SOLUBILITY REVIEW

1. Two solutions are mixed and a precipitate forms, then the trial ion product is

   A. equal to K_{sp}.
   B. greater than K_{sp}.
   C. less than K_{sp}.
   D. less than OR equal to K_{sp}.

2. Determine the solubility of limestone, $CaCO_3$, in water. K_{sp} ($CaCO_3$) = 4.80×10^{-9}

   A. 2.19×10^{-5} M
   B. 4.31×10^{-9} M
   C. 6.93×10^{-5} M
   D. 2.30×10^{-18} M

3. Given the following data,

K_{sp}	Ions in solution
AgCN = 1.6×10^{-14}	$[CN^-]$ = 0.1 M
AgCl = 1.8×10^{-10}	$[Cl^-]$ = 0.1 M
AgBr = 7.7×10^{-13}	$[Br^-]$ = 0.1 M
AgI = 8.3×10^{-17}	$[I^-]$ = 0.1 M

   Which of the following precipitates would form first on dropwise addition of 0.10 M $AgNO_3$ to 5 mL samples of each solution?

   A. AgCN
   B. AgCl
   C. AgBr
   D. AgI

4. What is the maximum concentration of magnesium ions (Mg^{2+}) in a solution which has a carbonate ion (CO_3^{2-}) concentration of 5.0×10^{-1} M ? K_{sp} $MgCO_3$ = 2.5×10^{-5}

   A. 5.0×10^{-1}
   B. 5.0×10^{-5}
   C. 4.0×10^{-3}
   D. 2.5×10^{-5}

5. 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 ($AgNO_3$) ?

   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} for AgCl.
   D. The concentration of aqueous Na^+ ions is greater than the concentration of aqueous Ag^+ ions.

6. The solubility of $Cd(OH)_2$ in water is 1.40×10^{-5} M. What is the value of the solubility product constant, K_{sp}?

   A. 2.74×10^{-15}
   B. 1.10×10^{-14}
   C. 1.71×10^{-10}
   D. 1.43×10^{-5}

7. Which one of the following occurs when equal volumes of 0.20 M $Ba(NO_3)_2$ and 0.20 M K_2SO_4 are mixed?

   A. No precipitate forms.
   B. A precipitate of KNO_3 forms.
   C. A precipitate of $BaSO_4$ forms
   D. Insufficient information is available to answer the question.

8. Given that K_{sp} for $CaF_2 = 4.9 \times 10^{-11}$, when 30 mL of 8.00×10^{-8} M $Ca(NO_3)_2$ is mixed with 10 mL of 3.00×10^{-2} M NaF, the trial ion product is

   A. 4.5×10^{-10} and a precipitate forms.
   B. 2.4×10^{-10} and a precipitate forms.
   C. 3.4×10^{-12} and a precipitate does not form.
   D. 4.5×10^{-10} and a precipitate does not form.

9. What is the equilibrium concentration of $Sr^{2+}_{(aq)}$ in a saturated aqueous solution of $SrSO_4$? (K_{sp} of $SrSO_{4(s)} = 2.8 \times 10^{-7}$)

   A. 1.4×10^{-7} M
   B. 2.8×10^{-7} M
   C. 5.3×10^{-4} M
   D. 5.3×10^{-3} M

10. $PbCl_{2(s)}$ is precipitated from a solution containing $Pb^{2+}_{(aq)}$ and $Cl^{-}_{(aq)}$. Which one of the following relationships describes the concentrations of the ions remaining in solution?

A. $[Pb^{2+}]^2[Cl^-] = K_{sp}$ of $PbCl_{2(s)}$

B. $[Pb^{2+}]^2[Cl^-]^2 = K_{sp}$ of $PbCl_{2(s)}$

C. $[Pb^{2+}][Cl^-] = K_{sp}$ of $PbCl_{2(s)}$

D. $[Pb^{2+}][Cl^-]^2 = K_{sp}$ of $PbCl_{2(s)}$

11. Which one of the following statements is **TRUE** about the result of mixing equal volumes of 0.020 M $CaCl_2$ and 0.00040 M Na_2SO_4 ?
(K_{sp} for $CaSO_{4(s)} = 4.2 \times 10^{-5}$)

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

12. Which one of the following is the correct relationship between the solubility and the solubility product of lead (II) chloride ($PbCl_2$)?

