SOLUBILITY STUDY GUIDE- Written

Written Section: This study guide covers questions from past Chem 12 provincial exams dating back to April 2000. The intent of this document is to prepare you for your UNIT EXAM and PROVINCIAL EXAM by providing you with questions of comparable difficulty. Please do the questions on a different sheet of paper so that this valuable resource may be of value to you when preparing for your Provincial Exam. Good Luck and Happy Studying….

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5 1. a) Write the balanced formula equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$. **(1mark)**
00 b) Write the net ionic equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$. **(1mark)**
01

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6 2. A saturated solution of nickel carbonate, $NiCO_3$, contains 0.090g in 2.0L of solution . Calculate K_{sp} for $NiCO_3$.
00 **(3marks)**
01

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5 3. Calculate the maximum concentration of Pb^{2+} that can exist in 3.0×10^{-2} M Na_2SO_4 without forming a precipitate.
00 **(2marks)**
04

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6 4. Consider the following:
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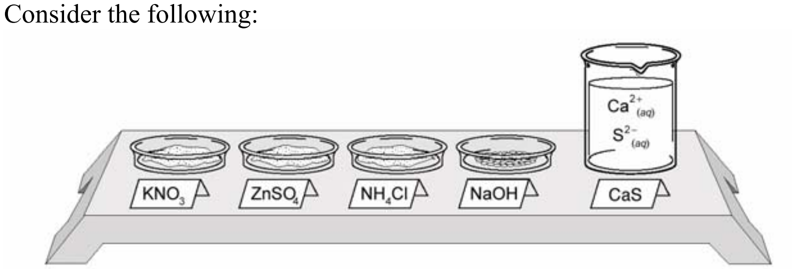

a) Which two solid samples could be added to the CaS solution in order to remove first one ion and then the other from the solution. Indicate the order in which to add them. **(2marks)**
First add:
Then add:

b) Write the net ionic equation for one of the precipitation reactions in part a). **(1 mark)**

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5 5. A 100 ml solution containing 0.2 M Al^{+2}, 0.2 M NH_4^+, and 0.2 M Mg^{2+} is added to a 100 ml solution containing
94 0.2 M S^{-2}, 0.2 M Cl^-, and 0.2 M OH^-. Identify the ions that do **not** form a precipitate. **(2 marks)**
01

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6 6. A science teacher needs 5.0 L of limewater for an experiment. Limewater is a saturated solution of $Ca(OH)_2$.
94 Calculate the minimum mass of $Ca(OH)_2$ required to make this solution. K_{sp} 1.3×10^{-6} **(5 marks)**
01

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5 7. A suspension of barium sulphate is used to improve the quality of X-rays in the digestive system. If a patient is
94 required to drink 0.400 L of this suspension, calculate the actual mass in grams of **dissolved** $BaSO_4$.
06 (K_{sp} of $BaSO_4 = 1.1\times10^{-10}$). **(4 marks)**

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6 8. Write an equation that describes the equilibrium present in a saturated solution of $Cu_3(PO_4)_2$.
94 **(2 marks)**
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5 9. A 1.0 M solution of sodium sulphite is added to a 1.0 M solution of copper(II) chloride resulting in the formation
95 of a precipitate.
01 a) Identify the precipitate. **(1 mark)**

b) Write the complete ionic equation for the reaction. **(1 mark)**

c) Identify all spectator ions. **(1 mark)**

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6 10. In an experiment, 100.0 mL samples containing silver ions are titrated with 0.200 M KSCN. The equation for the
95 reaction is
01 $Ag^+_{(aq)} + SCN^-_{(aq)} \rightarrow AgSCN_{(s)}$
The following data are recorded.

Trial	Volume KSCN (mL)
1	23.10
2	22.62
3	22.58

Calculate the concentration of the silver ion in the solution. **(4 marks)**

5 **11.** 95 04

Calculate the maximum moles of Br^- that can exist in 0.500 L of 0.10 M $Pb(NO_3)_2$. **(4 marks)**

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6 **12.** 95 04

In an acid-base reaction, the **two Brönsted-Lowry acids** are hydrofluoric acid (HF) and the hydrogen sulphite ion (HSO_3^-). Write the equation for this reaction. **(2 marks)**

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5 **13.** 95 06

Will a precipitate form if 30.0mL of 0.054 M $Ca(NO_3)_2$ is mixed with 60.0mL of 8.1×10^{-4}M Na_2SO_4? **(4 marks)**

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6 **14.** 95 06

A weak acid, $H_2C_6H_6O_6$, is dissolved in water. Write a chemical equation to represent this system. **(2marks)**

