Answers to extra questions for Study Unit 9

QUESTION 1

Die oplosbaarheidsproduk-konstante van kadmiumfluoried is 6.44 x 10^{-3} by 25^0C. Bereken die hoeveelheid (in gram en in milligram) CdF_2 wat sal oplos in 'n half liter water by 25^0C.

The solubility product constant of cadmium fluoride is 6.44 x 10^{-3} at 25^0C. Calculate the amount (in gram and in milligram) of CdF_2 that will dissolve in half a litre of water at 25^0C.

(**Gegee: /** ***Given:*** M_{H2O} = 18.02 g.mol^{-1} en/*and* M_{CdF2} = 150.38 g.mol^{-1})

$K_{sp} = 6.44 \times 10^{-3}$

$CdF_2(s) \rightleftarrows Cd^{2+}(aq) + 2F^-(aq)$

A	—	0	0
V	—	+x	+2x
E	—	x ✓½	2x ✓½

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

$x(2x)^2 = 6.44 \times 10^{-3}$

$4x^3 = 6.44 \times 10^{-3}$

$x = \sqrt[3]{\frac{6.44 \times 10^{-3}}{4}}$

$x = 0.1172$ ✓✓

$x = [Cd^{2+}] = [CdF_2] = 0.1172\ M$

$\therefore [CdF_2] = 0.1172$ mol CdF_2 per 1.00 L oploss.

$M_{CdF_2} = n \times M$

$= 0.1172\ mol \times 150.38\ g.mol^{-1}$

$=$ ✓17.63 g CdF_2 per 1.00 L oploss. ✓

$\therefore \frac{17.63}{2} = 8.815$ g in ½ L ✓ | $8.815 \times 1000 = 8815$ mg in ½ L

Question 2

Definieer 'n bufferoplossing. Van wat word 'n bufferoplossing berei? Beskryf hoe buffers bygevoegde H^+- en OH^--ione absorbeer sodat 'n baie klein pH verandering plaasvind. 'n Sekere buffer is berei deur $NaHCO_3$ en $NaCO_3$ in water op te los. Skryf reaksievergelykings neer wat wys hoe die buffer bygevoegde H^+- en OH^--ione sal neutraliseer. *Define a buffer solution. What makes up a buffered solution? Explain how buffers absorb added H^+ or OH^- with little pH change. A certain buffer is made by dissolving $NaHCO_3$ and Na_2CO_3 in come water. Write equations to show how this buffer neutralizes added H^+ and OH^-.*

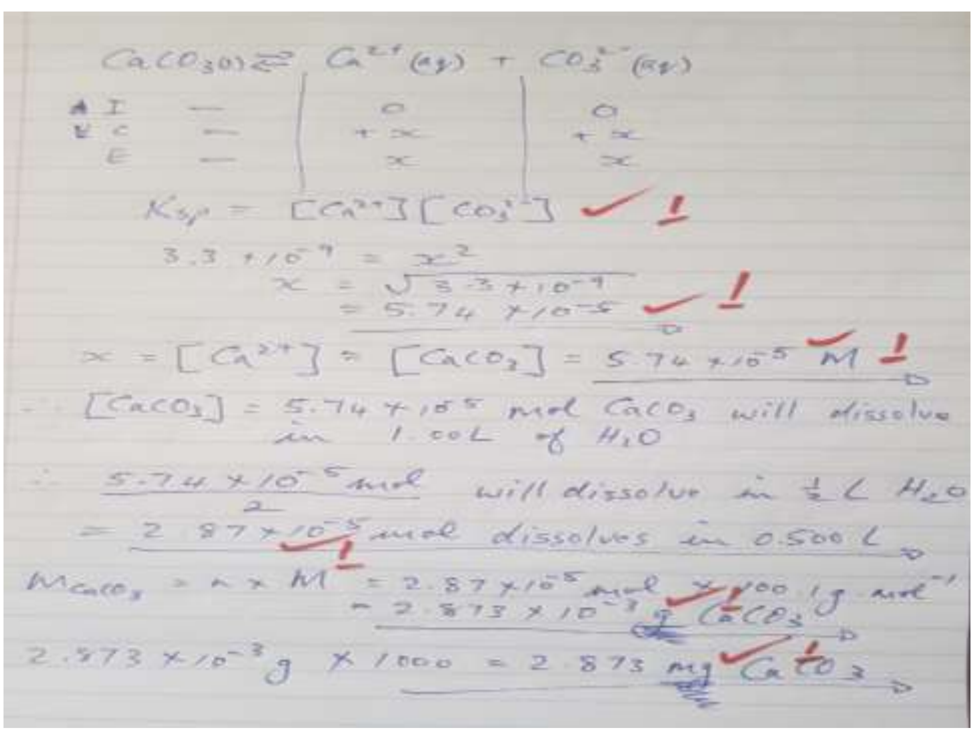
A buffer solution is a solution that resists a change in its pH when H^+ or OH^- are added. Any solution that contains a weak acid and its conjugate base OR a weak base and its conjugate acid, is classified as a buffer. The pH of the buffer depends on the [base] / [acid] ratio. **When H^+** is added to the buffer, the weak base component of the buffer reacts with the H^+ and forms the acid component of the buffer. Even though the concentrations of the acid and the base components of the buffer change some, the ratio of [base] / [acid] does not change that much. **When OH^-** is added to the buffer, the weak acid component of the buffer reacts with the OH^- and forms the base component of the buffer. Again, the ratio of [base] / [acid] does not change a lot, so that the pH does not change much.