A. Solubility = K_{sp}

B. Solubility = $\sqrt{K_{sp}}$

C. Solubility = $\sqrt{\frac{K_{sp}}{2}}$

D. Solubility = $\sqrt[3]{\frac{K_{sp}}{4}}$

13. Silver acetate, $AgCH_3COO_{(s)}$, crystals are in equilibrium with a saturated solution. Which of the following would cause more $AgCH_3COO_{(s)}$ to dissolve?

A. The addition of a few crystals of silver nitrate ($AgNO_3$).

B. The addition of a few drops of concentrated nitric acid.

C. The addition of a few crystals of sodium acetate ($NaCH_3COO$)

D. The evaporation of some water from the solution with no temperature change.

14. 1.0 L of a saturated solution of thallium bromide (TlBr) was evaporated to dryness to produce 0.56 g of $TlBr_{(s)}$. What is the solubility product constant of thallium bromide? (Molar mass of thallium bromide is 284 g/mol)

A. 2.0×10^{-6}
B. 3.9×10^{-6}
C. 2.0×10^{-3}
D. 4.4×10^{-2}

15. A solution contains $Ba^{2+}_{(aq)}$, $Pb^{2+}_{(aq)}$, $Fe^{2+}_{(aq)}$, and $Mg^{2+}_{(aq)}$. Which of the follwoing negative ions would cause a precipitate with only **ONE** of these metal ions?

A. $I^-_{(aq)}$
B. $SO_4^{2-}{}_{(aq)}$
C. $NO_3^-{}_{(aq)}$
D. $PO_4^{3-}{}_{(aq)}$

16. The equation for the dissolving of Ag_2SO_4 in water is

$$Ag_2SO_{4(s)} \Leftrightarrow 2Ag^+_{(aq)} + SO_4^{2-}{}_{(aq)}$$

If $Ag_2SO_{4(s)}$ is in equilibrium with a saturated solution, which of the following will result in more $Ag_2SO_{4(s)}$ dissolving?

A. Add H_2SO_4 solution
B. Add $AgNO_{3(s)}$
C. Add more $Ag_2SO_{4(s)}$
D. Add Cl^- which precipitates AgCl

17. The solubility of copper (I) bromide, CuBr, is 2.0×10^{-4} mol/L. What is the value of K_{sp} for CuBr?

A. 3.2×10^{-11}
B. 4.0×10^{-8}
C. 1.4×10^{-2}
D. 2.9×10^{-2}

18. What is the maximum $[Mg^{2+}]$ that can exist in a solution of 1.0×10^{-3} M NaOH without precipitating $Mg(OH)_{2(s)}$? K_{sp} for $Mg(OH)_2 = 1.2 \times 10^{-11}$

A. 1.2×10^{-8} M
B. 1.2×10^{-5} M
C. 1.4×10^{-4} M
D. 2.9×10^{-2} M

Use the following equations to answer question 19.

$$PbCrO_{4(s)} \Leftrightarrow Pb^{2+}_{(aq)} + CrO_4^{2-}{}_{(aq)}$$

$$2CrO_4^{2-}{}_{(aq)} + 2H^{+}_{(aq)} \Leftrightarrow H_2O_{(l)} + Cr_2O_7^{2-}{}_{(aq)}$$

19. A precipitate of $PbCrO_{4(s)}$ is formed by mixing solution of K_2CrO_4 and $Pb(NO_3)_2$. It would be possible to redissolve this precipitate by adding a concentrated solution of

A. Na_2CrO_4.
B. $Na_2Cr_2O_7$
C. a strong acid.
D. as strong base.

20. A beaker contains an unsaturated solution and some solid solute. The rate of dissolving of the solid is

A. zero.
B. equal to the rate of precipitation.
C. less than the rate of precipitation.
D. greater than the rate of precipitation.

