CHEMISTRY 12  
SOLUBILITY REVIEW QUESTIONS

1. The equation for silver chromate dissolving in water is
   \[ Ag_2CrO_4(s) \rightleftharpoons 2 Ag^+(aq) + CrO_4^{2-}(aq) \]
   What is the \( K_{sp} \) expression?
   a) \([Ag^+]^2[CrO_4^{2-}]\)
   b) \([Ag^+]^2[CrO_4^{2-}]\)
   c) \([2 Ag^+][CrO_4^{2-}]\)
   d) \([Ag^+]^2[CrO_4^{2-}]\)

2. What is the solubility of silver chloride, \( AgCl \), in water, given
   \( K_{sp}(AgCl) = 1.8 \times 10^{-10} \)?
   a) \(3.24 \times 10^{-20} \text{ M}\)
   b) \(1.80 \times 10^{-10} \text{ M}\)
   c) \(1.34 \times 10^{-5} \text{ M}\)
   d) \(1.9 \times 10^{-5} \text{ M}\)

3. What is the solubility of lead II iodide (\( PbI_2 \)) in water, given
   \( K_{sp}(PbI_2) = 7.10 \times 10^{-9} \)?
   a) \(7.10 \times 10^{-9} \text{ M}\)
   b) \(8.44 \times 10^{-5} \text{ M}\)
   c) \(1.92 \times 10^{-3} \text{ M}\)
   d) \(1.21 \times 10^{-3} \text{ M}\)

4. 10.0 mL of 1.00 \( \times 10^{-5} \text{ M AgNO}_3 \) and 30.0 mL of 2.00 \( \times 10^{-4} \text{ M NaCl} \) are mixed.
   \( K_{sp}(AgCl) = 1.8 \times 10^{-10} \). Which one of the following occurs?
   a) Ion product is \(3.75 \times 10^{-10} \) and precipitate forms.
   b) Ion product is \(3.75 \times 10^{-10} \) and precipitate does not form.
   c) Ion product is \(2.00 \times 10^{-9} \) and precipitate forms.
   d) Ion product is \(2.00 \times 10^{-9} \) and precipitate does not form.

5. What is the highest concentration of magnesium ion possible at equilibrium in a
   solution containing 2.0 \( \times 10^{-2} \text{ M oxalate ions (C}_2\text{O}_4^{2-}) \) given that
   \( K_{sp}(MgC}_2\text{O}_4) = 8.6 \times 10^{-5} \)?
   a) \(4.3 \times 10^{-3} \text{ M}\)
   b) \(5.16 \times 10^{-2} \text{ M}\)
   c) \(1.04 \times 10^{-1} \text{ M}\)
   d) \(2.33 \times 10^{-2} \text{ M}\)
6. What is the equilibrium concentration of $\text{Sr}^{2+}$ (aq) in a saturated aqueous solution of $\text{SrSO}_4$? ($K_{sp}$ of $\text{SrSO}_4 = 2.3 \times 10^{-7}$)
   a) $1.4 \times 10^{-7}$ M
   b) $2.8 \times 10^{-7}$ M
   c) $5.3 \times 10^{-4}$ M
   d) $5.3 \times 10^{-3}$ M

7. $\text{PbCl}_2(s)$ is precipitated from a solution containing $\text{Pb}^{2+}$ (aq) and $\text{Cl}^-$ (aq). Which one of the following relationships describes the concentrations of the ions remaining in solution?
   a) $[\text{Pb}^{2+}]^{2}[\text{Cl}^-] = K_{sp}$ of $\text{PbCl}_2(s)$
   b) $[\text{Pb}^{2+}]^{2}[\text{Cl}^-] = K_{sp}$ of $\text{PbCl}_2(d)$
   c) $[\text{Pb}^{2+}][\text{Cl}^-]^2 = K_{sp}$ of $\text{PbCl}_2(s)$
   d) $[\text{Pb}^{2+}][\text{Cl}^-]^2 = K_{sp}$ of $\text{PbCl}_2(d)$

8. Which one of the following statements is TRUE about the result of mixing equal volumes of 0.020 M $\text{CaCl}_2$ and 0.00040 M $\text{MgSO}_4$? ($K_{sp}$ for $\text{CaSO}_4(s) = 2.4 \times 10^{-5}$)
   a) The trial product is smaller than the $K_{sp}$ and a precipitate will form.
   b) The trial product is larger than the $K_{sp}$ and a precipitate will form.
   c) The trial product is smaller than the $K_{sp}$ and a precipitate will not form.
   d) The trial product is larger than the $K_{sp}$ and a precipitate will not form.