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5 **15.** 95 08

In an experiment, a student pipettes a sample of saturated $MgBr_2$ solution into a beaker and evaporates the sample to dryness. He recorded the following data:

Volume of saturated $MgBr_{2(aq)}$	25.00 mL
Mass of beaker	89.05 g
Mass of beaker and residue	93.47 g

Calculate the solubility of $MgBr_2$ in moles per litre. (3marks)

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6 **16.** 95 08

What is the solubility of $CaCO_3$ in g/L? **(3 marks)**

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5 **17.** 96 01

A saturated solution of $BaSO_4$ is given to patients needing digestive tract x-rays.

a) Write an equation that represents the solubility equilibrium. **(1mark)**

b) Calculate the $[Ba^{2+}]$ present in the saturated solution. **(2marks)**

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6 **18.** 96 01

Will a precipitate form when 90.0 mL of 1.00×10^{-2} M Cu $(NO_3)_2$ and 10.0 mL of 1.00×10^{-2} M $NaIO_3$ are mixed? Explain using appropriate calculations. (3marks)

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5 **19.** 96 04

Write a balanced chemical equation for the equilibrium in a saturated solution of an ionic compound with low solubility. **(2marks)**

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6 **20.** 96 04

A saturated solution of $AgCH_3COO$ was evaporated to dryness. The 250.0 mL sample was found to contain 1.84 g $AgCH_3COO$. Calculate the solubility product constant for $AgCH_3COO$. **(4marks)**

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5 **21.** 96 06

A 25.00 mL sample of a saturated ZnF_2 solution was evaporated to dryness. The mass of the residue was 0.508 g. Calculate the solubility product constant of ZnF_2 . **(4marks)**

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6 **22.** 96 06

The following data were collected when a 25.00 mL sample of water containing chloride ion was titrated using 0.100 M $AgNO_3$ to completely precipitate the chloride ion.

Initial volume of $AgNO_3$	18.20 mL
Final volume of $AgNO_3$	27.22 mL

a) Write the net ionic equation for the precipitation reaction. **(1mark)**

b) Calculate the $[Cl^-]$. **(3marks)**

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5 **23.** 96 08

a) Identify a compound that could be used to precipitate both the $Mg^{2+}_{(aq)}$ and $Ca^{2+}_{(aq)}$ from "hard water". **(1mark)**

b) Write the net ionic equations for the reactions. **(2 marks)**

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6 **24.** 96 08

How many grams of $CaSO_4$ (Plaster of Paris) are dissolved in 100.0 mL of a saturated $CaSO_4$ solution at 25° C? **(3marks)**

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5 **25.** 97 01

A saturated solution of BaF_2 has a $[Ba^{2+}]$ of 3.6×10^{-3} M. Calculate the K_{sp} value. **(2 marks)**