21. Which of the following has low solubility at room temperature?

A. $ZnCl_2$
B. $ZnSO_4$
C. $ZnCO_3$
D. $Zn(NO_3)_2$

22. 1.0×10^{-3} mole Cu^{2+} and 9.0×10^{-3} mole OH^- are added to 1.0 L of H_2O. Which one of the following is the correct value for trial K_{sp} of $Cu(OH)_2$?

A. 2.0×10^{-8}
B. 8.1×10^{-8}
C. 3.2×10^{-7}
D. 9.0×10^{-6}

23. Which of the following relationships must be used to calculate the $[I^-]$ that would be needed to just start precipitation of PbI_2 form a solution of $Pb(NO_3)_2$?

A. $[I^-] = \dfrac{K_{sp}}{[Pb^{2+}]}$

B. $[I^-] = \dfrac{[Pb^{2+}]}{K_{sp}}$

C. $[I^-] = \sqrt{\dfrac{K_{sp}}{[Pb^{2+}]}}$

D. $[I^-] = \sqrt{K_{sp} \times [Pb^{2+}]}$

24. Consider the following equilibrium:

$$Ag_2CrO_{4(s)} \Leftrightarrow 2Ag^+_{(aq)} + CrO_4^{2-}{}_{(aq)}$$

Which of the following procedures will increase the solubility of Ag_2CrO_4 in a a saturated solution of Ag_2CrO_4 ?

A. Add $KI_{(s)}$

B. Add $Na_2CrO_{4(s)}$

C. Add $AgCH_3COO_{(s)}$

D. Add more $Ag_2CrO_{4(s)}$

25. When equal volumes of 0.2 M CaS and 0.2 M $Sr(OH)_2$ are mixed,

A. no precipitate will form.
B. a precipitate of SrS will form.
C. a precipitate of $Ca(OH)_2$ will form.
D. a precipitate of both SrS and $Ca(OH)_2$ will form.

26. Which of the following reagents could be used to indicate the presence of Ca^{2+} in solution?

A. H_2S
B. $AgNO_3$
C. Na_2CO_3
D. $Ca(CH_3COO)_2$

27. If the solubility of $Pb(OH)_2$ is 0.155 g/L, then the concentration of each ion is a saturated solution of a $Pb(OH)_2$ is

A. $[Pb^{2+}] = 0.155$ g/L and $[OH^-] = 0.155$ g/L

B. $[Pb^{2+}] = 0.052$ g/L and $[OH^-] = 0.103$ g/L

C. $[Pb^{2+}] = 6.43 \times 10^{-4}$ M and $[OH^-] = 1.29 \times 10^{-3}$ M.

D. $[Pb^{2+}] = 6.43 \times 10^{-4}$ M and $[OH^-] = 6.43 \times 10^{-4}$ M

28. When equal volumes of 0.2 M K_2CO_3 and 0.2 M Na_3PO_4 are mixed,

A. no precipitate will form.
B. a precipitate of K_3PO_4 will form.
C. a precipitate of Na_2CO_3 will form.
D. a precipitate of both K_3PO_4 and Na_2CO_3 will form.

29. Which of the following solutes could dissolve to produce at least 0.1 M SO_3^{2-} in solution at 25°C?

A. $FeSO_3$
B. $ZnSO_3$
C. Na_2SO_3
D. $Al_2(SO_3)_3$

30. A solution is known to contain one of these ions: Mg^{2+} , Ca^{2+} , Sr^{2+} , Be^{2+} . Mixing samples of the solution with various reagents gives the following data:

Reagent	Na_2S	Na_2SO_4	NaOH
Result	no ppt	ppt	no ppt

From these data the ion is

A. Ca^{2+}
B. Be^{2+}
C. Sr^{2+}
D. Mg^{2+}

31. Consider the following equilibrium:

$$Zn_3(PO_4)_{2(s)} \Leftrightarrow 3Zn^{2+}_{(aq)} + 2PO_4^{3-}{}_{(aq)}$$

If K_3PO_4 is added to this equilibrium, the equilibrium

A. shifts left, and the value of K_{sp} decreases.

B. shifts right, and the value of K_{sp} increases.

C. shifts left, and the value of K_{sp} remains constant.

D. remains the same, and the value of K_{sp} remains constant.

32. Which of the following is the net ionic equation for the reaction that occurs when 0.2 M $Pb(NO_3)_2$ is mixed with 0.2 M NaI ?