9. Which one of the following is the correct relationship between the solubility and the solubility product of lead II chloride ($\text{PbCl}_2$)?
   a) Solubility = $K_{sp}$
   b) Solubility = $\sqrt{K_{sp}}$
   c) Solubility = $\sqrt[3]{K_{sp}}$
   d) Solubility = $\sqrt[4]{K_{sp}}$

10. The $K_{sp}$ for the salt $\text{MA}_2$ is $4.0 \times 10^{-5}$. What is the [M$^{2+}$] in a saturated solution formed by dissolving $\text{MA}_2(s)$ in water?
    a) $1.0 \times 10^{-3}$ M
    b) $2.0 \times 10^{-3}$ M
    c) $1.0 \times 10^{-2}$ M
    d) $1.6 \times 10^{-2}$ M
11. Silver acetate, AgCH$_3$COO (aq), crystals are in equilibrium with a saturated solution. Which of the following would cause more AgCH$_3$COO (aq) to dissolve?
   a) The addition of a few crystals of silver nitrate.
   b) The addition of a few drops of concentrated nitric acid.
   c) The addition of a few crystals of sodium acetate.
   d) The evaporation of some water from the solution with no temperature change.

12. 1.0 L of a saturated solution of thallium bromide (TIBr) was evaporated to dryness to produce 0.56 g of TIBr(s). What is the K$_{sp}$ of thallium bromide? (molar mass of TIBr = 284 g/mol)
   a) 2.0 x 10$^{-6}$
   b) 3.9 x 10$^{-6}$
   c) 2.0 x 10$^{-3}$
   d) 4.4 x 10$^{-2}$

13. A solution contains Ba$^{2+}$(aq), Pb$^{2+}$(aq), Fe$^{2+}$(aq), and Mg$^{2+}$(aq). Which of the following negative ions would cause a precipitate with only one of these metals?
   a) I$^-$ (aq)
   b) SO$_4^{2-}$(aq)
   c) NO$_3^-$(aq)
   d) PO$_4^{3-}$(aq)

14. The K$_{sp}$ for PbS is 3.4 x 10$^{-28}$. What is the [S$^{2-}$] in a saturated solution of PbS?
   a) 4.4 x 10$^{-10}$ M
   b) 5.9 x 10$^{-13}$ M
   c) 1.8 x 10$^{-14}$ M
   d) 1.7 x 10$^{-28}$ M

15. Phosphate ions, PO$_4^{3-}$, form a compound of low solubility with
   a) NH$_4^+$
   b) K$^-$
   c) H$^+$
   d) Ca$^{2+}$

16. Some solid NaCH$_3$COO is added to a saturated AgCH$_3$COO solution in contact with AgCH$_3$COO crystals. Which of the following occurs?
   a) The NaCH$_3$COO solid does not dissolve.
   b) More AgCH$_3$COO dissolves.
   c) AgCH$_3$COO precipitates.
   d) There is no change in the amount of dissolved AgCH$_3$COO.

17. The process by which ions are surrounded by water molecules is called
   a) hydration.
   b) ionization.
   c) hydrolysis.
   d) dissociation.
18. Which is the most soluble of the silver salts listed below?

- a) AgBr \( K_{sp} = 5.0 \times 10^{-13} \)
- b) AgBrO₃ \( K_{sp} = 4.0 \times 10^{-5} \)
- c) AgCl \( K_{sp} = 1.7 \times 10^{-10} \)
- d) AgI \( K_{sp} = 4.0 \times 10^{-8} \)

19. When crystals of ammonium chloride are added to water, the crystals dissolve readily and the temperature decreases. The dissolving of ammonium chloride in water is therefore

- a) endothermic and spontaneous.
- b) exothermic and spontaneous.
- c) endothermic but not spontaneous.
- d) exothermic but not spontaneous.