Buffer HCO_3^- and CO_3^{2-}

$\mathbf{H^+} + CO_3^{2-} \leftrightarrows HCO_3^-$ OR $\mathbf{OH^-} + HCO_3^- \leftrightarrows H_2O + CO_3^{2-}$

Question 3

Die oplosbaarheidsproduk-konstante van kalsiumkarbonaat is 3.3×10^{-9} by 25^0C. Bereken die hoeveelheid (in gram en in milligram) $CaCO_3$ wat sal oplos in 'n half liter water by 25^0C. / The solubility product constant of calcium carbonate is 3.3×10^{-9} at 25^0C. Calculate the amount (in gram and in milligram) of $CaCO_3$ that will dissolve in half a litre of water at 25^0C. (**Gegee: / *Given:*** $M_{H2O} = 18.02$ g.mol^{-1} en/*and* $M_{CaCO3} = 100.1$ g.mol^{-1})



$CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$

	$CaCO_3$	Ca^{2+}	CO_3^{2-}
I	—	0	0
C	—	+x	+x
E	—	x	x

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

$3.3 \times 10^{-9} = x^2$

$x = \sqrt{3.3 \times 10^{-9}} = 5.74 \times 10^{-5}$

$x = [Ca^{2+}] = [CaCO_3] = 5.74 \times 10^{-5}$ M

∴ $[CaCO_3] = 5.74 \times 10^{-5}$ mol $CaCO_3$ will dissolve in 1.00 L of H_2O

∴ $\frac{5.74 \times 10^{-5} \text{ mol}}{2}$ will dissolve in ½ L H_2O

$= 2.87 \times 10^{-5}$ mol dissolves in 0.500 L

$m_{CaCO_3} = n \times M = 2.87 \times 10^{-5}$ mol $\times 100.1$ g mol^{-1}

$= 2.873 \times 10^{-3}$ g $CaCO_3$

2.873×10^{-3} g $\times 1000 = 2.873$ mg $CaCO_3$

Question 4

Jy wil 'n 1.0 L bufferoplossing met 'n pH van 4.30 berei. 'n Lys van moontlike sure (en hul gekonjugeerde basisse) word gegee: / *You wish to prepare 1.0 L of a buffer solution with a pH of 4.30. A list of possible acids (and their conjugate bases) is given:*

Suur. / *Acid.*	**Gekonjugeerde basis.** ***Conjugate base.***	**K_a**	**pK_a**
HSO_4^-	SO_4^{2-}	1.2×10^{-2}	1.92
CH_3COOH	CH_3COO^-	1.8×10^{-5}	4.74
HCO_3^-	CO_3^{2-}	4.8×10^{-11}	10.32