A. $PbI_{2(s)} \rightarrow Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$

B. $Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$

C. $Na^+_{(aq)} + NO_3^-{}_{(aq)} \rightarrow NaNO_{3(s)}$

D. $NaNO_{3(s)} \rightarrow Na^+_{(aq)} + NO_3^-{}_{(aq)}$

33. What is the value of K_{sp} for AgCl if its solubility is 1.3×10^{-5} mol/L?

A. 4.2×10^{-11}
B. 1.7×10^{-10}
C. 2.6×10^{-5}
D. 1.3×10^{-5}

34. Which of the following units could be used to represent the solubility of a compound?

(1) g (2) g / L (3) mol / L

A. 3 only
B. 1 and 2 only
C. 1 and 3 only
D. 2 and 3 only

35. The $[Mg^{2+}]$ and $[Br^-]$ in 2.00 L of 0.250 M $MgBr_2$ is

A. $[Mg^{2+}] = 0.500$ M and $[Br^-] = 1.00$ M
B. $[Mg^{2+}] = 0.250$ M and $[Br^-] = 0.250$ M
C. $[Mg^{2+}] = 0.250$ M and $[Br^-] = 0.500$ M
D. $[Mg^{2+}] = 0.120$ M and $[Br^-] = 0.250$ M

36. Which one of the following can be used to produce a 0.20 M solution?

A. $BeCl_2$
B. $Be\ SO_3$
C. $Be(OH)_2$
D. $Be_3(PO_4)_2$

37. When equal volumes of 0.50 M $Sr(OH)_2$ and 0.50 M $MgBr_2$ are mixed

A. no precipitate will form.
B. a precipitate of $SrBr_2$ will form.
C. a precipitate of $Mg(OH)_2$ will form.
D. precipitates of $SrBr_2$ and $Mg(OH)_2$ will form.

38. Which one of the following ions could be used to remove **only** Cu^{2+} by precipitation from a solution containing Cu^{2+}, Mg^{2+}, and Ca^{2+} ?

A. S^{2-}
B. Cl^-
C. OH^-
D. PO_4^{3-}

39. Which one of the following would form an ionic solution when dissolved in water?

A. I_2
B. CH_3OH
C. $Ca(NO_3)_2$
D. $C_{12}H_{22}O_{11}$

40. In a saturated solution of $Zn(OH)_2$, the $[Zn^{2+}]$ is

A. less than 0.10 M.
B. more than 10.0 M.
C. more than 0.10 M, but less than 1.0 M
D. more than 1.0 M, but less than 10.0 M

41. The **complete** ionic equation for the reaction between $MgCl_{2(aq)}$ and $AgNO_{3(aq)}$ is

A. $Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$
B. $2AgNO_{3(aq)} + MgCl_{2(aq)} \rightarrow 2AgCl_{(s)} + Mg(NO_3)_{(aq)}$
C. $2Ag^+_{(aq)} + Mg^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Cl^-_{(aq)} \rightarrow MgCl_{2(s)} + 2Ag^+_{(aq)} + 2NO_3^-{}_{(aq)}$
D. $2Ag^+_{(aq)} + Mg^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Cl^-_{(aq)} \rightarrow 2AgCl_{(s)} + Mg^{2+}_{(aq)} + 2NO_3^-{}_{(aq)}$