20. Which of the following anions in a concentrated solution will form a precipitate with 0.10 M Pb²⁺ but will not form a precipitate with 0.10 M Ba²⁺?

- a) CO₂⁻
- b) SO₄²⁻
- c) PO₄³⁻
- d) Cl⁻

21. \( K_{sp} \) for PbCO₃ is 3.2 \( \times \) 10⁻¹⁴. What is the solubility of PbCO₃ in moles per litre?

- a) 1.6 \( \times \) 10⁻¹⁴
- b) 1.8 \( \times \) 10⁻⁷
- c) 2.0 \( \times \) 10⁻⁵
- d) 1.9 \( \times \) 10⁻²⁷

22. A solution of SrCl₂ is added to a solution of CuSO₄ and a precipitate forms. According to the solubility table, the precipitate is probably

- a) SrSO₄
- b) CuCl₂
- c) CuCl₃
- d) Both SrSO₄ and CuCl

23. 20.0 mL of 0.012 M AgNO₃ is added to 20.0 mL of 0.018 M NaBrO₃. The \( K_{sp} \) for AgBrO₃ is 5.8 \( \times \) 10⁻³. Which of the following statements is correct?

- a) The trial ion product is 2.2 \( \times \) 10⁻⁴ and a precipitate will form.
- b) The trial ion product is 2.2 \( \times \) 10⁻⁴ and a precipitate will not form.
- c) The trial ion product is 5.4 \( \times \) 10⁻⁵ and a precipitate will form.
- d) The trial ion product is 3.4 \( \times \) 10⁻⁵ and a precipitate will not form.

24. According to the table of solubilities, what will happen when 0.1 M solutions of Ba(OH)₂ and Fe₂(SO₄)₃ are mixed.

- a) No precipitates will form.
- b) Only BaSO₄ will precipitate.
- c) Only Fe(OH)₃ will precipitate.
- d) Both BaSO₄ and Fe(OH)₃ will precipitate.
25. The equation for the dissolving of Ag₂SO₄ in water is
   \[ \text{Ag}_2\text{SO}_4(s) \rightleftharpoons 2\text{Ag}^+(aq) + \text{SO}_4^{2-}(aq) \]
   If Ag₂SO₄(s) is in equilibrium with a saturated solution, which of the following will result in more Ag₂SO₄(s) dissolving?
   a) Add H₂SO₄ solution.
   b) Add AgNO₃.
   c) Add more Ag₂SO₄(s).
   d) Add Cl⁻ which precipitates AgCl.

26. The solubility of copper(I) bromide, CuBr, is 2.0 \times 10⁻⁴ mol/L. What is the value of K_sp for CuBr?
   a) 3.2 \times 10⁻¹¹ M
   b) 4.0 \times 10⁻⁴ M
   c) 1.4 \times 10⁻² M
   d) 2.9 \times 10⁻² M

27. What is the maximum [Mg²⁺] that can exist in a solution of 1.0 \times 10⁻³ M NaOH without precipitating Mg(OH)₂? (K_sp for Mg(OH)₂ is 1.2 \times 10⁻¹¹)
   a) 1.2 \times 10⁻⁹ M
   b) 1.2 \times 10⁻¹ M
   c) 1.4 \times 10⁻¹ M
   d) 5.0 \times 10⁻¹ M

28. Which one of the following statements is TRUE about what occurs when 30.0 mL of 8.00 \times 10⁻⁴ M Ca(NO₃)₂ is mixed with 10.0 mL of 3.0 \times 10⁻² M NaF?
   (K_sp for CaF₂ = 4.9 \times 10⁻¹²)
   a) The trial ion product is 4.5 \times 10⁻¹⁰ and a precipitate forms.
   b) The trial ion product is 2.4 \times 10⁻¹⁰ and a precipitate forms.
   c) The trial ion product is 3.4 \times 10⁻¹⁰ and a precipitate does not form.
   d) The trial ion product is 4.5 \times 10⁻¹⁰ and a precipitate does not form.