6	26. 97 01	Calculate the maximum mass of Na_2SO_4 which can be dissolved in 2.0 L of 1.5 M $Ca(NO_3)_2$ without a precipitate forming. **(3 marks)**
4	27. 97 04	A solution contains 0.20 M Cl^- and 0.20 M SO_4^{2-}. a) Identify a cation that could be added to the solution to give a precipitate with only one of these anions. **(1 mark)** b) Write the net ionic equation for the precipitation reaction in part a). **(1 mark)**
5	28. 97 04	Will a precipitate form when 25.0 mL of 0.15 M $AgNO_3$ is added to 15.0 mL of 0.20 M NaCl? Support your answer with appropriate calculations. **(3 marks)**
4	29. 97 06	a) Write the net ionic equation for the precipitation reaction that occurs when solutions of $NaIO_3$ and $AgNO_3$ are mixed. **(1 mark)** b) Using appropriate calculations, explain why a precipitate forms when 15.0 mL of 0.50 M $NaIO_3$ are added to 35.0 mL of 0.50 M $AgNO_3$. **(3 marks)**
5	30. 97 06	What is the maximum $[CO_3^{2-}]$ that can exist in a 1.3×10^{-4} M $AgNO_3$ solution? **(2 marks)**
5	31. 97 08	A container is filled with 10.0 L of 0.050 M NaI. Calculate the maximum mass of solid $Pb(NO_3)_2$ that can be dissolved without forming a precipitate. **(3 marks)**
6	32. 97 08	Write net ionic equations for all precipitation reactions that occur when equal volumes of 0.20 M $Sr(OH)_2$ and 0.20 M $MgSO_4$ are mixed together. **(2 marks)**
3	33. 98 01	A 100.00 mL sample of a saturated solution of $Ca(OH)_2$ is evaporated to dryness. The mass of the solid residue is 0.125 g. Calculate the solubility product of Ca $(OH)_2$. **(4 marks)**
4	34. 98 01	Write the net ionic equation representing the reaction that occurs when equal volumes of 0.20 M H_2SO_4 and 0.20 M $Ba(NO_3)_2$ are mixed together. **(2 marks)**
4	35. 98 04	Consider the following reaction: $Cu_{(s)} + 2AgCH_3COO_{(aq)} \rightarrow Cu(CH_3COO)_{2(aq)} + 2Ag_{(s)}$ A piece of Cu wire is placed into 1.00 L of a saturated solution of silver acetate, $AgCH_3COO$. When all the Ag^+ has reacted, 2.00 g of Cu has been used. a) Write the net ionic equation for the reaction between Cu and Ag^+. **(1mark)** b) Calculate the K_{sp} of $AgCH_3COO$. **(4marks)**
4	36. 98 06	Consider the following net ionic equation: $Ag_{(aq)}SCN_{(aq)} \rightarrow AgSCN_{(s)}$ A 20.00 mL sample of 0.200 M NH_4SCN is used to titrate a 30.00 mL sample containing Ag^+. Calculate the $[Ag^+]$ in the original sample. **(3marks)**
5	37. 98 06	A solution contains 0.020 M Ba^{2+} and an unknown concentration of Sr^{2+}. When dilute Na_2CO_3 is slowly added to the mixture, both Ba^{2+} and Sr^{2+} start to precipitate at the same time. **(3 marks)** a) Calculate the $[CO_3^{2-}]$ when $BaCO_3$ starts to precipitate. b) Calculate the initial $[Sr^{2+}]$.
3	38. 98 08	What is the maximum $[Mg^{2+}]$ that can exist in a solution with a pOH of 2.00? **(3marks)**
4	39. 98 08	When 1.00 L of a saturated solution of CaF_2 was evaporated to dryness, 2.66×10^{-2} g of residue was formed. Calculate the value of K_{sp}. **(3marks)**

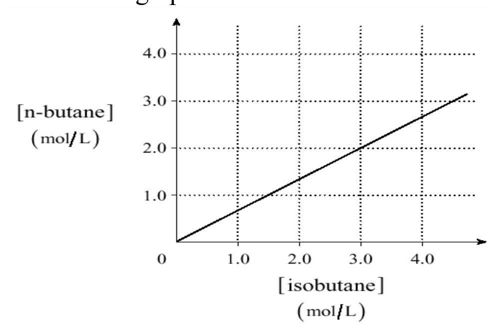
3 40. In an experiment to determine the solubility of barium fluoride, 500.0 mL of the saturated
99 solution was heated in an evaporating dish to remove the water. The evaporating dish and
01 residue were heated two more times, to ensure all the water had been driven off.

I.	Volume of saturated solution of BaF_2	500.0 mL
II.	Mass of evaporating dish	72.540 g
III.	Mass of evaporating dish and BaF_2 after first heating	73.500 g
IV.	Mass of evaporating dish and BaF_2 after second heating	72.855 g
V.	Mass of evaporating dish and BaF_2 after third heating	72.855 g

Using the data above, calculate the K_{sp} for BaF_2. **(4 marks)**

3 41. Consider the graph below representing the following equilibrium:
99
$$CH_3CH_2CH_2CH_{3\,(g)} \leftrightarrow CH_3CH(CH_3)_{2\,(g)}$$
04 n-butane isobutene

Data for the graph was obtained from various equilibrium mixtures.



Calculate the value of K_{eq} for the equilibrium. **(2 marks)**

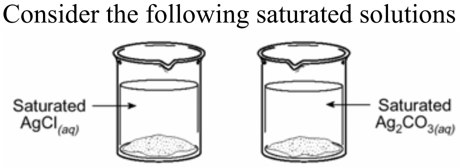
4 42. A 100. 0 mL sample of 0. 600 M Ca $(NO_3)_2$ is diluted by adding 400. 0mL of water.
99 Calculate the concentration of ions in the resulting solution. **(2 marks)**
04

5 43. A maximum of 0.60g Pb $(NO_3)_2$ can be added to 1.5 L of $NaBr_{(aq)}$ without forming a
99 precipitate. Calculate the[NaBr]. **(4 marks)**
04

4 44. The solubility of Mn $(IO_3)_2$ is 4.8×10^{-3} mol/L.
99 a) Write the net ionic equation that describes a saturated solution of Mn $(IO_3)_2$. **(1 mark)**
08

b) Calculate the concentrations of the ions in a saturated solution of Mn $(IO_3)_2$. **(1 mark)**