42. Which of the following would precipitate the Ca^{2+} and Mg^{2+} found in hard water?

A. S^{2-}
B. PO_4^{3-}
C. SO_4^{2-}
D. CH_3COO^-

43. The $[SO_4^{2-}]$ in a saturated solution of $PbSO_4$ is
($K_{sp} = 1.1 \times 10^{-8}$)

A. 1.2×10^{-16} M
B. 5.5×10^{-9} M
C. 1.1×10^{-8} M
D. 1.0×10^{-4} M

44. Which one of the following salts is soluble?

A. $BaSO_4$
B. $CaCO_3$
C. K_3PO_4
D. $Fe(OH)_2$

45. The compound Ag_2S has a solubility of 1.3×10^{-4} moles per litre at 25°C. The K_{sp} for this compound is

A. 2.2×10^{-12}
B. 8.8×10^{-12}
C. 1.7×10^{-8}
D. 3.4×10^{-8}

46. Molecular solutions do not conduct electricity because they contain

A. molecules only.
B. cations and anions.
C. molecules and anions.
D. molecules and cations.

47. To determine the solubility of a solute in water, a solution must be prepared that is

A. saturated.
B. unsaturated.
C. concentrated.
D. supersaturated.

48. From the list of salts below, how many are considered soluble at 25°C?

$CuCl_2$ $CaSO_4$ PbS Ag_3PO_4

A. zero
B. one
C. two
D. three

49. Identify the **most** soluble sulphide.

A. HgS, $K_{sp} = 1.6 \times 10^{-54}$
B. PbS, $K_{sp} = 7.0 \times 10^{-29}$
C. FeS, $K_{sp} = 3.7 \times 10^{-19}$
D. MnS, $K_{sp} = 2.3 \times 10^{-13}$

50. During a lab on qualitative analysis an unknown solution containing one cation was analyzed and the following data were collected:

0.2 M Anions Added to the Unknown Solution	Observation
S^{2-}	No precipitate
SO_4^{2-}	Precipitate
OH^-	Precipitate
CO_3^{2-}	Precipitate

Which one of the following cations is found in the unknown solution?

A. Mg^{2+}
B. Ca^{2+}
C. Sr^{2+}
D. Ba^{2+}

uses old sol table...change question or throw out

51. Which one of the following equilibrium systems is described by a K_{sp}?

A. $CaCO_{3(s)} \Leftrightarrow CaO_{(s)} + CO_{2(g)}$
B. $CaCO_{3(s)} \Leftrightarrow Ca^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)}$
C. $Ca^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)} \Leftrightarrow CaCO_{3(s)}$
D. $Ca(OH)_{2(aq)} + H_2CO_{3(aq)} \Leftrightarrow CaCO_{3(s)} + 2H_2O_{(l)}$

52. In an experiment, a student mixes equal volumes of 0.0020 M Pb^{2+} ions with 0.0040 M I^- ions. The trial ion product is

A. 4.0×10^{-9}
B. 3.2×10^{-8}
C. 1.3×10^{-7}
D. 8.0×10^{-6}

53. If the K_{sp} of $SrCO_3$ is 1.6×10^{-9}, then the solubility of $SrCO_3$ is

A. 2.6×10^{-18} mol / L
B. 8.0×10^{-10} mol / L
C. 1.6×10^{-9} mol / L
D. 4.0×10^{-5} mol / L

54. What is the maximum $[Br^-]$ which can exist in a solution of 0.025 M $Pb(NO_3)_2$?

K_{sp} of $PbBr_2 = 6.3 \times 10^{-6}$

A. 1.6×10^{-2} M
B. 5.0×10^{-2} M
C. 2.5×10^{-2} M
D. 2.5×10^{-4} M

55. Consider the following equilibrium system:

$$PbI_{2(s)} + \text{heat} \Leftrightarrow Pb^{2+}_{(aq)} + 2I^-_{(aq)}$$

Which of the following changes would result in more PbI_2 dissolving?