29. Which one of the following conditions will result in the formation of a precipitate of AgCl when solid NaCl is added to a solution of silver nitrate (AgNO₃)?
   a) The product of the molar concentrations of aqueous Ag⁺ and Cl⁻ ions is less than the K_sp for AgCl.
   b) No precipitate will occur unless the solution becomes saturated with NaCl first.
   c) The product of the molar concentrations of aqueous Ag⁺ and Cl⁻ ions exceeds the K_sp of AgCl.
   d) The concentration of aqueous Na⁺ ions is greater than the concentration of aqueous Ag⁺ ions.

30. The solubility of Cd(OH)₂ in water is 1.40 \times 10⁻⁵ M. What is the value of the solubility product constant, K_sp?
   a) 2.74 \times 10⁻¹⁵
   b) 1.10 \times 10⁻¹⁴
   c) 1.71 \times 10⁻¹⁰
   d) 1.43 \times 10⁻⁵
31. Which one of the following occurs when equal volumes of 0.20 M Ba(NO₃)₂ and 0.20 M K₂SO₄ are mixed?
   a) No precipitate forms.
   b) A precipitate of KNO₃ forms.
   c) A precipitate of BaSO₄ forms.
   d) Insufficient information is available to answer the question.

32. Which of these ions could be used to distinguish between Na⁺ ions and Mg²⁺ ions in solution?
   a) H⁺
   b) Cl⁻
   c) SO₄²⁻
   d) OH⁻

33. What is the K_sp for CaCO₃ if 0.0014 grams can dissolve in water to make 100.0 mL of solution?
   a) 1.4 x 10⁻⁴
   b) 1.4 x 10⁻⁵
   c) 2.0 x 10⁻⁴
   d) 2.0 x 10⁻¹⁰

34. What is the relationship between the rate of dissolving and the rate of precipitation in a saturated solution where excess solute is present?
   a) The rate of dissolving equals the rate of precipitation.
   b) The rate of dissolving is less than the rate of precipitation.
   c) The rate of dissolving is greater than the rate of precipitation.
   d) The rate of dissolving and the rate of precipitation are zero.

35. What is the [Ni²⁺] in a saturated solution of Ni(OH)₂?
   a) Less than 0.10 M
   b) Greater than 0.10 M but less than 1.0 M
   c) Greater than 1.0 M but less than 5.0 M
   d) Greater than 5.0 M

36. Which of the following salts has the greatest solubility in water?
   a) AgCl
   b) BaSO₄
   c) MgCO₃
   d) NaCl₃COO

37. For the following solubility equilibrium, what is the K_sp expression?
   Ag₂S(s) ⇌ 2Ag⁺(aq) + S²⁻(aq)
   a) K_sp = [Ag⁺]²[S²⁻]
   b) K_sp = [2Ag⁺][S²⁻]
   c) K_sp = [Ag⁺][S⁻²]
   d) K_sp = [Ag⁺][S⁻²]²
28. A student prepares a saturated solution of lead sulphate by adding an excess of the \( \text{PbSO}_4 \) to 1.0 L of water. He finds that 3.4 \( \times \) 10\(^{-2} \) g of \( \text{PbSO}_4 \) has dissolved. Based on this data, the \( K_{sp} \) of \( \text{PbSO}_4 \) is:
   
a) 1.1 \( \times \) 10\(^{-4} \)  
b) 1.2 \( \times \) 10\(^{-3} \)  
c) 1.3 \( \times \) 10\(^{-8} \)  
d) 3.4 \( \times \) 10\(^{-2} \)

39. What is the maximum number of moles of \( \text{I}_2 \) that may exist in a 1.0 L solution which has a \( [\text{Pb}^{2+}] \) of 2.0 \( \times \) 10\(^{-4} \) M? \( K_{sp} \) of \( \text{PbI}_2 = 1.4 \times 10^{-9} \)
   
a) 1.4 \( \times \) 10\(^{-2} \) mol  
b) 3.5 \( \times \) 10\(^{-5} \) mol  
c) 7.0 \( \times \) 10\(^{-5} \) mol  
d) 8.4 \( \times \) 10\(^{-3} \) mol