Watter suur/basis kombinasie moet gebruik word as buffer **en** wat moet die verhouding van die suur en gekonjugeerde basis wees? / *Which combination should be selected as a buffer solution **and** what should be the ratio of the acid to conjugate base?*

pH should be close to pKa value of acid. ✓ 1

pH = 4.30 and pKa of CH_3COOH = 4.74

∴ CH_3COOH/CH_3COO^- should be used. ✓ 1

$$pH = pK_a + \log\left(\frac{[CH_3COO^-]}{[CH_3COOH]}\right) \quad ✓ 1$$

$$\log\left(\frac{[CH_3COO^-]}{[CH_3COOH]}\right) = pH - pK_a = 4.30 - 4.74 = -0.44 \quad ✓ 1$$

$$✓ 1 \quad \frac{[CH_3COO^-]}{[CH_3COOH]} = 10^{-0.44} = 0.36 \quad ✓ 1$$

0.36 mol CH_3COO^- : 1 mol CH_3COOH

OR

$$✓ 1 \quad \frac{[CH_3COOH]}{[CH_3COO^-]} = 10^{+0.44} = 2.75 \quad ✓ 1$$

2.75 mol CH_3COOH : 1 mol CH_3COO^-

Question 5

Bereken die wateroplosbaarheid van Ag_3PO_4 (K_{sp} = 1.8 x 10^{-18} and M_{Ag3PO4} = 418.7 g.mol^{-1}) in mol per liter **en** in gram per liter. / *Calculate the water solubility of* Ag_3PO_4 *(*K_{sp} *= 1.8 x* 10^{-18} *and* M_{Ag3PO4} *= 418.7 g.mol*$^{-1}$*) in moles per litre* ***and*** *in grams per litre.*

$$Ag_3PO_4(s) \rightleftharpoons 3Ag^+(aq) + PO_4^{3-}(aq)$$ ✓ 1

	$Ag_3PO_4(s)$	$3Ag^+(aq)$	$PO_4^{3-}(aq)$
I	–	0	0
C	–	+3x	+x
E	–	3x	x ✓ 1

$K_{sp} = [Ag^+]^3[PO_4^{3-}]$ ✓ 1

$K_{sp} = (3x)^3 x$ ✓ 1

$27x^4 = K_{sp}$

$27x^4 = 1.8 \times 10^{-18}$

$x = \sqrt[4]{\frac{1.8 \times 10^{-18}}{27}}$

$x = \sqrt[4]{6.666 \times 10^{-20}}$

$x = 1.61 \times 10^{-5}$ ✓ 1

⟹ from ICE table:

$x = [PO_4^{3-}] = [Ag_3PO_4] = 1.61 \times 10^{-5}$ M ✓ 1

∴ 1.61×10^{-5} mole of Ag_3PO_4 will dissolve in 1L.

