Common Ion Effect Chemistry Questions with Solutions

Q1. In a saturated solution of an electrolyte, the ionic product of their concentration is constant at a constant temperature, and this constant for electrolyte is known as
(a) Ionic product
(b) Solubility product
(c) Ionization constant
(d) Dissociation constant
Answer: (b) In a saturated solution of an electrolyte, the ionic product of their concentration is constant at a constant temperature, and this constant for electrolyte is known as solubility product.

Q2. On passing a current of hydrochloric acid gas in a saturated solution of sodium chloride, the solubility of sodium chloride
(a) Decreases
(b) Increases
(c) Remains unaffected
(d) Sodium chloride decomposes
Answer: (a) On passing a current of hydrochloric acid gas in a saturated solution of sodium chloride, the solubility of sodium chloride decreases.

Q3. The dissociation and ionisation are practically the same as both give
(a) Free anions only
(b) Free cations only
(c) Both free cations and anions
(d) None of the above
Answer: (c) The dissociation and ionisation are practically the same as both give both free cations and anions.

Q4. The solubility product is a kind of equilibrium constant, and its value depends on
(a) Volume
(b) Energy
(c) Temperature
(d) None of the above
Answer: (c) The solubility product is a kind of equilibrium constant, and its value depends on the temperature.

Q5. The solubility product increases with an increase in
(a) Energy
(b) Temperature

(c) Pressure
(d) None of the above
Answer: (b) The solubility product increases with an increase in temperature.

Q6. What is the common ion effect?
Answer: The common ion effect describes the decrease in solubility of an ionic precipitate by adding a solution of a soluble compound with an ion common with the deposit. It is under Le Chatlier's principle of ionic association or dissociation.

Q7. What is the importance of the common ion effect?
Answer: Common ion effect plays a critical role in physical chemistry.
1. It helps in controlling the pH of the reaction.
2. It helps to estimate the solubility of a slightly soluble salt.

Q8. What is Le Chatlier's principle?
Answer: Le Chatlier's principle states that the change in pressure, temperature and volume leads to a resisting change in the system to reach a new equilibrium state. It can either be in the direction of the reactant or the product.

Q9. What are concentration of $[Na^+]$, $[Cl^-]$, $[Ca^{2+}]$, and $[H^+]$ in a solution containing 0.10 M each of NaCl, $CaCl_2$, and HCl?
Answer: By the law of conservation of ions, the concentration of sodium ions, calcium ions, and hydrogen ions will be equivalent, i.e. 0.10M.
$[Na^+] = [Ca^{2+}] = [H^+] = 0.10$ M.
but the concentration of $[Cl^-]$ will be 0.10 (Due to NaCl), 0.20 (Due to $CaCl_2$) and 0.10 (Due to HCl).
Thus the total concentration of $[Cl^-]$ will be = 0.10 + 0.20 + 0.10 = 0.40 M.

Q10. John poured 10.0 mL of 0.10 M NaCl, 10.0 mL of 0.10 M KOH, and 5.0 mL of 0.20 M HCl solutions together and then he made the total volume 100.0 mL. What is the concentration of $[Cl^-]$ in the final solution?
Answer: Here,
$M_1 = 0.10$
$M_2 = 0.20$
$V_1 = 10.0$ mL
$V_2 = 5.0$ mL
$V = 100.0$ mL
Concentration of $[Cl^-]$ in the final solution = $(M_1V_1 + M_2V_2) / V$
Concentration of $[Cl^-]$ in the final solution = (0.10 X 10.0 + 0.20 X 5.0) / 100
Concentration of $[Cl^-]$ in the final solution = 2 / 100
Concentration of $[Cl^-]$ in the final solution = 0.02 M

Q11. If the pH of a saturated solution of $Ba(OH)_2$ is 12. What is the value of solubility product (Ksp) of $Ba(OH)_2$?

Answer: Reaction: $Ba(OH)_2 \rightleftarrows Ba^{2+} + 2\ OH^-$

The pH of a saturated solution of $Ba(OH)_2$ = 12.

The pOH of a saturated solution of $Ba(OH)_2$ = 14 - pH.

The pOH of a saturated solution of $Ba(OH)_2$ = 14 - 12.

The pOH of a saturated solution of $Ba(OH)_2$ = 2.

We will now calculate the concentration of OH^- ions.

$[OH^-] = 10^{-pOH}$

$[OH^-] = 10^{-2}$

$[OH^-] = 1 \times 10^{-2}$

According to the law of conservation of ions, the concentration of barium would be half of hydroxide ions.