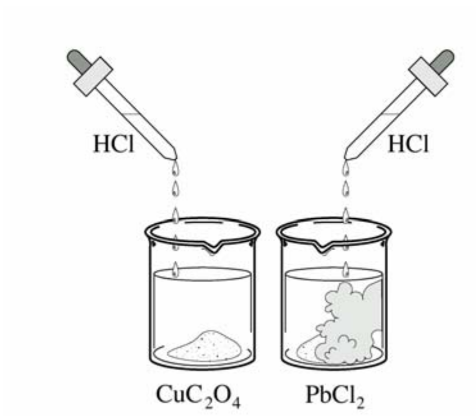
5 45. Consider the following saturated solutions at 25° C:
99
08



Using calculations, identify the solution with the greater $[Ag^+]$. **(5 marks)**

46. At 25°C, will a precipitate form when 25.0mL of 0.010M $Pb(NO_3)_2$ is combined with 75.0mL of 0.010M NaI?
00 Support your answer with calculations. **(3marks)**
06

47. 0006 When HCl is added to a saturated solution of CuC_2O_4 , some precipitate dissolves. However, when HCl is added to a saturated solution of $PbCl_2$, additional precipitate forms.



Explain these observations. Support your explanation with chemical equations. **(3marks)**

Solubility Study Guide – Written Answers

1. $2Na_3PO_{4\,(aq)} + 3CuCl_{2\,(aq)} \rightarrow 6NaCl_{(aq)} + Cu_3(PO_4)_{2\,(s)}$ **(1 mark)**

   $3Cu^{2+}_{(aq)} + 2PO_4^{3-}_{(aq)} \rightarrow Cu_3(PO_4)_{2\,(s)}$ **(1 mark)**

2.

$[NiCO_3]$= 0.090g /2.0 L × 1 mol / 118.7g = 3.79×10^{-4} mol/L (1 mark)

$NiCO_{3\,(s)} \rightleftarrows Ni^{2+}_{(aq)} + CO_3^{2-}$

3.79×10^{-4} M 3.79×10^{-4} M

Ksp = $[Ni^{2+}][CO_3^{2-}]$

= $(3.79 \times 10^{-4})(3.79 \times 10^{-4})$

= 1.4×10^{-7}

(Deduct **1/2 mark** for incorrect significant figures.)

3. $PbSO_{4\,(s)} \rightleftarrows Pb^{2+} + SO_4^{2-}$ (1/2 mark)

$K_{sp} = [Pb^{2+}][SO_4^{2-}]$
$1.8 \times 10^{-8} = (x)(3.0 \times 10^{-2})$ (1.5 marks)
$[Pb^{2+}] = x = 6.0 \times 10^{-7}$ M

4. First add: NaOH
Then add: $ZnSO_4$ **(2 marks)**

$Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Ca(OH)_{2(s)}$
Or $Zn^{2+}_{(aq)} + S^{2-}(aq) \rightarrow ZnS_{(s)}$

5. NH and Cl_4 **(2 marks)**

6. K_{sp} for $Ca(OH)_2 = 1.3 \times 10^{-6}$
Let s = solubility of $Ca(OH)_2 = [Ca^{2+}]$
$2s = [OH^-]$ **(3 marks)**
$Ksp = [Ca^{2+}][OH^-] = (s)(2s)^2 = 4s^3$
$4s^3 = 1.3 \times 10^{-6}$
$s = 6.87 \times 10^{-3}$ M

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

g = $(6.87 \times 10^{-3}$ mol/L) (74.1 g/mol) (5.0L) **(1 mark)**
= 2.5g **(1/2 mark)**

7.

8.

9. Copper(II) sulphite or $CuSO_3$

b) $2Na^+_{(aq)} + SO_3^{2-}{}_{(aq)} Cu^{2+} + 2Cl^-_{(aq)} \rightarrow CuSO_{3(aq)} + 2Na^+ + 2Cl^-$
or
$Na^+_{(aq)} + SO_3^{2-}{}_{(aq)} + Cu^{2+}_{(aq)} + Cl^-_{(aq)} \rightarrow CuSO_{3(s)} + Na^+_{(aq)} + Cl^-_{(aq)}$

c) Na^+, Cl^-

10. Average volume = 22. 62 + 22. 58 / 2 = 22.60 **(1 mark)**
mol SCN^- = 0. 02260 L × 0. 200 mol/L **(1 mark)**
= 0. 00452 mol
mol Ag^+ = 0. 00452 mol **(1 mark)**
$[Ag^+]$ = 0. 00452 mol / 0.1000 L = 0. 0452 M **(1 mark)**
NOTE: Deduct $^1/_2$ point for incorrect significant figures.