A. adding more PbI_2
B. increasing the pressure
C. adding some $Pb(NO_3)_2$
D. increasing the temperature

56. A soluble magnesium salt is

A. $MgSO_3$
B. $MgCO_3$
C. $Mg(NO_3)_2$
D. $Mg_3(PO_4)_2$

57. What is the $[Co^{2+}]$ and $[Cl^-]$ when 0.35 mol of $CoCl_2$ is dissolved in enough water to make 100.0 mL of solution?

A. $[Co^{2+}] = 3.5$ M and $[Cl^-] = 3.5$ M

B. $[Co^{2+}] = 3.5$ M and $[Cl^-] = 7.0$ M

C. $[Co^{2+}] = 0.35$ M and $[Cl^-] = 0.35$ M

D. $[Co^{2+}] = 0.35$ and $[Cl^-] = 0.70$ M

58. If equal volumes of KBr and 0.2 M $FeSO_4$ are mixed, then

A. no precipitate will be observed.
B. a precipitate of $FeBr_2$ will be observed.
C. a precipitate of K_2SO_4 will be observed.
D. a precipitate of both K_2SO_4 and $FeBr_2$ will be observed.

59. In an experiment, 20.0 mL of 0.0060 M $CaCl_2$ and 20.0 mL of 0.0050 M Na_2SO_4 are mixed together. The trial ion product (trial K_{sp}) is

A. 7.5×10^{-6} and a precipitate will form.
B. 7.5×10^{-6} and a precipitate will not form.
C. 3.0×10^{-6} and a precipitate will form.
D. 3.0×10^{-6} and a precipitate will not form.

60. Which of the following ions could be added to an aqueous mixture containing Pb^{2+} and Ba^{2+} to separate the ions by precipitating one of them?

A. I^-
B. NO_3^-
C. PO_4^{3-}
D. SO_4^{2-}

61. In which of the following would solid AgCl be **most** soluble?

A. 1 M HCl
B. 1 M $MgCl_2$
C. 1 M $AgNO_3$
D. 1 M NH_4NO_3

WRITTEN RESPONSE QUESTIONS:

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 $Ag_2CO_{3\,(s)} \Leftrightarrow 2\,Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)}$
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 1.5×10^{-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 3.00×10^{-6} M $AgNO_3$ is mixed with 30.0 ml of 1.00×10^{-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 :
$$ZnF_{2\,(s)} \Leftrightarrow Zn^{2+}_{(aq)} + 2\,F^-_{(aq)}$$
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 $Na_2SO_{4\,(s)}$ 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 1.3×10^{-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. 30.0 mL of 0.10 M LiCl is added to 20.0 mL of 0.20 M Na_2CO_3.
The K_{sp} for Li_2CO_3 is 1.7×10^{-3}. Will Li_2CO_3 precipitate ? Support your answer with calculations. **(3 marks)**

9. A beaker contains OH^- and S^{2-} ions in solution, both at a concentration of 0.10 M. You are asked to precipitate the OH^- while leaving the S^{2-} 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 $BaSO_4$ will form when 0.150 g of K_2SO_4 is added to 2.00 L of 1.70×10^{-5} M $BaCl_{2\,(aq)}$ solution. K_{sp} of $BaSO_4 = 1.5 \times 10^{-9}$. (4 marks)

11. What happens to the solubility of $CaSO_4$ when K_2SO_4 is added to a saturated solution of $CaSO_4$? Explain your answer. (2 marks)

12. A solution contains Ag^+, Sr^{2+}, and Ba^{2+} 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. $K_{sp} = 5.00 \times 10^{-3}$ (4 marks)

14. 30.0 mL of 0.10 M LiCl is added to 20.0 mL of 0.20 M Na_2CO_3. The K_{sp} for Li_2CO_3 is 1.7×10^{-3}. Will $Li_2CO_{3(s)}$ precipitate? Support your answer with calculations. **(4 marks)**

15. What is the value of K_{sp} for MgF_2 if its solubility is 0.0736 g/L? **(4 marks)**

16. Write the net ionic equation(s) for the reaction(s) when equal volumes of 0.2 M $Ba(OH)_2$ and 0.2 M $Fe(SO_4)_3$ are mixed. **(2 marks)**

