3.7 Aqueous Solutions 2006 Answers

QUESTION ONE: PARTICLES IN SOLUTIONS

a (i) C (ii) A (iii) D

A = Two out of three correct.

Reasons:
(i) Strong acid **–** no acid molecules, HA, are present so acid must have **completely dissociated** in solution. Dilute – only a small number of solute particles compared to number present in B.

(ii) Weak acid – particles in solution are mostly acid molecules with only a few conjugate base and hydronium ions present implying only **partial dissociation**. Concentrated – a large number of solute particles present in the given volume of water.

(iii) Both the **acid** HA particles and its conjugate **base** A^- particle are present in **similar quantities**.

A = Evidence of understanding of relationship between definitions and particles present in solution. Must mention at least two of: weak acid, strong acid, concentrated, dilute, define buffer correctly.
M = Explanations for two are correct but lack some details.
E = All three explanations correct, including the key points in bold.

b pH not affected by dilution because $\frac{[\text{acid}]}{[\text{base}]}$ ratio remains the same on dilution.

Buffering capacity reduced as not so many acid or base particles are available to react with added acid or base if same volume is taken.

A = Both factors correct OR One correct explanation.
M = Both explanations correct.

QUESTION TWO: EXTRACTION OF SALT

a **i** $CaSO_4(s) \rightleftharpoons Ca^{2+}(aq) + SO_4^{2-}(aq)$

A = Correct answer.
Reverse equation is also acceptable. (*Subscripts not required but penalise $CaSO_4(aq)$.*)

ii $K_s\ (CaSO_4) = [Ca^{2+}][SO_4^{2-}]$
$= 2.45 \times 10^{-5}$

$s = \sqrt{(2.45 \times 10^{-5})}$
$= 4.95 \times 10^{-3}\ \text{mol L}^{-1}$

A = Correct answer.

b The added Cl^- reduces the solubility of the NaCl. For the saturated solution: $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$. The addition of Cl^- causes the equilibrium to favour the reactants and hence a precipitate will begin to form.

A = Recognition of common ion.
M = Answer discusses shift in equilibrium.

c For precipitation to occur the ionic product has to be greater than K_s
$[Mg^{2+}(aq)][OH^-(aq)]^2 > 7.10 \times 10^{-12}$
$0.555 \text{ mol L}^{-1} \times [OH^-(aq)]^2 > 7.10 \times 10^{-12}$
$[OH^-(aq)] > 3.58 \times 10^{-6}$
Minimum pH = 8.55

A = Correct K_s expression substituted correctly.
M = Correct method, but may be one error in calculation.
E = Answer correct.

QUESTION THREE: TITRATION CURVES

A pK_a = pH at half equivalence volume
$pK_a(NH_4^+) = 9.2$ **or** 9.3
$K_a(NH_4^+) = 10^{-9.2}$
$= 6.3 \times 10^{-10}$ **or** 5.01×10^{-10}

A = pK_a correct OR K_a correctly converted from pK_a.

b At equivalence point all the NH_3 has been converted to NH_4^+ which reacts with water to produce H_3O^+ ions and hence an acidic solution.

$$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$$

A = Either a correctly balanced equation OR recognises that NH_4^+ is responsible for acidity.
M = Correctly links acidity to NH_4^+ and equation for reaction.

c pH of 9.6 occurs after 3 mL (to 4 mL) of 0.200 mol L^{-1} HCl has been added.
Hence, to 40.00 mL of 0.0500 mol L^{-1} NH_3 add 3.00 mL (to 4 mL) of 0.2 mol L^{-1} HCl solution.

A = Correct answer.

d $NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$

A = Correct answer (Accept molecular equations. $NH_4Cl + NaOH \rightarrow NH_3 + H_2O + NaCl$)

e i $\frac{n(OH^-)}{n(NH_3)} = \frac{1}{1}$

$n(NH_3) = c(NH_3) \times V(NH_3)$
$= 0.0400 \text{ mol L}^{-1}\ 0.0500 \text{ L}$
$= 2.00 \times 10^{-3} \text{ mol}$

$n(OH^-) = 2.00 \times 10^{-3} \text{ mol}$
$V(OH^-) = \frac{2.00 \times 10^{-3} \text{ mol}}{0.200 \text{ mol L}^{-1}}$
$= 10 \times 10^{-3} \text{ L}$
$= 10 \text{ mL}$

Total volume is 50.0 mL

At equivalence point all NH_4^+ converted to NH_3
$c(NH_4^+)$ at start = 0.0500 mol L^{-1}
$c(NH_3)$ at finish = $0.0500 \times 40/50$
= 0.0400 mol L^{-1}

ii $[H_3O^+]^2 = \dfrac{1\times 10^{-14} \times 6.3 \times 10^{-10}}{0.04}$

$[H_3O^+] = 1.26 \times 10^{-11}$
pH = 10.9

A = Correct method used for either calculation.
M = Correct method used for both calculations.
E = Both answers correctly calculated.

Judgement Statement
Achievement
SIX opportunities answered at Achievement level or higher.
6 × A

Achievement with Merit
SEVEN opportunities answered with at least FOUR at Merit level or higher.
3 × M *plus* 4 × A

Achievement with Excellence
NINE opportunities answered with at least TWO at Excellence level and THREE at Merit level.
2 × E *plus* 3 × M *plus* 4 × A