



DPP-12 (Solubility Product – K_{sp})-Solutions

Chapter: Ionic Equilibrium

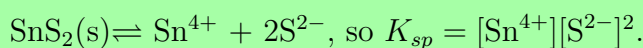
“Some are studying to escape poverty. Some to fulfill a promise. What are you doing this for?”

GROUP-A : K_{sp} EXPRESSION

Q1. The correct representation of solubility product of SnS_2 is :-

- (1) $[\text{Sn}^{4+}][\text{S}^{2-}]^2$
- (2) $[\text{Sn}^{4+}][\text{S}^{2-}]$
- (3) $[\text{Sn}^{4+}][2\text{S}^{2-}]$
- (4) $[\text{Sn}^{4+}][2\text{S}^{2-}]^2$

Write dissociation using stoichiometric coefficients as powers in K_{sp} .



Correct option: (1)

Q2. K_{sp} of $\text{Ca}_3(\text{PO}_4)_2$ is :-

- (1) $[\text{Ca}^{2+}][\text{PO}_4^{3-}]^2$
- (2) $[\text{Ca}^{2+}]^3[\text{PO}_4^{3-}]^2$
- (3) $[\text{Ca}^{2+}]^2[\text{PO}_4^{3-}]^3$
- (4) $[\text{Ca}^{2+}][\text{PO}_4^{3-}]$

$\text{Ca}_3(\text{PO}_4)_2$ gives 3 Ca^{2+} and 2 PO_4^{3-} .

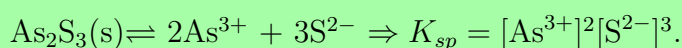


Correct option: (2)

Q3. The solubility product of As_2S_3 is given by the expression :-

- (1) $K_{sp} = [\text{As}^{3+}][\text{S}^{2-}]$
- (2) $K_{sp} = [\text{As}^{3+}][\text{S}^{2-}]^2$
- (3) $K_{sp} = [\text{As}^{3+}]^3[\text{S}^{2-}]^2$
- (4) $K_{sp} = [\text{As}^{3+}]^2[\text{S}^{2-}]^3$

Use coefficients as powers.

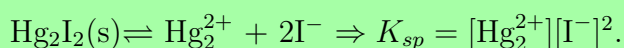


Correct option: (4)

Q4. The expression of solubility product of mercurous iodide is :-

- (1) $[2\text{Hg}^+]^2 \times 2[\text{I}^-]^2$
- (2) $[\text{Hg}^+]^2[\text{I}^-]^2$
- (3) $[\text{Hg}_2^{2+}][\text{I}^-]^2$
- (4) $[\text{Hg}_2^{2+}]^2[\text{I}^-]^2$

Mercurous iodide is Hg_2I_2 and mercurous ion is Hg_2^{2+} .



Correct option: (3)

Q5. What will be the solubility product of AX_3 :-

- (1) $27s^4$
- (2) $4s^3$
- (3) $36s^4$
- (4) $9s^3$

Assume $\text{AX}_3(\text{s}) \rightleftharpoons \text{A}^{3+} + 3\text{X}^-$ and molar solubility = s .

$$K_{sp} = [\text{A}^{3+}][\text{X}^-]^3 = s(3s)^3 = 27s^4.$$

Correct option: (1)

Q6. If the solubility of lithium sodium hexafluoro aluminate $\text{Li}_2\text{Na}_3(\text{AlF}_6)_2$ is $S \text{ mol L}^{-1}$. Its solubility product is equal to :-

- (1) S^8
- (2) $12S^3$
- (3) $18S^3$
- (4) $2916S^8$

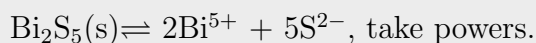
Write ions and then plug [] in terms of S .

Note: To match correct stoichiometry, the intended neutral formula is effectively $\text{Li}_3\text{Na}_3(\text{AlF}_6)_2$. Dissociation: $\text{Li}_3\text{Na}_3(\text{AlF}_6)_2(\text{s}) \rightleftharpoons 3\text{Li}^+ + 3\text{Na}^+ + 2(\text{AlF}_6)^{3-}$. So $K_{sp} = (3S)^3(3S)^3(2S)^2 = 27 \cdot 27 \cdot 4S^8 = 2916S^8$.