11. Since $Pb(NO_3)_2 \rightarrow Pb^{2+}_{(aq)} + 2NO_3^-$

$[Pb^{2+}] = 0.10$ M (1/2 mark)

$PbBr_{2(s)} \rightleftarrows Pb^{2+}_{(aq)} + 2Br^-_{(aq)}$ (1/2 mark)

$K_{sp} = [Pb^{2+}][Br^-]^2$ (1/2 mark)

$6.6 \times 10^{-6} = (0.10\text{ M})[Br^-]^2$ (1/2 mark)

$[Br^-] = 8.1 \times 10^{-3}$ M (1mark)

mol $Br^- = 8.1 \times 10^{-3}\text{ M} \times 0.500\text{L} = 4.1 \times 10^{-3}$ mol (1mark)

(- 1/2 mark for incorrect sig. figs.)

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13. $[Ca^{2+}] = 0.054 \times 30.0\text{ mL} / 90.0\text{ mL}$

$= 0.018$ M (1 mark)

$[SO_4^{2-}] = 8.1 \times \text{M} \times 60.0\text{ mL} / 90.0\text{ mL}$

$= 5.4 \times 10^{-4}$ M (1 mark)

TIP $= [Ca^{2+}][SO_4^{2-}]$

$= (0.018)(5.4 \times 10^{-4})$

$= 9.7 \times 10^{-6}$ (1 mark)

Since trial ion product < K *sp* ,(7.1×10^{-5}), no precipitate will form. (1 mark)

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15. Mass of $MgBr_2$ = 93.47g

-89.05g (1 mark)

4.42g

Molar mass of $MgBr_2$ = 184.1 g/mol

Mol $MgBr_2$ = 4.42g × 1 mol/184.1g

$= 2.40 \times 10^{-2}$ mol (1 mark)

Solubility= 2.40×10^{-2} mol/ 0.02500 L = 0.960 mol/L (1 mark)

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16. $CaCO_3 \rightleftarrows Ca^{2+} + CO_3^{2-}$ (1mark)

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

$= 7.07 \times 10^{-5}$ mol/L (1mark)

$= 7.07 \times 10^{-5}$ (100.1g / 1 mol) (1mark)

$= 7.08 \times 10^{-3}$ g/L ($^1/_2$mark)

$= 7.1\times10^{-3}$ g/L

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17. $BaSO_{4(s)} \rightleftarrows Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)}$ (1 mark)

b) $BaSO_{4\,(s)} \rightleftarrows Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)}$

[ ] x x

$K_{sp} = [Ba^{2+}][SO_4^{2-}]$ (1/2 mark)

$1.10 \times 10^{-10} = (x)(x)$

$\sqrt{1.10 \times 10^{-10}} = \sqrt{x^2}$ (1 mark)

$[Ba^{2+}] = x = 1.0 \times 10^{-5}$ M (1/2 mark)

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18. $[Cu(NO_3)_2] = 1.00 \times 10^{-2}\text{ M} \times \frac{90.0\text{mL}}{100.0\text{ mL}} = 9.00 \times 10^{-3}$ M (1 mark)

$[NaIO_3] = 1.00 \times 10^{-2}\text{ M} \times \frac{10.0\text{ mL}}{100.0\text{ mL}} = 1.00 \times 10^{-3}$ M

$Cu(IO_3)_2 \rightleftarrows Cu^{2+} + 2IO_3^-$

9.00×10^{-3} M 1.00×10^{-3} M (1 mark)

TIP $= [Cu^{2+}][IO_3^-]^2$

$= (9.00 \times 10^{-3})(1.00 \times 10^{-3})^2$

$= 9.00 \times 10^{-9}$

TIP (9.00×10^{-9}) < K_{sp} (6.9×10^{-8}) -Therefore, a precipitate does not form. (1 mark)

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19. $AgCl_{(s)} \rightleftarrows Ag^+_{(aq)} + Cl^-_{(aq)}$

20. Mol mass $AgCH_3COO$ = 107.9 +2(12.0) + 3(1.0) + 2(16.0) = 166.9g/mol

Mol $AgCH_3COO$ = 1.84g $AgCH_3COO$ (1mol $AgCH_3COO$ / 166.9g) = 0.0110mol $AgCH_3COO$

[$AgCH_3COO$] = 0.0110mol/ 0.250L = 0.0441mol/L $AgCH_3COO$ (2marks)

$AgCH_3COO \rightleftarrows Ag^+_{(aq)} + CH_3COO^-_{(aq)}$

0.441 0.0441

$K_{sp} = [Ag^+][CH_3COO^-]$

= (0.0441)(0.0441)

$= 1.94 \times 10^{-3}$ (2marks)