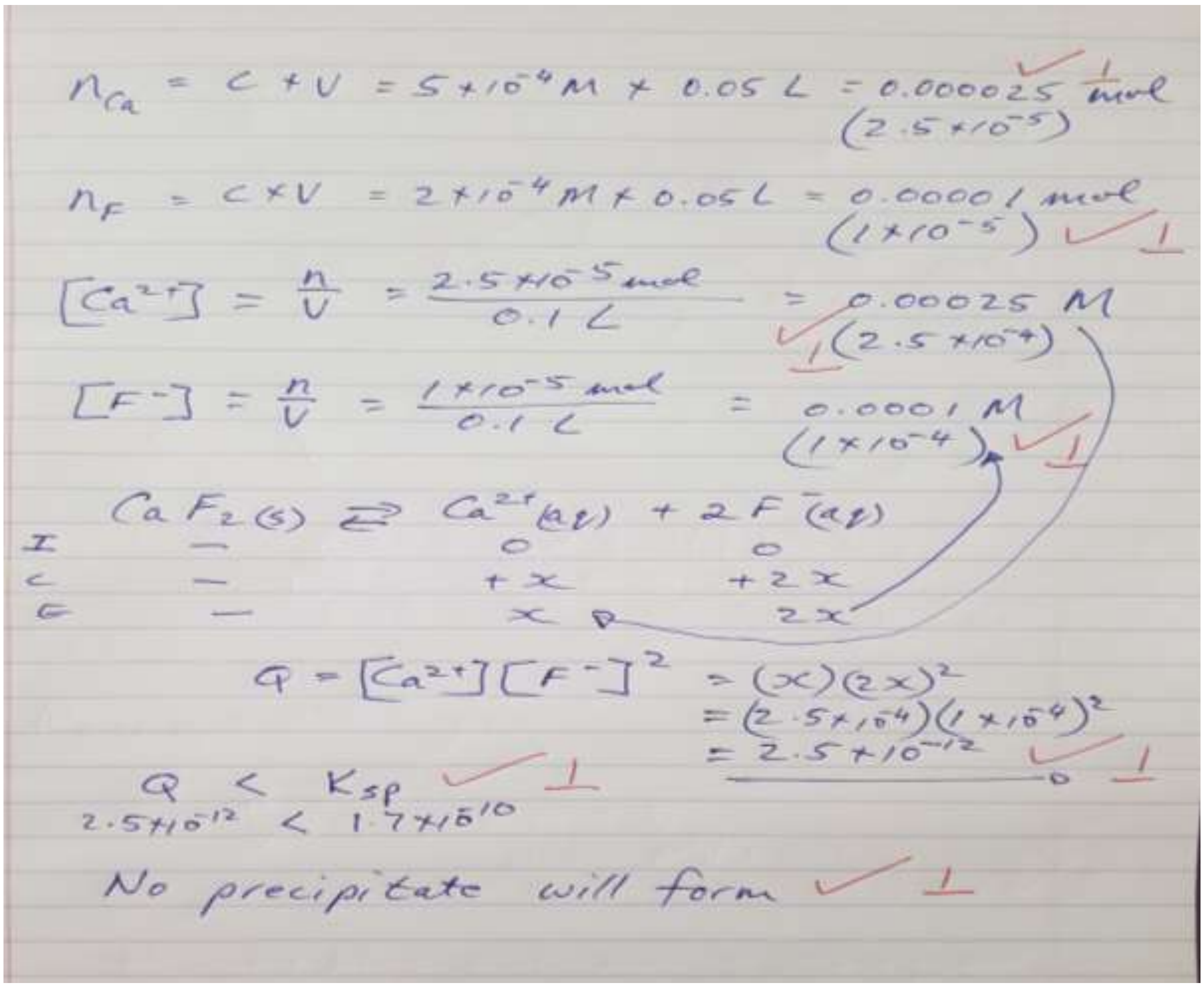
⟹ $m = n \times M = 1.61 \times 10^{-5}$ mol $\times$ 418.7 g.mol^{-1}

$m = 6.74 \times 10^{-3}$ g Ag_3PO_4 will dissolve in 1L. ✓ 1

Question 6

Sal 'n presipitaat vorm wanneer 50 cm^3 van 'n 5 x 10^{-4} mol/dm^3 $Ca(NO_3)_2$ oplossing by 'n 50 cm^3 van 'n 2 x 10^{-4} mol/dm^3 NaF oplossing gevoeg word? (K_{sp} (CaF_2) = 1.7 x 10^{-10}). / *Will a precipitate form when 50 cm^3 of a 5 x 10^{-4} mol/dm^3 $Ca(NO_3)_2$ solution is added to 50 cm^3 of a 2 x 10^{-4} mol/dm^3 NaF solution? (K_{sp} (CaF_2) = 1.7 x 10^{-10}).*

$$CaF_2\ (s) \leftrightarrows Ca^{2+}\ (aq) + 2F^-\ (aq)$$



$n_{Ca} = c \times V = 5 \times 10^{-4}\ M \times 0.05\ L = 0.000025$ mol (2.5×10^{-5}) ✓

$n_F = c \times V = 2 \times 10^{-4}\ M \times 0.05\ L = 0.00001$ mol (1×10^{-5}) ✓

$[Ca^{2+}] = \frac{n}{V} = \frac{2.5 \times 10^{-5}\ mol}{0.1\ L} = 0.00025\ M$ (2.5×10^{-4}) ✓

$[F^-] = \frac{n}{V} = \frac{1 \times 10^{-5}\ mol}{0.1\ L} = 0.0001\ M$ (1×10^{-4}) ✓

	$CaF_2(s)$	$\rightleftharpoons$	$Ca^{2+}(aq)$	+	$2F^-(aq)$
I	—		0		0
C	—		$+x$		$+2x$
E	—		x		$2x$

$Q = [Ca^{2+}][F^-]^2 = (x)(2x)^2$
$= (2.5 \times 10^{-4})(1 \times 10^{-4})^2$
$= 2.5 \times 10^{-12}$ ✓

$Q < K_{sp}$ ✓
$2.5 \times 10^{-12} < 1.7 \times 10^{-10}$

No precipitate will form ✓