Correct option: (4)

Q7. The solubility of sparingly soluble salt Bi_2S_5 is S mol dm^{-3} . Its solubility product is :-

- (1) $6250 S^5$
- (2) $3125 S^6$
- (3) $108 S^7$
- (4) $12500 S^7$



$$K_{sp} = (2S)^2(5S)^5 = 4 \cdot 3125 S^7 = 12500 S^7.$$

Correct option: (4)

Q8. If the solubility of PbBr_2 is S g-molecules per litre, considering 100% ionisation its solubility product is :-

- (1) $2S^3$
- (2) $4S^2$
- (3) $4S^3$
- (4) $2S^4$

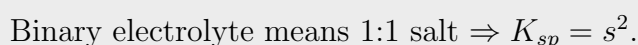


$$K_{sp} = s(2s)^2 = 4s^3.$$

Correct option: (3)

Q9. If s and S are respectively solubility and solubility product of a sparingly soluble binary electrolyte then :-

- (1) $s = S$
- (2) $s = S^2$
- (3) $s = S^{1/2}$
- (4) $s = \frac{1}{2}S$



$$\text{So } s = \sqrt{K_{sp}} = S^{1/2}.$$

Correct option: (3)

Q10. The solubility product of sparingly soluble univalent salt is defined as the product of ionic concentration in a :-

- (1) 1 M solution

- (2) Concentrated solution
- (3) Very dilute solution
- (4) Saturated solution

K_{sp} is defined at saturation equilibrium.

Correct option: (4) Saturated solution

GROUP-B : FINDING K_{sp} FROM SOLUBILITY OR [ION]

Q11. Solubility of MX_2 -type electrolytes is $0.5 \times 10^{-4} \text{ mol L}^{-1}$ then find out K_{sp} of electrolytes :-

- (1) 5×10^{-12}
- (2) 25×10^{-10}
- (3) 1×10^{-13}
- (4) 5×10^{-13}

$MX_2: K_{sp} = 4s^3.$

$s = 0.5 \times 10^{-4} = 5 \times 10^{-5}$, so $K_{sp} = 4(5 \times 10^{-5})^3 = 4(125 \times 10^{-15}) = 5 \times 10^{-13}.$

Correct option: (4)

Q12. Solubility of $BaSO_4 = 2.42 \times 10^{-3} \text{ g/L}$. K_{sp} is :-

- (1) 1.08×10^{-10}
- (2) 1.08×10^{-12}
- (3) 1.08×10^{-14}
- (4) 1.08×10^{-8}

Convert to molar solubility s then for 1:1 salt $K_{sp} = s^2.$

$M(BaSO_4) \approx 233. s = \frac{2.42 \times 10^{-3}}{233} \approx 1.04 \times 10^{-5}. K_{sp} = s^2 \approx (1.04 \times 10^{-5})^2 \approx 1.08 \times 10^{-10}.$

Correct option: (1)

Q13. If solubility of $AgCl$ is $1.43 \times 10^{-4} \text{ g/100mL}$, K_{sp} is :-

- (1) 1×10^{-5}
- (2) 2×10^{-5}
- (3) 1×10^{-10}
- (4) 2×10^{-10}

Convert to g/L then mol/L, then square.

$$1.43 \times 10^{-4} \text{ g/100 mL} = 1.43 \times 10^{-3} \text{ g/L. } M(\text{AgCl}) \approx 143.5, \text{ so } s \approx \frac{1.43 \times 10^{-3}}{143.5} \approx 1.0 \times 10^{-5}.$$
$$K_{sp} = s^2 \approx 1 \times 10^{-10}.$$

Correct option: (3)

Q14. One litre of saturated solution of CaCO_3 is evaporated to dryness, when 7.0 g of residue is left. The solubility product for CaCO_3 is:-

- (1) 4.9×10^{-3}
- (2) 4.9×10^{-5}
- (3) 4.9×10^{-9}
- (4) 4.9×10^{-7}

Residue gives molar solubility in 1 L; for 1:1 salt $K_{sp} = s^2$.

$$M(\text{CaCO}_3) = 100. \text{ Moles in 1 L} = 7/100 = 0.07 = s. K_{sp} = s^2 = (0.07)^2 = 0.0049 = 4.9 \times 10^{-3}.$$