40. In which of the following solutions is \( \text{Pb(CH}_3\text{COO)}_2 \) MOST soluble?
   
a) 0.1 M \( \text{HNO}_3 \)  
b) 0.1 M \( \text{NaNO}_3 \)  
c) 0.1 M \( \text{NaCH}_3\text{COO} \)  
d) 0.1 M \( \text{Ca(CH}_3\text{COO)}_2 \)

41. \( \text{BaSO}_4 \) has low solubility in water. The equation for the dissolving of \( \text{BaSO}_4 \) is:
   
   \[ \text{BaSO}_4(s) + \text{energy} \rightleftharpoons \text{Ba}^{2+}(aq) + \text{SO}_4^{2-}(aq) \]

   Which of the following changes would increase the solubility of \( \text{BaSO}_4(s) \)?
   
a) Add \( \text{Na}_2\text{SO}_4 \)  
b) Add \( \text{Ba(NO}_3)_2 \)  
c) Add more water  
d) Increase the temperature

42. A solution that will not dissolve additional solute is
   
a) insoluble  
b) saturated  
c) unsaturated  
d) unsolvated

43. When gold (III) chloride, \( \text{AuCl}_3 \), is dissolved in water, analysis would show that
   
a) \([\text{Cl}^-]\) = 3 \([\text{Au}^{3+}]\)  
b) \([\text{Cl}^-]\) = \( \frac{1}{3} \) \([\text{Au}^{3+}]\)  
c) \([\text{Cl}^-]\) = \([\text{Au}^{3+}]\)  
d) \([\text{Cl}^-]\) = \([\text{Au}^{3+}]\)

44. When equal volumes of 0.20 M solutions of the following solutes are mixed, which combination will produce a precipitate?
   
a) \( \text{K}_2\text{S} \) and \( \text{NaOH} \)  
b) \( \text{BaBr}_2 \) and \( \text{NaOH} \)  
c) \( \text{MgCl}_2 \) and \( \text{NaOH} \)  
d) \( \text{(NH}_4\text{)}_2\text{SO}_4 \) and \( \text{NaOH} \)
45. What is the net ionic equation for the precipitation reaction when aqueous solutions of Na₂CO₃ and AgNO₃ are mixed?

a) \(2\text{AgNO}_3(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow \text{Ag}_2\text{CO}_3(\text{s}) + 2\text{NaNO}_3(\text{aq})\)

b) \(\text{Ag}_2\text{CO}_3(\text{s}) \rightarrow 2\text{Ag}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq})\)

c) \(\text{Ag}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{Ag}_2\text{CO}_3(\text{s})\)

d) \(2\text{Ag}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{Ag}_2\text{CO}_3(\text{s})\)

46. Which of the following salts is LEAST soluble in water?

a) \(\text{CuS} \quad K_{sp} = 8.5 \times 10^{-14}\)

b) \(\text{CuCO}_3 \quad K_{sp} = 7.4 \times 10^{-21}\)

c) \(\text{CuBr} \quad K_{sp} = 5.3 \times 10^{-9}\)

d) \(\text{CuCl} \quad K_{sp} = 1.2 \times 10^{-6}\)

47. If \(K_{sp}\) of PbSO₄ is \(1.7 \times 10^{-8}\), what is the solubility of PbSO₄?

a) \(2.9 \times 10^{-16}\)

b) \(1.3 \times 10^{-8}\)

c) \(1.7 \times 10^{-8}\)

d) \(1.3 \times 10^{-4}\)

48. Which of the following will form an ionic solution when 0.1 mol dissolves in 1.0 L of water?

a) \(\text{Br}_2\)

b) \(\text{NaCl}\)

c) \(\text{CH}_3\text{OH}\)

d) \(\text{C}_2\text{H}_5\text{OH}\)

49. When 0.2 M Rb₃PO₄ is mixed with an equal volume of 0.2 M CaS, the precipitate will be

a) \(\text{CaS}\)

b) \(\text{Rb}_2\text{S}\)

c) \(\text{Rb}_3\text{PO}_4\)

d) \(\text{Ca}_3(\text{PO}_4)_2\)