(subtract $^1/_2$ **mark** for incorrect sig. fig)

21.

$$\text{mol } ZnF_2 = \frac{0.508 \text{ g}}{103.4 \text{ g/mol}} = 4.91 \times 10^{-3}$$

$$\text{solubility } ZnF_2 = \frac{4.91 \times 10^{-3} \text{ mol}}{0.02500 \text{ L}} = 1.97 \times 10^{-1} \text{ M}$$

← $1\frac{1}{2}$ **marks**

$$ZnF_{2(s)} \rightleftarrows Zn^{2+}_{(aq)} + 2F^-_{(aq)}$$

x $2x$

$$[Zn^{2+}] = x = 1.97 \times 10^{-1} \text{ M}$$

$$[F^-] = 2x = 2(1.97 \times 10^{-1}) = 3.93 \times 10^{-1} \text{ M}$$

← **1 mark**

$$K_{sp} = [Zn^{2+}][F^-]^2$$

$$= (1.97 \times 10^{-1})(3.93 \times 10^{-1})^2$$

$$= 3.04 \times 10^{-2}$$

← $1\frac{1}{2}$ **marks**

Deduct $\frac{1}{2}$ mark for incorrect significant figures.

22. $Ag^+_{(aq)} + Cl^- \rightarrow AgCl_{(s)}$

Volume of $AgNO_3$ used = 27.22 − 18.20 = 9.02 mL ← 1 mark

$\text{mol } AgNO_3 = 0.100 \text{ M} \times 0.00902 \text{ L} = 9.02 \times 10^{-4}$ ← $\frac{1}{2}$ mark

$\text{mol } Cl^- = 9.02 \times 10^{-4} \text{ mol } Ag^+ \times \frac{1 \text{ mol } Cl^-}{1 \text{ mol } Ag^+} = 9.02 \times 10^{-4}$ ← $\frac{1}{2}$ mark

$[Cl^-] = \frac{9.02 \times 10^{-4} \text{ mol}}{0.02500\text{L}} = 3.61 \times 10^{-2} \text{ M}$ ← 1 mark

Deduct $^1/_2$ **mark** for incorrect significant figures.

23. Add NaOH to precipitate Mg^{2+} and Ca^{2+}.

b) $Mg^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Mg(OH)_{2(s)}$ (1 mark)

$Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Ca(OH)_{2(s)}$ (1 mark)

24. $CuSO_{4(s)} \rightleftarrows Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$

x x

$K_{sp} = [Ca^{2+}][SO_4^{2-}]$

7.1×10^{-5} = (x)(x) (2 marks)

$7.1 \times 10^{-5} = x^2$

$x = 8.4 \times 10^{-3}$

g $CaSO_4$ = 8.4×10^{-3} M × 136.2 g/mol × 0.1000 L

$= 1.1 \times 10^{-1}$ g (1 mark)

25. $BaF_{2(s)} \rightleftarrows Ba^{2+}_{(aq)} + 2F^{-}_{(aq)}$

$3.6 \times 10^{-3}M \quad 7.2 \times 10^{-3}M$

$K_{sp} = [Ba^{2+}] [F^{-}]^2$

$= (3.6 \times 10^{-3})(7.02 \times 10^{-3})^2$

$= 1.9 \times 10^{-7}$ }2 marks

26. $CaSO_4 \rightleftarrows Ca^{2+} + SO_4^{2-}$

$1.5M \quad x$

K_{sp} for $CaSO_4 = [Ca^{2+}][SO_4^{2-}]$

$7.1 \times 10^{-5} = (1.5)(x)$

$x = [SO_4^{-2}] = [Ns_2SO_4] = 4.7 \times 10^{-5}$ }2 marks

mass of Na_2SO_4 required $= 4.7 \times 10^{-5}$ mol/L $\times$ 142.1 g/mol $\times$ 2.0L

$= 1.3 \times 10^{-2}g$ }2 marks

27. For example: Ca^{+2} or Sr^{+2} or Ba^{+2}

b) $Ca^{+2}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow CaSO_{4(s)}$

$Sr^{+2}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow SrSO_{4(s)}$

$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$

28. $[Ag^{+}] = (25.0mL / 40.0mL) \times 0.15M = 0.094M$ (1/2 mark)

$[Cl^{-}] = (15.0mL / 40.0mL) \times 0.20M = 0.075M$ (1/2 mark)

TIP (Trial K_{sp}) $= [Ag^{+}][Cl^{-}] = (0.094)(0.075) = 7.0 \times 10^{-3}$ (1 mark)

Since TIP (Trial K_{sp}) $> K_{sp}$ (1.8×10^{-10}), a precipitate **does** form. (1 mark)