Correct option: (1)

Q15. Concentration of Ag^+ in saturated Ag_2CrO_4 is 1.5×10^{-4} M. K_{sp} is :-

- (1) 3.3750×10^{-12}
- (2) 1.6875×10^{-10}
- (3) 1.68×10^{-12}
- (4) 1.6875×10^{-11}

Ag_2CrO_4 : $K_{sp} = [\text{Ag}^+]^2[\text{CrO}_4^{2-}]$ and $[\text{Ag}^+] = 2s$.

$$2s = 1.5 \times 10^{-4} \Rightarrow s = 7.5 \times 10^{-5}. K_{sp} = (1.5 \times 10^{-4})^2(7.5 \times 10^{-5}) = 1.6875 \times 10^{-12} \approx 1.68 \times 10^{-12}.$$

Correct option: (3)

Q16. If the concentration of CrO_4^{2-} ion in a saturated solution of silver chromate will be 2×10^{-4} M, solubility product of silver chromate will be :-

- (1) 4×10^{-8}
- (2) 8×10^{-10}
- (3) 32×10^{-12}
- (4) 6×10^{-12}

If $[\text{CrO}_4^{2-}] = s$, then $[\text{Ag}^+] = 2s$.

$$s = 2 \times 10^{-4}, \text{ so } [\text{Ag}^+] = 4 \times 10^{-4}. K_{sp} = (4 \times 10^{-4})^2(2 \times 10^{-4}) = 32 \times 10^{-12}.$$

Correct option: (3)

GROUP-C : FIND SOLUBILITY (s) FROM K_{sp}

Q17. The K_{sp} for Cr(OH)₃ is 1.6×10^{-30} . The molar solubility is :-

- (1) $\sqrt[3]{\frac{1.6 \times 10^{-30}}{3}}$
- (2) $\sqrt[4]{1.6 \times 10^{-30}}$
- (3) $\sqrt[4]{\frac{1.6 \times 10^{-30}}{27}}$
- (4) $\frac{1.6 \times 10^{-30}}{27}$

Cr(OH)₃: $K_{sp} = 27s^4$.

$$K_{sp} = s(3s)^3 = 27s^4 \Rightarrow s = \sqrt[4]{\frac{K_{sp}}{27}}$$

Correct option: (3)

Q18. Solubility of A₂X₃ if $K_{sp} = 1.08 \times 10^{-23}$:-

- (1) 10^{-5} M
- (2) 3.7×10^{-4} M
- (3) 1.2×10^{-3} M
- (4) 7.5×10^{-4} M

A₂X₃: $K_{sp} = 108s^5$.

$$K_{sp} = (2s)^2(3s)^3 = 108s^5. \quad s^5 = \frac{1.08 \times 10^{-23}}{108} = 10^{-25} \Rightarrow s = 10^{-5} \text{ M.}$$

Correct option: (1)

Q19. M₂SO₄ has $K_{sp} = 1.2 \times 10^{-5}$. Max [M⁺] is :-

- (1) 3.46×10^{-3}
- (2) 2.89×10^{-2}
- (3) 2.8×10^{-3}
- (4) 7×10^{-3}

M₂SO₄: $K_{sp} = 4s^3$ and $[M^+] = 2s$.

$$4s^3 = 1.2 \times 10^{-5} \Rightarrow s^3 = 3 \times 10^{-6} \Rightarrow s \approx 1.44 \times 10^{-2}. \text{ So } [M^+] = 2s \approx 2.88 \times 10^{-2}.$$

Correct option: (2)

Q20. K_{sp} of $\text{Sr}(\text{OH})_2$ is x , then calculate value of $[\text{OH}^-]$ in saturated solution?

- (1) $\left(\frac{3x}{4}\right)^{1/3}$
- (2) $\left(\frac{x}{4}\right)^{1/3}$
- (3) $\left(\frac{x}{4}\right)^{1/2}$
- (4) $\left(\frac{x}{3}\right)^{1/4}$

$\text{Sr}(\text{OH})_2$: if solubility = s , then $[\text{OH}^-] = 2s$ and $K_{sp} = s(2s)^2 = 4s^3$.

