CHEMISTRY 3.7 Paper 2

Describe aqueous systems using equilibrium principles

Credits: Five

INSTRUCTIONS

Answer **ALL** questions

You are advised to spend about 50 minutes answering these questions.

Question One (Bursary 2002 Question 5: modified)

Barium hydroxide monohydrate and barium hydroxide octahydrate are base materials for the production of stabilisers used in the manufacture of the polymer PVC.

In an experiment, a student placed 5.10 g of anhydrous barium hydroxide in a volumetric flask and added water up to the 250 mL mark. The mixture was shaken.

$K_s\ (Ba(OH)_2) = 1.32 \times 10^{-2}$ $M(Ba(OH)_2) = 171.3\ g\ mol^{-1}$

a Write the expression for the solubility product (K_s) for barium hydroxide. A

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b Complete the following statements concerning solubility products.

i Solubility products are only constant at a _____ A

ii Solubility products only apply to _____ A

iii Solubility products only apply if the solution _____

_____ A

c Carry out calculations to determine whether the solution is saturated. A M E

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d Explain what a saturated solution is. A M

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Question Two (Bursary 2002 Question 7: modified)

Tooth decay is caused when bacteria in plaque, a substance which collects on the surface of the teeth, breaks down sugars and produces a mixture of acids.

The pH of plaque is normally close to 7. After a meal it falls to 3.5.

a Calculate the hydronium ion concentration, $[H_3O^+]$, when the pH is 3.5. A

One of the acids that causes the drop in pH is lactic acid. K_a (lactic acid) = 1.3×10^{-4}

b Calculate the concentration of undissociated lactic acid (HLac) present in a lactic acid solution with a pH of 3.5. A M

$$HLac + H_2O \rightleftharpoons Lac^- + H_3O^+$$

Sodium lactate is added to cheese and sweets. As a result of eating these foods, the lactate ion concentration in the mouth increases.

c Describe, giving reasons, the effect this has on the pH of the plaque. A M (No calculations are required.)

Tooth enamel is composed largely of $Ca_5(PO_4)_3OH$. When it is exposed to acid, the following reactions occur:

$2Ca_5(PO_4)_3OH(s) + 2H_3O^+(aq) \rightleftharpoons 3Ca_3(PO_4)_2(s) + Ca^{2+}(aq) + 4H_2O(l)$ Reaction (1)

$Ca_3(PO_4)_2(s) + 2H_3O^+(aq) \rightleftharpoons 3Ca^{2+}(aq) + 2HPO_4^{2-}(aq) + 2H_2O(l)$ Reaction (2)

d **i** Explain why bathing a decaying tooth in a solution containing Ca^{2+} and HPO_4^{2-} ions will reform the enamel of the tooth. A M

ii Explain why Sr^{2+} in the solution would also be effective in reforming tooth enamel. A M

Saliva contains carbonic acid (H_2CO_3) and its conjugate base (HCO^-) and hence is able to act as a buffer.

e Explain how this buffer solution works. A M

When fluoride ions are present in toothpaste or water supplies, there is strong evidence to suggest that dental health is improved.

A town water supply is rather hard and is found to contain 1.96×10^{-3} mol L^{-1} of Ca^{2+} ions.

f Calculate the maximum concentration of fluoride ions possible in this domestic water supply. A M E
*K*s (CaF_2) = 3.20×10^{-11}

Question Three (Bursary 2002 Question 8A: modified)

The following table provides information about 0.100 mol L–1 solutions of ammonia, ammonium nitrate and nitric acid.

Compound	**Electrical Conductivity**	**$[H_3O^+]$ / mol L^{-1}**
NH_3	Slight	8×10^{-12}
NH_4NO_3	Good	8×10^{-6}
HNO_3	Good	1×10^{-1}

a Discuss the electrical conductivities of solutions of NH_4NO_3 and NH_3. A M E

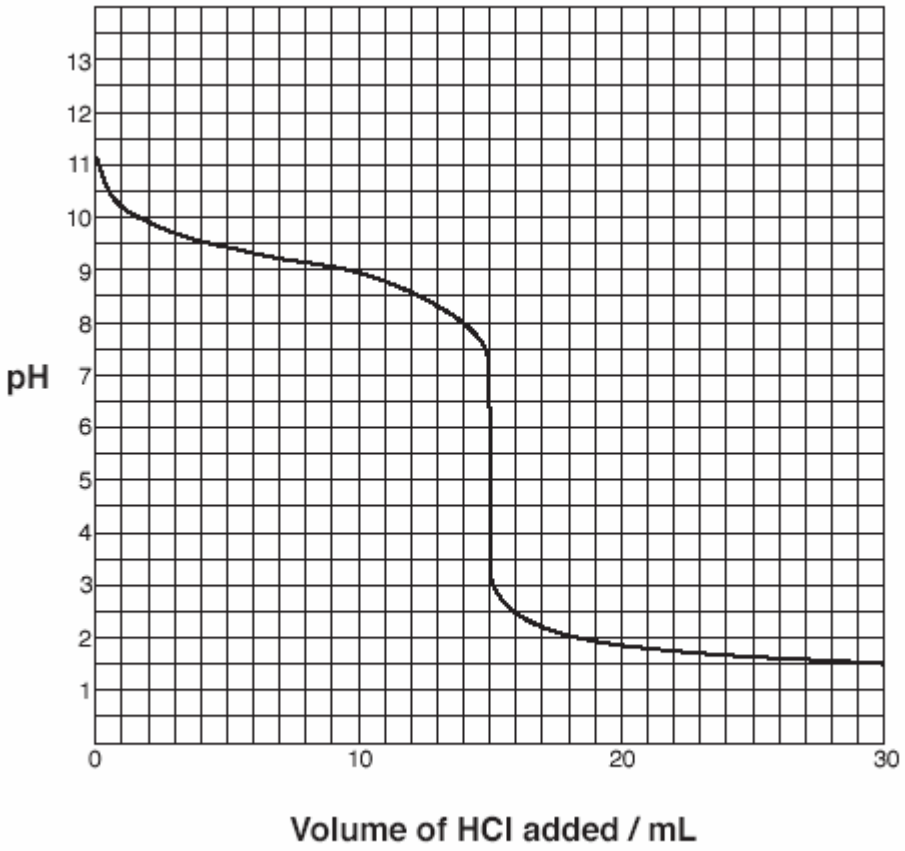
b Give reasons for the different values for $[H_3O^+]$ in the above table. Use equations to help illustrate your discussion. Calculations are not required. A M E

Question Four (Bursary 2002 Question 8B: modified)

The concentration of ammonia solutions can be determined by volumetric analysis.

A 15.00 mL sample of 0.100 mol L^{-1} ammonia solution was titrated with 0.100 mol L^{-1} HCl.

The graph below shows how the pH of the ammonia solution changes on addition of HCl.



a Mark and label the position of the buffer region on the graph. A

b Use the graph to determine the p*K*a for NH_4^+. A pK = _____

c Write an equation to show why the pH at the equivalence point is less than 7. A

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d Show (by calculation) that when a total of 25.00 mL of HCI has been added, the pH of the solution is 1.60. M E

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e Draw a dotted line on the graph, showing the curve that would be expected if the titration was carried out using 15 mL of 0.100 mol L^{-1} NaOH instead of ammonia. A M

f Explain why phenolphthalein could be used to determine the end point of the titration with NaOH but not the titration with NH_3. pK_a (phenolphthalein) = 9.2 A M

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g **i** An ammonia/ammonium buffer solution has a pH of 10. Circle below the species present in the higher concentration. A

NH_3 NH_4^+

ii Give a reason for your answer. M

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