29. $Ag^{+} + IO_3^{-}{}_{(aq)} \rightarrow AgIO_{3(s)}$ (1 mark)

b) $[IO_3^{-}] = 0.50M \times (15.0mL / 50.0mL) = 0.15M$ (1/2 mark)

$[Ag^{+}] = 0.50M \times (35.0mL / 50.0mL) = 0.35M$ (1/2 mark)

Trail $K_{sp} = [Ag^{+}][IO_3^{-}]$

$= 0.35M \times 0.15M$

$= 0.052$ }1 mark

Since Trial K_{sp} 0.052 ( ) > K_{sp} 3.2´10 -8

Since Trial K_{sp} (0.052) > K_{sp} (3.2×10^{-8}), a precipitate forms. (1 mark)

30. $2Ag^{+} + CO_3^{2-}{}_{(aq)} \rightarrow AgCO_{3(s)}$

$K_{sp} = [Ag^{+}]^2[CO_3^{2-}]$ } 1/2 mark

$8.5 \times 10^{-12} = (1.3 \times 10^{-4})^2 [CO_3^{2-}]$ (1 mark)

$[CO_3^{2-}] = 5.0 \times 10^{-4}M$ (1/2 mark)

1/2 mark was deducted for incorrect significant figures

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

[E] $\quad x \quad 0.050$

$K_{sp} = [Pb^{2+}][I^{-}] = 8.5 \times 10^{-9}$ (1 mark)

$(x) (0.050)^2 = 8.5 \times 10^{-9}$

$x = [Pb^{2+}] = 3.4 \times 10^{-6}M$ (1 mark)

$3.4 \times 10^{-6}M \times 331.2g/mol = 1.1 \times 10^{-3}g/L$ (1/2 mark)

$1.1 \times 10^{-3}g/L \times 10.0L = 1.1 \times 10^{-2}g$ (1/2 mark)

32. $Sr^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow SrSO_{4(s)}$ (1 mark)

$Mg^{2+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Mg(OH)_{2(s)}$ (1 mark)

33. Moles of $Ca(OH)_2$ = 0.125g (1 mol / 74.1g) $= 1.687 \times 10^{-3}$ mol

Solubility $= 1.687 \times 10^{-3}$mol / 0.10000L

$= 1.987 \times 10^{-2}$ mol/L

$Ca(OH)_2 \rightleftarrows Ca^{2+} + 2OH^{-}$

$K_{sp} = [Ca^{2+}][PH^{-}]^2$

$= (1.687 \times 10^{-2})(3.374 \times 10^{-2})^2$

$= 1.92 \times 10^{-5}$

(Deduct 1/2 mark for incorrect significant figures.)

34. $Ba^{2+}_{(aq)}$ + $SO_4^{2-}_{(aq)}$ → $BaSO_{4(s)}$ (2 marks)

35. $Cu_{(s)}$ + $Ag^+_{(aq)}$ → $Cu^{2+}_{(aq)}$ + $2Ag_{(s)}$ (1 mark)

b) $Ag\ CH_3COO_{(s)} \rightleftarrows Ag^+_{(aq)} + CH_3COO^-_{(aq)}$

mol of Cu reacted = 2.00g (1 mol / 63.5g) = 3.15×10^{-2}mol
mol Ag^+ reacted = 3.15×10^{-2}mol Cu (2 mol Ag^+ / 1 mol Cu)
= 6.30×10^{-2} mol Ag^+ } $1\,^1/_2$ marks)

$[Ag^+] = [CH_3COO^-] = 6.30 \times 10^{-2}$ M (1 mark)

$K_{sp} = [Ag^+][CH_3COO^-]$
$= (6.30 \times 10^{-2})^2$
$= 3.97 \times 10^{-3}$ }$1\,^1/_2$marks

36. mol SCN^- = 0.200L (0.200mol / 1L) = 4.00×10^{-3}mol (1 mark)

mol Ag^+ = mol SCN^-
= 4.00×10^{-3}mol } 1 mark

$[Ag^+]$ = (4.00×10^{-3}mol / 0.0300L) = 0.133M (1 mark)

NOTE: ($^1/_2$ mark) is deducted for incorrect significant figures.