From $4s^3 = x \Rightarrow s = \left(\frac{x}{4}\right)^{1/3}$. Hence $[\text{OH}^-] = 2s = 2\left(\frac{x}{4}\right)^{1/3} = (2x)^{1/3}$.

Note: The correct expression is $(2x)^{1/3}$; the matching option seems misprinted in the PDF.

Answer: $[\text{OH}^-] = (2x)^{1/3}$ (Option mismatch due to print-typo)

Q21. The K_{sp} value for $\text{Gd}(\text{OH})_3$ is 2.8×10^{-23} , the pH of $\text{Gd}(\text{OH})_3$ in saturated solution :-

- (1) 6.08
- (2) 5.08
- (3) 8.47
- (4) 4.08

$\text{Gd}(\text{OH})_3$: $K_{sp} = 27s^4$ and $[\text{OH}^-] = 3s$.

$27s^4 = 2.8 \times 10^{-23} \Rightarrow s \approx 1.0 \times 10^{-6}$. So $[\text{OH}^-] \approx 3 \times 10^{-6}$, $pOH \approx 5.52$, $pH \approx 14 - 5.52 = 8.48 \approx 8.47$.

Correct option: (3) 8.47

Q22. pH of saturated $\text{Ba}(\text{OH})_2 = 12$. K_{sp} is :-

- (1) 5.00×10^{-7}
- (2) 4.00×10^{-6}
- (3) 4.00×10^{-7}
- (4) 5.00×10^{-6}

pH 12 $\Rightarrow pOH = 2 \Rightarrow [\text{OH}^-] = 10^{-2}$.

For $\text{Ba}(\text{OH})_2$: $[\text{Ba}^{2+}] = \frac{[\text{OH}^-]}{2} = 5 \times 10^{-3}$. $K_{sp} = [\text{Ba}^{2+}][\text{OH}^-]^2 = 5 \times 10^{-3} \times (10^{-2})^2 = 5 \times 10^{-7}$.

Correct option: (1)

Q23. K_{sp} of $\text{AgCl} = 2.56 \times 10^{-10}$. Volume needed to dissolve 0.01 mol :-

- (1) 800 L
- (2) 400 L
- (3) 625 L
- (4) 50 L

AgCl is 1:1, so $s = \sqrt{K_{sp}}$ and volume $V = \frac{n}{s}$.

$$s = \sqrt{2.56 \times 10^{-10}} = 1.6 \times 10^{-5} \text{ M. } V = \frac{0.01}{1.6 \times 10^{-5}} = 625 \text{ L.}$$

Correct option: (3) 625 L

Q24. How many grams of CaC_2O_4 dissolve in 1L? $K_{sp} = 2.5 \times 10^{-9}$

- (1) 0.0064 g
- (2) 0.0128 g
- (3) 0.0032 g
- (4) 0.064 g

CaC_2O_4 is 1:1, so $s = \sqrt{K_{sp}}$.

$$s = \sqrt{2.5 \times 10^{-9}} = 5 \times 10^{-5} \text{ M. } M(\text{CaC}_2\text{O}_4) = 128, \text{ grams in 1L} = s \times 128 = 5 \times 10^{-5} \times 128 = 6.4 \times 10^{-3} \text{ g.}$$

Correct option: (1) 0.0064 g

Q25. Volume of water needed to dissolve 1g BaSO_4 ($K_{sp} = 1.1 \times 10^{-10}$) :-

- (1) 820 L
- (2) 1 L
- (3) 205 L
- (4) 430 L

BaSO_4 is 1:1, so $s = \sqrt{K_{sp}}$. Then grams per L = $s \times M$.

$$s = \sqrt{1.1 \times 10^{-10}} \approx 1.05 \times 10^{-5} \text{ M. } M(\text{BaSO}_4) \approx 233, \text{ so g/L} \approx 233 \times 1.05 \times 10^{-5} \approx 2.44 \times 10^{-3}. \\ \text{Volume for 1 g} \approx \frac{1}{2.44 \times 10^{-3}} \approx 4.1 \times 10^2 \approx 430 \text{ L (nearest).}$$