50. Which anion below could be used to separate \(\text{Sr}^{2+}\) from \(\text{Pb}^{2+}\) by precipitation?

a) \(\text{Cl}^-\)

b) \(\text{SO}_4^{2-}\)

c) \(\text{CO}_3^{2-}\)

d) \(\text{PO}_4^{3-}\)
51. What is the maximum [Zn\(^{2+}\)] possible in a solution containing 0.010 M OH\(^{-}\)? Assume that the K\(_{sp}\) for Zn(OH)\(_2\) is 1.3 x 10\(^{-14}\).
   a) 1.8 x 10\(^{-18}\) M
   b) 1.8 x 10\(^{-16}\) M
   c) 1.8 x 10\(^{-12}\) M
   d) 1.8 x 10\(^{-10}\) M

52. Consider the following equilibrium equation for a saturated solution of Ag\(_2\)CO\(_3\):
   \[ \text{Ag}_2\text{CO}_3(s) \rightleftharpoons 2 \text{Ag}^{+}(aq) + \text{CO}_3^{2-}(aq) \]
Which of the following, when added to this saturated solution, would cause more Ag\(_2\)CO\(_3\) solid to dissolve?
   a) HNO\(_3\)
   b) AgNO\(_3\)
   c) AgCl
   d) Na\(_2\)CO\(_3\)

53. | Temperature | Solubility of Ca(CH\(_3\)COO\(_2\))
|-------------|-----------------|
| 0°C         | 37.4 g/100 g H\(_2\)O
| 100°C       | 29.7 g/100 g H\(_2\)O

Use the information above to answer the following:
A saturated solution of Ca(CH\(_3\)COO\(_2\)) at 20°C is warmed to 30°C. The solubility of Ca(CH\(_3\)COO\(_2\)) will
   a) more than double.
   b) increase slightly.
   c) remain the same.
   d) decrease slightly.

54. The solubility of KI is 35 g of KI per 100 g of H\(_2\)O at 20°C. A KI solution at 20°C containing 25 g of KI per 100 g of H\(_2\)O would be
   a) saturated
   b) insoluble
   c) unsaturated
   d) supersaturated

55. The \(\text{NO}_3^+\) ion concentration in a 0.10 M solution of Ba(NO\(_3\))\(_2\) is
   a) 0.10 M
   b) 0.13 M
   c) 0.20 M
   d) 0.50 M

56. Which compound has the lowest solubility at 25°C?
   a) CuI
   b) CaS
   c) FeSO\(_4\)
   d) Pb(CH\(_3\)COO\(_2\))
57. Which ion should be used to remove the cations Ca$^{2+}$ and Mg$^{2+}$ from hard water?

- a) CO$_3^{2-}$
- b) Cl$^-$
- c) NO$_3^-$
- d) CH$_3$COO$^-$

58. The $K_{sp}$ expression for a saturated Fe(OH)$_3$ solution is:

- a) $K_{sp} = [Fe^{3+}][OH^-]^3$
- b) $K_{sp} = [Fe^{3+}][OH^-]^3$
- c) $K_{sp} = \frac{[Fe^{3+}][3OH^-]}{[Fe(OH)_3]}$
- d) $K_{sp} = \frac{[Fe^{3+}][OH^-]^3}{[Fe(OH)_3]}$

For the remainder of the questions, marks will be awarded as shown. Your steps and assumptions leading to a solution must be shown. In questions involving calculations, full marks will not be given for providing only an answer. Students will be expected to communicate the knowledge and understanding of chemical principles in a clear and logical manner.

1. For the reaction $Ag_2CO_3(s) \rightleftharpoons 2 Ag^{+}(aq) + CO_3^{2-}(aq)$
   what will be the effect on the position of this equilibrium of adding solid AgNO$_3$?
   Give a brief explanation for your answer. (2 marks)

2. The solubility of thallium iodate, TlIO$_3$, is $1.5 \times 10^{-3}$ M at 25°C. What is its $K_{sp}$ at this temperature? (2 marks)

3. Explain why a precipitate of AgCl will NOT be produced when 20.0 mL of $3.00 \times 10^{-6}$ M AgNO$_3$ is mixed with 30.0 mL of $1.00 \times 10^{-4}$ M NaCl. For AgCl, the $K_{sp} = 1.8 \times 10^{-10}$. Support your explanation by calculation. (4 marks)