17. Determine the maximum $[OH^-]$ that can exist in a solution of 0.20 M $Cu(NO_3)_2$ if K_{sp} for $Cu(OH)_2$ is 1.6×10^{-19}? **(2 marks)**

18. A solution contains SO_4^{2-} and Cl^-. Out line an experimental procedure to remove each ion individually from the solution, and identify the reagents (ions or compounds) used in the procedure. **(3 marks)**

19. If a solution of calcium nitrate is added to a saturated solution of calcium sulphate, a precipitate is observed to form. Explain why this occurs, including any relevant equation(s), and identify the precipitate. **(2 marks)**

20. If 75.0 mL of 0.015 M $Na_2C_2O_4$ and 150.0 mL of 0.020 M $Mg(NO_3)_2$ are mixed, will a precipitate form? K_{sp} of MgC_2O_4 is 8.6×10^{-5}. Use appropriate calculations to justify your answer. **(4 marks)**

21. A science teacher needs 5.0 L of limewater for an experiment. Limewater is a saturated solution of $Ca(OH)_2$. Calculate the minimum mass of $Ca(OH)_2$ required to make this solution. $K_{sp} = 1.3 \times 10^{-6}$ **94-1 #6 (5 marks)**

ANSWER KEY

MULTIPLE CHOICE

1.	B	17.	B	33.	B	49.	D
2.	C	18.	B	34.	D	50.	B
3.	D	19.	C	35.	C	51.	B
4.	B	20.	C	36.	A	52.	A
5.	C	21.	C	37.	C	53.	D
6.	B	22.	B	38.	A	54.	A
7.	C	23.	C	39.	C	55.	D
8.	C	24.	A	40.	A	56.	C
9.	C	25.	C	41.	D	57.	B
10.	D	26.	C	42.	B	58.	A
11.	C	27.	C	43.	D	59.	B
12.	D	28.	A	44.	C	60.	A
13.	B	29.	C	45.	B	61.	D
14.	B	30.	C	46.	A		
15.	A	31.	C	47.	A		
16.	D	32.	B	48.	B		

WRITTEN RESPONSES

1. The equilibrium will shift towards the left (more precipitate will be formed). Adding $AgNO_3$ 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. $K_{trial} = 7.2 \times 10^{-11}$. Because K_{trial} 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. $K_{sp} = 3.67 \times 10^{-9}$

7. 0.17 grams

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

9. a) $Be(NO_3)_2$, $Ca(NO_3)_2$, $Mg(NO_3)_2$
   b) $Mg^{2+}_{(aq)} + 2\ OH^-_{(aq)} \rightarrow Mg(OH)_{2\ (s)}$

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

11. Solubility decreases. Adding K_2SO_4 will cause the $[SO_4^{2-}]$ to increase (beacuse the K_2SO_4 will dissolve). The increase in $[SO_4^{2-}]$ will cause the equilibrium to shift towards producing more $CaSO_{4\ (s)}$.

12. a) AgI
b) $Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$

13. 92.3 grams

14. $[Li^+]_{dil} = 0.10\ M \times \frac{30.0\ mL}{50.0\ mL} = 0.060\ M$ **(1 mark)**

$[CO_3^{2-}]_{dil} = 0.20\ M \times \frac{20.0\ mL}{50.0\ mL} = 0.080\ M$ **(1mark)**

$Li_2CO_3 \Leftrightarrow 2Li^+_{(aq)} + CO_3^{2-}{}_{(aq)}$

Trial $K_{sp} = [Li^+]^2[CO_3^{2-}]$

$= (0.060)^2(0.080)$

$= 2.88 \times 10^{-4}$ **(1 mark)**

Trial $K_{sp} < K_{sp}$ **(½ mark)** therefore no precipitate will form. **(½ mark)**

15. $MgF_{2(s)} \Leftrightarrow Mg^{2+}_{(aq)} + 2F^-_{(aq)}$

Solubility $MgF_2 = \frac{0.0736\ g}{L} \times \frac{1\ mole}{62.3\ g} = 0.00118$ mol/L **(1 mark)**