Correct option: (4) 430 L

Q26. K_{sp} of $\text{CaSO}_4 \cdot 5\text{H}_2\text{O}$ is 9×10^{-6} , Find the volume of CaSO_4 for 1 gm (Mw = 136)

- (1) 2.45 litre
- (2) 5.1 litre
- (3) 4.52 litre
- (4) 3.2 litre

Treat as 1:1: $\text{Ca}^{2+} + \text{SO}_4^{2-}$, so $K_{sp} = s^2$.

$$s = \sqrt{9 \times 10^{-6}} = 3 \times 10^{-3} \text{ M. g/L} = s \times 136 = 0.003 \times 136 = 0.408 \text{ g/L. Volume for 1 g} \\ = \frac{1}{0.408} \approx 2.45 \text{ L.}$$

Correct option: (1) 2.45 litre

GROUP-D : RELATION BETWEEN K_{sp} SOLUBILITY ORDER

Q27. The solubility product of CuS , Ag_2S and HgS are 10^{-37} , 10^{-44} and 10^{-54} respectively. The solubility order is :-

- (1) $\text{HgS} > \text{Ag}_2\text{S} > \text{CuS}$
- (2) $\text{Ag}_2\text{S} > \text{HgS} > \text{CuS}$
- (3) $\text{CuS} > \text{Ag}_2\text{S} > \text{HgS}$
- (4) $\text{Ag}_2\text{S} > \text{CuS} > \text{HgS}$

Compare molar solubility using correct stoichiometry.

$$\text{CuS and HgS are 1:1} \Rightarrow s = \sqrt{K_{sp}}. \text{ Ag}_2\text{S is 2:1} \Rightarrow K_{sp} = 4s^3 \Rightarrow s = (K_{sp}/4)^{1/3}. \text{ Numerically:} \\ s(\text{Ag}_2\text{S}) \sim 10^{-15} \gg s(\text{CuS}) \sim 10^{-18.5} \gg s(\text{HgS}) \sim 10^{-27}.$$

Correct option: (4) $\text{Ag}_2\text{S} > \text{CuS} > \text{HgS}$

Q28. Which of the following has maximum solubility (K_{sp} value is given in brackets) :-

- (1) HgS (1.6×10^{-54})
- (2) PbSO_4 (1.3×10^{-8})
- (3) ZnS (7.0×10^{-26})
- (4) AgCl (1.7×10^{-10})

All are 1:1 salts, so larger $K_{sp} \Rightarrow$ larger solubility.

Correct option: (2) PbSO_4

Q29. Maximum soluble is :- (K_{sp} is given)

- (1) CuS (8.5×10^{-36})
- (2) CdS (3.6×10^{-28})
- (3) ZnS (1.2×10^{-28})

(4) MnS (1.4×10^{-10})

All are 1:1; compare K_{sp} directly.

Correct option: (4) MnS

Q30. If the solubility product of AgBrO_3 and Ag_2SO_4 are 5.5×10^{-5} and 2×10^{-5} respectively, then :-

- (1) $s_{\text{AgBrO}_3} > s_{\text{Ag}_2\text{SO}_4}$
- (2) $s_{\text{AgBrO}_3} = s_{\text{Ag}_2\text{SO}_4}$
- (3) $s_{\text{AgBrO}_3} < s_{\text{Ag}_2\text{SO}_4}$
- (4) Can't predict

AgBrO_3 is 1:1 so $s = \sqrt{K_{sp}}$; Ag_2SO_4 is 2:1 so $4s^3 = K_{sp}$.

$s_{\text{AgBrO}_3} = \sqrt{5.5 \times 10^{-5}} \approx 7.4 \times 10^{-3}$. $s_{\text{Ag}_2\text{SO}_4} = \left(\frac{2 \times 10^{-5}}{4}\right)^{1/3} = (5 \times 10^{-6})^{1/3} \approx 1.7 \times 10^{-2}$. So $s_{\text{AgBrO}_3} < s_{\text{Ag}_2\text{SO}_4}$.

Correct option: (3)

Q31. MY and NY_3 , two nearly insoluble salts, have the same K_{sp} values of 6.2×10^{-13} . Which statement is true?

- (1) The molar solubilities of MY and NY_3 are identical.
- (2) The molar solubility of MY in water is less than that of NY_3 .
- (3) The salts MY and NY_3 are more soluble in 0.5 M KY than in pure water.
- (4) The addition of KY will have no effect on solubility.