$[Ba^{2+}] = 0.5 \times 10^{-2}$

Solubility product Ksp = $[Ba^{2+}]\ [OH^-]^2$

Solubility product Ksp = $0.5 \times 10^{-2} \times (1 \times 10^{-2})^2$

Solubility product Ksp = 0.5×10^{-6}

Solubility product Ksp = 5×10^{-7}

Q12. If the pH of a saturated solution of $Ca(OH)_2$ is 9. What is the solubility product (Ksp) of $Ca(OH)_2$?

Answer: Reaction: $Ca(OH)_2 \rightleftharpoons Ca^{2+} + 2\ OH^-$

The pH of a saturated solution of $Ca(OH)_2$ = 9.

The pOH of a saturated solution of $Ca(OH)_2$ = 14 - pH.

The pOH of a saturated solution of $Ca(OH)_2$ = 14 - 9.

The pOH of a saturated solution of $Ca(OH)_2$ = 5.

We will now calculate the concentration of OH^- ions.

$[OH^-] = 10^{-pOH}$

$[OH^-] = 10^{-5}$

$[OH^-] = 1 \times 10^{-5}$

According to the law of conservation of ions, the concentration of calcium would be half of hydroxide ions.

$[Ca^{2+}] = 0.5 \times 10^{-5}$

Solubility product Ksp = $[Ca^{2+}]\ [OH^-]^2$

Solubility product Ksp = $0.5 \times 10^{-5} \times (1 \times 10^{-5})^2$

Solubility product Ksp = 0.5×10^{-15}

Solubility product Ksp = 5×10^{-16}

Q13. The solubility product (Ksp) of $BaSO_4$ is 1.5 X 10^{-9}. Calculate the solubility of barium sulphate in pure water and 0.1 M $BaCl_2$.
Answer: Reaction: $BaSO_4$ (s) ⟶ Ba^{2+} (aq) + SO_4^{2-} (aq)
Hence, Ksp = $[Ba^{2+}]$ $[SO_4^{2-}]$ = x
Then, 1.5 X 10^{-9} = x X x
x^2 = 15 X 10^{-10}
x = 3.87 X 10^{-5}
Then, the solubility of $BaSO_4$ in pure water is 3.87 X 10^{-5}.
Let the solubility of $BaSO_4$ in 0.1 M $BaCl_2$ be 's'
Reaction: $BaSO_4$ (s) ⟶ Ba^{2+} (aq) + SO_4^{2-} (aq)
Initial (From $BaCl_2$) 0
At equilibrium (0.1 M + s) s
Hence, 1.5 X 10^{-9} = (s + 0.1) X s = s X 0.1 (As s<<1)
s = 1.5 X 10^{-8}
Thus, the solubility of $BaSO_4$ in the presence of 0.1 M $BaCl_2$ is 1.5×10^{-8}.

Q14. What is the solubility of AgCl (s) if the solubility product of AgCl is 1.6×10^{-10} in 0.1 M NaCl solution?
Answer: Equation:
$AgCl \rightleftharpoons Ag^+ + Cl^-$
a 0 0
a - S S S + 0.1
The solubility product of AgCl Ksp = 1.6 X 10^{-10}
The solubility product of AgCl Ksp = $[Ag^+]$ $[Cl^-]$
The solubility product of AgCl Ksp = S (0.1 + S)
As the value of Ksp is very small.
We can ignore the value of S, with respect to 0.1 M.
1.6 X 10^{-10} = S X 0.1
S = 1.6 X 10^{-9} M
Hence, the solubility of AgCl (s) is 1.6 X 10^{-9} M.

Q15. If the Concentration of the Ag^+ ions in a saturated solution of $Ag_2C_2O_4$ is 2.2 X 10^{-4} $molL^{-1}$. What is the solubility product of $Ag_2C_2O_4$?
Answer: Given, Concentration of Ag^+ = 2.2 X 10^{-4} $molL^{-1}$
The concentration of C_2O_4 would be half of that of Ag.
Concentration of C_2O_4 = 0.5 X 2.2 X 10^{-4} $molL^{-1}$
Concentration of C_2O_4 = 1.1 X 10^{-4} $molL^{-1}$
Ksp = $[Ag^+]^2$ $[C_2O_4]$
Ksp = (2.2 X 10^{-4} $molL^{-1})^2$ X 1.1 X 10^{-4} $molL^{-1}$
Ksp = 5.3 X 10^{-12}
Hence, the solubility product of $Ag_2C_2O_4$ is 5.3 X 10^{-12}.

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Practise Questions on Common Ion Effect

Q1. If the solubility of $BaSO_4$ in water is 2.42 X 10^{-3} g L^{-1} at 298 K., What will be the solubility product (Ksp) of $BaSO_4$? Given the molar mass of $BaSO_4$ is 233 $gmol^{-1}$.

