrium to the left, forming more reactants as this is an exothermic reaction.

c) Raising the temperature will shift the equilibrium to the right, forming more products as this is an endothermic reaction.

9. The opposite effect to what is stated in question 8 above will occur in each case.

10. a) $k_{eqm.} = \{[Ca^{2+}] \times [OH^-]^2\}$
b) $k_{eqm} = [NH_3]^2 \div [N_2] \times [H_2]^3$
c) $k_{eqm.} = [NO_2]^2 \div [NO]^2 \times [O_2]$
d) $k_{eqm.} = [Mn^{2+}] \times [Fe^{2+}]^5 \div [MnO_4^-] \times [Fe^{2+}]^5 \times [H^+]^8$
e) $k_{eqm.} = [Mn^{2+}]^2 \times [CO_2]^{10} \div [MnO_4^-]^2 \times [H_2C_2O_4]^5 \times [H^+]^6$

11. a) $k_{eqm.} = [Co(H_2O)_6]^{2+}] \times [Cl^-]^4 \div [CoCl_4^{2-}]$
$Co(H_2O)_6^{2+}$ is green while $CoCl_4^{2-}$ is blue.
b) If you sprinkle some NaCl solution, the increased concentration of chloride ions will shift the equilibrium to the left and the solution will become blue.

$[CoCl_4]^{2+}(aq) + 6H_2O(l) \leftrightarrow [Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq)$
Blue Green

c) On a dry day the blue paper will remain blue and the green one will turn blue. The shift in equilibrium is to the left as water is removed from the paper.

12. a) At the beginning of the reaction, SO_2, Cl_2, and SO_2Cl_2, – are all present.
($SO_2 = 0.05$ M, $Cl_2 = 0.07$, $SO_2Cl_2 = 0.05$ M)
b) Four minutes.
c) $k_{eqm.} = [SO_2] \times [Cl_2] \div [SO_2Cl_2]$
d) Chlorine was pumped into the system. The increased concentration of one of the products shifts the equilibrium to the left. Chlorine starts reacting with SO_2, producing SO_2Cl_2. Therefore, $[SO_2]$ begins to decrease and $[SO_2Cl_2]$ begins to increase.
e) After another three minutes.
f) The temperature was decreased.
g) The pressure was decreased or the volume of the system was increased.