4. The equilibrium in a saturated ZnF$_2$ solution is given by:
   ZnF$_2(s) \rightleftharpoons Zn^{2+}(aq) + 2 F^-(aq)$
   Predict the effect on the solubility of ZnF$_2$ of adding some solid KF. Explain the reasoning for your prediction. (2 marks)

5. What is the minimum mass of Na$_2$SO$_4$ crystals that must be dissolved in 5.0 L of 0.0010 M Ca(NO$_3$)$_2$ solution in order to initiate precipitation of calcium sulphate? (4 marks) $K_{sp}$ for CaSO$_4 = 2.6 \times 10^{-5}$.

6. Calculate the value of the $K_{sp}$ for SrF$_2$ if the solubility is 0.122 g/L. (4 marks)

7. The $K_{sp}$ for PbSO$_4$ is $1.3 \times 10^{-8}$ at 25°C. Calculate the mass in grams of PbSO$_4$ which could be dissolved in 5.0 L of water at 25°C. (3 marks)

8. 20.0 mL of 0.10 M LiCl is added to 20.0 mL of 0.20 M Na$_2$CO$_3$. The $K_{sp}$ for Li$_2$CO$_3$ is $1.7 \times 10^{-5}$. Will Li$_2$CO$_3$ precipitate? Support your answer with calculations. (3 marks)
9. A beaker contains OH⁻ and S²⁻ ions in solution, both at a concentration of 0.10 M. You are asked to precipitate the OH⁻ while leaving the S²⁻ in solution.
   a) Which reagent could you use? (1 mark)
   b) Write a net ionic equation for the precipitation reaction. (1 mark)

10. Show by calculation and state whether or not a precipitate of BaSO₄ will form when 0.150 g of K₂SO₄ is added to 2.00 L of 1.70 × 10⁻⁵ M BaCl₂(aq) solution. $K_{sp}$ of BaSO₄ = 1.5 × 10⁻⁹. (4 marks)

11. What happens to the solubility of CaSO₄ when K₂SO₄ is added to a saturated solution of CaSO₄? Explain your answer. (2 marks)

12. A solution contains Ag⁺, Sr²⁺, and Ba²⁺ all at a concentration of 0.10 M. When KI is added, a yellow precipitate is formed. Identify the precipitate and write the net ionic equation of the reaction. (2 marks)

13. Calculate the mass of Ba(OH)₂ dissolved in 5.00 L of a saturated solution of this compound. $K_{sp}$ = 5.00 × 10⁻³ (4 marks)
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<td></td>
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**Written responses**

1. The equilibrium will shift towards the left (more precipitate will be formed). Adding AgNO₃ will increase [Ag⁺] therefore the system will react by trying to minimize the stress (Le Chatelier’s Principle).

2. \(K_{sp} = 2.3 \times 10^{-6}\)

3. \(K_{sp} = 7.2 \times 10^{-11}\). Because \(K_{sp}\) is less than \(K_{sp}\), no precipitate will be formed.

4. The equilibrium will shift towards the left (more precipitate will be formed). Adding KF will increase [F⁻] therefore the system will react by trying to minimize the stress (Le Chatelier’s Principle).

5. 18 grams

6. \(K_{sp} = 3.67 \times 10^{-6}\)

7. 0.17 grams

8. \(K_{sp} = 2.8 \times 10^{-4}\). Because \(K_{sp}\) is less than \(K_{sp}\), no precipitate will be formed.

9. a) Ba(NO₃)₂, Ca(NO₃)₂, Mg(NO₃)₂
   b) Mg²⁺(aq) + 2 OH⁻(aq) → Mg(OH)₂(s)

10. \(K_{sp} = 7.3 \times 10^{-9}\). Because \(K_{sp}\) is greater than \(K_{sp}\), a precipitate will be formed.

11. Solubility decreases. Adding K₂SO₄ will cause the [SO₄²⁻] to increase (because the K₂SO₄ will dissolve). The increase in [SO₄²⁻] will cause the equilibrium to shift towards producing more CaSO₄(s).

12. a) Ag⁺(aq) + I⁻(aq) → AgI(s)
    b) 92.5 grams

13. 92.5 grams