Answer: Given solubility of $BaSO_4$ in water S = 2.42 X 10^{-3} g L^{-1}

S = 2.42 X 10^{-3} g L^{-1} / 233 g mol^{-1}
S = 1.04 X 10^{-5} $molL^{-1}$

Ksp = $[Ba^{2+}]$ $[SO_4^{2-}]$
Ksp = S X S
Ksp = S^2
Ksp = (1.04 X 10^{-5} $molL^{-1})^2$
Ksp = 1.08 X 10^{-10} mol^2L^{-2}
Hence, the solubility product (Ksp) of $BaSO_4$ is 1.08 X 10^{-10} mol^2L^{-2}.

Q2. The Ksp of Ag_2CrO_4, AgCl, AgBr and AgI are respectively, 1.1 X 10^{-12}, 1.8 X 10^{-10}, 5.0 X 10^{-13}, 8.3 X 10^{-17}. Which one of the following salts will precipitate last if $AgNO_3$ solution is added to the solution containing equal moles of NaCl, NaBr, NaI and Na_2CrO_4?

Answer: Equation
$Ag_2CrO_4 \rightarrow 2\,Ag^+ + CrO_4^{2-}$
1 0 0
1-s 2s s

Ksp = $(2\,s)^2$ / 1 - s, s < < 1
Ksp = $4s^3$ = 1.1 X 10^{-12}
s = 6.5 X 10^{-5}

$AgCl \rightarrow Ag^+ + Cl^-$
s s
s^2 = 1.8 X 10^{-10}
s = 1.34 X 10^{-5}

Similarly s for AgBr and AgCl is 7.1 X 10^{-7} and 9 × 10^{-9} respectively since solubility of Ag_2CrO_4 is lightest, its precipitate will last.

Q3. Find out the solubility of $Ni(OH)_2$ in 0.1 M NaOH. Given that the ionic product of $Ni(OH)_2$ is 2 X 10^{-15}.

Answer: The value of α = 1 for NaOH
Equation
NaOH (aq) → Na^+ (aq) + OH^- (aq)
0.1M 0.1M

$Ni(OH)_2$ (s) ⇋ Ni^{+2} (aq) + 2 OH^- (aq)
S (0.1+2S)
Ionic product = $[Ni^{+2}] [OH^-]^2$
$2 \times 10^{-15} = [Ni^{+2}] [10^{-1}]^2$
$2 \times 10^{-13} = [Ni^{+2}]$

Q4. Let the solubilities of AgCl in H_2O, 0.01 M $CaCl_2$, 0.01 M NaCl and 0.05 M $AgNO_3$ be s1,s2,s3 and s4 respectively. What will be the correct relationship between these quantities?

Answer: Solubility of AgCl in water = $(Ksp)^{½}$
Solubility of AgCl in water = $(Ksp)^{½}$ = s1
In 0.01 M $CaCl_2$,
Solubility of AgCl in $CaCl_2$ = s X (0.01 X 2 + s)
Solubility of AgCl in $CaCl_2$ = Ksp / 0.02 = s2
In 0.01 M NaCl
Solubility of AgCl in NaCl = s X (0.01 + s)
Solubility of AgCl in NaCl = Ksp / 0.01 = s3
In 0.05 M $AgNO_3$
Solubility of AgCl in $AgNO_3$ = s X (0.05 + s)
Solubility of AgCl in $AgNO_3$ = Ksp / 0.05 = s4

The solubilities are derived by neglecting s compared to 0.02, 0.01, and 0.05.
So the order is s1 > s3 > s2 > s4.

Q5. If the pH of a saturated solution of $Mg(OH)_2$ is 9. What is the solubility product (Ksp) of $Mg(OH)_2$?
Answer: Reaction: $Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2\ OH^-$
The pH of a saturated solution of $Mg(OH)_2$ = 9.
The pOH of a saturated solution of $Mg(OH)_2$ = 14 - pH.
The pOH of a saturated solution of $Mg(OH)_2$ = 14 - 9.
The pOH of a saturated solution of $Mg(OH)_2$ = 5.

We will now calculate the concentration of OH^- ions.
$[OH^-] = 10^{-pOH}$

$[OH^-] = 10^{-5}$
$[OH^-] = 1 \times 10^{-5}$
According to the law of conservation of ions, the concentration of magnesium would be half of hydroxide ions.
$[Mg^{2+}] = 0.5 \times 10^{-5}$

Solubility product Ksp = $[Mg^{2+}] [OH^-]^2$
Solubility product Ksp = $0.5 \times 10^{-5} \times (1 \times 10^{-5})^2$
Solubility product Ksp = 0.5×10^{-15}
Solubility product Ksp = 5×10^{-16}