$\therefore [Mg^{2+}] = 0.00118\ M$ **(½ mark)**

$[F^-] = 2 \times [Mg^{2+}] = 0.00236\ M$ **(½ mark)**

$K_{sp} = [Mg^{2+}][F^-]^2 = (1.18 \times 10^{-3})(2.36 \times 10^{-3})^2$ **(1 mark)**

$= 6.60 \times 10^{-9}$ **(½ mark)**

(½ mark for sig figs)

16. $3Ba^{2+}_{(aq)} + 6OH^-_{(aq)} + 2Fe^{3+}_{(aq)} + 3SO_4^{2-}{}_{(aq)} \rightarrow 3BaSO_{4(s)} + 2Fe(OH)_{3(s)}$

↑ **(½ mark)** ↑ **(½ mark)**

(1 mark for balancing)

17. $Cu(OH)_2 \Leftrightarrow Cu^{2+} + 2OH^-$

$K_{sp} = [Cu^{2+}][OH^-]^2$ **(1/2 mark)**

$[OH^-] = \sqrt{\frac{K_{sp}}{[Cu^{2+}]}} = \sqrt{\frac{1.6\times10^{-19}}{0.20}}$ **(1/2 mark for correct substitution)**

$= 8.9 \times 10^{-10}$ M **(1/2 for correct value)**
(1/2 for correct sig figs)

18. eg. Add Sr^{2+} (or Ba^{2+} or Ca^{2+}), form ppt of $SrSO_4$ (or $BaSO_4$, or $CaSO_4$), filter (or decant or centrifuge)

Add Pb^{2+} (or Ag^+, or Cu^+, or Hg_2^{2+}), form ppt of $PbCl_2$ (or AgCl, CuCl, Hg_2Cl_2).

(1 mark for sequence of SO_4^{2-} before Cl^-)
(1/2 mark for each correct positive ion or compound added)
(1 mark for appropriate method of separation of precipitate)

19. I. $CaSO_{4(s)} \Leftrightarrow Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$ II. $CaNO_3 \rightarrow Ca^{2+}_{(aq)} + NO_3^-{}_{(aq)}$

When $CaNO_3$ is added to solution it dissociates (see II above) producing calcium ions. **(½ mark).** The increase in $[Ca^{2+}]$ causes the equilibrium (see I above) to shift to the left **(1 mark)** causing precipitate of $CaSO_4$.**(1/2 mark)**

20. $[C_2O_4^{2-}]_{trial} = 0.015\text{ M} \times \frac{75.0\text{ mL}}{225.0\text{ mL}} = 0.0050\text{ M}$ **(1 mark)**

$[Mg^{2+}]_{trial} = 0.020\text{ M} \times \frac{150.0\text{ mL}}{225.0\text{ mL}} = 0.01333\text{M}$ **(1 mark)**

$K_{trial} = [Mg^{2+}][C_2O_4^{2-}] = (0.0133)(0.0050) = 6.67 \times 10^{-5}$ **(1 mark)**

$K_{trial} < K_{sp}$ **(1/2 mark)** therefore a precipitate will not form **(1/2 mark)**

21. Let s = solubility of $Ca(OH)_2 = [Ca^{2+}]$ **(1/2 mark)**

$\therefore 2s = [OH^-]$ **(1/2 mark)**

$K_{sp} = [Ca^{2+}][OH^-]^2$ **(1/2 mark)**

$= (s)(2s)^2 = 4s^3$ **(1/2 mark)**

$4s^3 = 1.3 \times 10^{-6}$ **(1/2 mark)**

$s = 6.87 \times 10^{-3}$ M **(1/2 mark)**

$Ca(OH)_2 = 74.1$ g/mol **(1/2 mark)**

g $Ca(OH)_2 = (6.87 \times 10^{-3}$ mol/L) (74.1 g/mol) (5.0 L) **(1 mark)**

$= 2.5$ g **(1/2 mark)**