Different stoichiometry gives different s even if K_{sp} is same.

MY (1:1): $K_{sp} = s^2 \Rightarrow s = \sqrt{6.2 \times 10^{-13}} \sim 10^{-6.1}$. NY_3 (1:3): $K_{sp} = 27s^4 \Rightarrow s = \left(\frac{K_{sp}}{27}\right)^{1/4} \sim 10^{-4}$. So NY_3 has much higher solubility.

Correct option: (2)

Q32. The solubility product of three sparingly soluble salts: PQ : 4.0×10^{-20} , PQ_2 : 3.2×10^{-14} , PQ_3 : 2.7×10^{-35} . Order of decreasing molar solubility is :-

- (1) 1, 2, 3
- (2) 2, 1, 3
- (3) 3, 2, 1
- (4) 2, 3, 1

Use: PQ (1:1) $\Rightarrow s = \sqrt{K_{sp}}$; PQ₂ (1:2) $\Rightarrow 4s^3 = K_{sp}$; PQ₃ (1:3) $\Rightarrow 27s^4 = K_{sp}$.

PQ: $s_1 = \sqrt{4 \times 10^{-20}} = 2 \times 10^{-10}$. PQ₂: $s_2 = \left(\frac{3.2 \times 10^{-14}}{4}\right)^{1/3} = (8 \times 10^{-15})^{1/3} = 2 \times 10^{-5}$.
PQ₃: $s_3 = \left(\frac{2.7 \times 10^{-35}}{27}\right)^{1/4} = (10^{-36})^{1/4} = 10^{-9}$. So $s_2 > s_3 > s_1$.

Correct option: (4) 2, 3, 1

Q33. If the salts M₂X, QY₂ and PZ₂ have the same solubilities, their K_{sp} values are related as – (S < 1)

- (1) M₂X = QY₂ < PZ₂
- (2) M₂X > QY₂ > PZ₂
- (3) M₂X = PZ₂ < QY₂
- (4) M₂X < QY₂ < PZ₂

For same molar solubility = S: 2:1 or 1:2 salts $\Rightarrow K_{sp} = 4S^3$; 1:1 salts $\Rightarrow K_{sp} = S^2$ and for $S < 1$, $S^2 > 4S^3$.

M₂X is 2:1 $\Rightarrow K_{sp} = 4S^3$. PZ₂ is 1:2 $\Rightarrow K_{sp} = 4S^3$. QY₂ is treated as effectively 1:1 (Q²⁺ with (Y₂)²⁻), so $K_{sp} = S^2$. Since $S < 1$, S^2 is larger than $4S^3$.

Correct option: (3) M₂X = PZ₂ < QY₂

GROUP-E : COMMON ION

Q34. At 25°C, K_{sp} of AgCl is 1.8 × 10⁻¹⁰. If 10⁻⁵ mol Ag⁺ is added, K_{sp} becomes :-

- (1) 1.8 × 10⁻¹⁵
- (2) 1.8 × 10⁻¹⁰
- (3) 1.8 × 10⁻⁵
- (4) 18 × 10⁻¹⁰

K_{sp} depends only on temperature, not on adding ions.

Correct option: (2) 1.8 × 10⁻¹⁰

Q35. K_{sp} of Ni(OH)₂ = 2 × 10⁻¹⁵. Solubility in 0.01 M NaOH :-

- (1) 2 × 10⁻¹⁵
- (2) 2^{1/3} × 10⁻⁵
- (3) 2 × 10⁻¹¹
- (4) 10⁻⁷

Common ion: $[\text{OH}^-] \approx 0.01$ (dominant), and $K_{sp} = [\text{Ni}^{2+}][\text{OH}^-]^2$.

Let solubility in NaOH be s , so $[\text{Ni}^{2+}] = s$. $2 \times 10^{-15} = s(10^{-2})^2 = s \times 10^{-4} \Rightarrow s = 2 \times 10^{-11}$.

Correct option: (3) 2×10^{-11}

Weird Chemist Tip: K_{sp} yaad nahi? Pehle dissociation likh, phir coefficients ko powers bana—bas!