37. $BaCO_3 \rightleftarrows Ba^{2+} + CO_3^{2-}$
0.20 x

$K_{sp} = [Ba^{2+}][CO_3^{2-}]$
$[CO_2^{2-}] = (2.6 \times 10^{-9} / 0.020)$
$= 1.3 \times 10^{-7}$ }$1\,^1/_2$marks

b) $SrCO_3 \rightleftarrows Sr^{2+} + CO_3^{2-}$
y 1.3×10^{-7}

$K_{sp} = [Sr^{2+}][CO_3^{2-}]$
$[Sr^{2+}] = (5.6 \times 10^{-10} / 1.3 \times 10^{-7})$
$= 4.3 \times 10^{-3}$ } 1 mark

38. $[OH^-]$ = antilog(-2.00) = 0.010M (1 mark)

$Mg(OH)_2 \rightleftarrows Mg^{2+} + OH^-$
x 0.010

$K_{sp} = [Mg^{2+}][OH^-]^2$
$= (x)\,(0.010)^2$
$= 5.6 \times 10^{-8}$M }$1\,^1/_2$ mark

$[Mg^{2+}] = x = 5.6 \times 10^{-8}$M ($^1/_2$ mark)

39. Mol CaF_2 = 2.66×10^{-2}g (1 mol / 78.1 g) = 3.41×10^{-4}
Solubility = (3.41×10^{-4}mol / 1.00L) = 3.41×10^{-4}M }1 mark

$CaF_{2(s)} \rightleftarrows Ca^{2+}_{(aq)} + F^-_{(aq)}$
3.41×10^{-4} $2(3.41 \times 10^{-4})$
$= 6.82 \times 10^{-4}$

$K_{sp} = [Ca^{2+}][F^-]^2$
$= (3.41 \times 10^{-4})(6.82 \times 10^{-4})^2$
$= 1.58 \times 10^{-10}$ }2 marks

40. Use the final unchanged mass (dish + BaF_2):
$\therefore$ Mass of BaF_2 = 72.855g – 72.540g = 0.315g (1 mark)

Solubility is
[0.315g × (1 mol / 175.3g) / 0.5000L] = 0.00359mol/L ($1\frac{1}{2}$marks)

$K_{sp} = [Ba^{2+}][F^-]^2$
$= (0.00359)(0.00718)^2$
$= 1.86 \times 10^{-7}$ }$1\frac{1}{2}$marks

41. K_{eq} = [isobutene] / [n – butane] ($\frac{1}{2}$mark)
= 3.0 / 2.0 (1 mark)
= 1.5 ($\frac{1}{2}$mark)

42. $[Ca(NO_3)_2]$ = 0.600M × (100.0mL / 500.0mL) = 0.120M (1 mark)
$[Ca^{2+}]$ = 0.120M
$[NO_3^-]$ = 0.240M (1 mark)

43.
$$\text{mol } Pb^{2+} = \text{mol } Pb(NO_3)_2 = 0.60\,g \times \frac{1\,mol}{331.2\,g} = 1.81\times10^{-3}\,mol$$
$$[Pb^{2+}] = \frac{1.81\times10^{-3}\,mol}{1.5\,L} = 1.208\times10^{-3}\,M \quad \leftarrow \textbf{2 marks}$$

$$PbBr_{2(s)} \rightleftarrows Pb^{2+}_{(aq)} + 2Br^-_{(aq)} \qquad K_{sp} = [Pb^{2+}][Br^-]^2 = 6.6\times10^{-6}$$

$$[Br^-] = \sqrt{\frac{K_{sp}}{[Pb^{2+}]}} = \sqrt{\frac{6.6\times10^{-6}}{1.208\times10^{-3}}} = 0.074\,M$$
$$[NaBr] = [Br^-] = 0.074\,M \quad \leftarrow \textbf{2 marks}$$

44. $Mn(IO_3)_{2(s)} \rightleftarrows Mn^{2+}_{(aq)} + 2IO_3^-{}_{(aq)}$ (1mark)

c) $[Mn^{2+}] = 4.8 \times 10^{-3}$M
$[IO_3^-] = 2 \times 4.8\times10^{-3}M = 9.6\times10^{-3}$M }1 mark

45. $Ag \rightleftarrows Ag^+ + Cl^-$
s s
$[Ag^+][Cl^-] = 1.8 \times 10^{-10}$
$s^2 = 1.8 \times 10^{-10}$
$s = 1.3 \times 10^{-5}$M
$[Ag^+] = 1.3 \times 10^{-5}$M }2 marks

$Ag_2CO_3 \rightleftarrows 2Ag^+ + CO_3^{2-}$
$2s$ s
$[Ag^+]^2[CO_3^{2-}] = 8.5 \times 10^{-12}$
$4s = 8.5 \times 10^{-12}$
$s = 1.3 \times 10^{-4}$M
$[Ag^+] = 2.6 \times 10^{-4}$M }2 marks

Therefore $[Ag^+]$ in Ag_2CO_3 is higher than $[Ag^+]$ in AgCl. (1 mark)