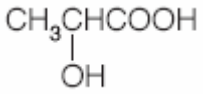
Practice exam questions Chapter 12: Buffers and titration curves (Write-on version)

Question 1 (Bursary 2001 Question 6)

Lactic acid

The major acidic component of soured milk is lactic acid. It is produced by the action of bacteria on lactose in milk.

Lactic acid has the structure: 

$K_a(\text{HLac}) = 1.38 \times 10^{-4}$ $\quad pK_a = 3.86$

A 20.0 mL sample of 0.100 mol L^{-1} lactic acid was titrated against 0.100 mol L^{-1} NaOH.

$$\text{HLac} + \text{NaOH} \rightleftharpoons \text{NaLac} + H_2O$$

a What will the pH be at the half equivalence point? A _____

b What volume of NaOH is required to reach the equivalence point? A _____

c Show that the pH at the equivalence point is 8.3. M E

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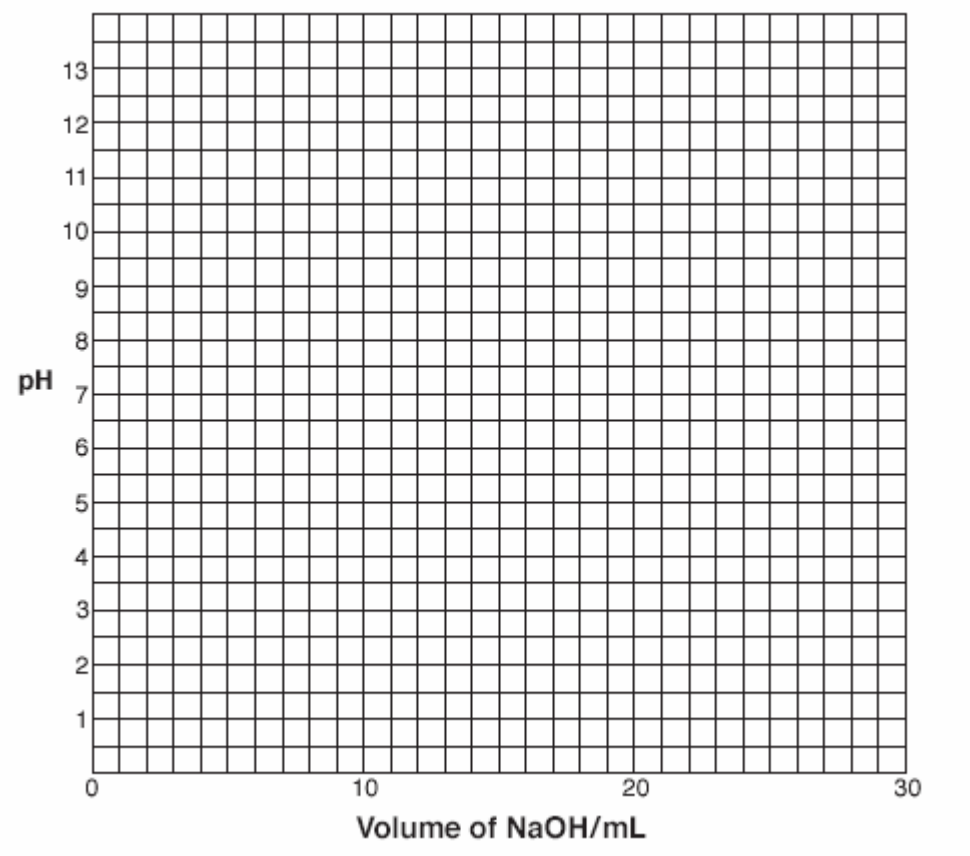
d Sketch the graph for the titration of 20.0 mL of 0.100 mol L^{-1} lactic acid against 0.100 mol L^{-1} sodium hydroxide. A M E



e Circle the letter of the most appropriate indicator for the above titration. A

	Indicator	**pK_a**
A	methyl orange	3.2
B	methyl red	5.2
C	bromothymol blue	6.9
D	phenolphthalein	9.2

Question 2 (Bursary 2001 Question 10)

Soda water

Commercial soda water is made by dissolving carbon dioxide in a sodium hydrogen carbonate solution. Carbon dioxide in solution can be written as H_2CO_3.

$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$$

H_2CO_3 is a weak acid and reacts with water according to the equation:

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

Since soda water contains both H_2CO_3 and HCO_3^- it behaves as a buffer solution.

a Explain the meaning of the term **buffer solution**. A

b Write equations to show how soda water can act as a buffer solution

i when small amounts of H_3O^+ are added. A

ii when small amounts of OH^- are added. A

The pH of a fresh sample of soda water is 6.11.

c Calculate the ratio of HCO_3^-/H_2CO_3 in fresh soda water. A M

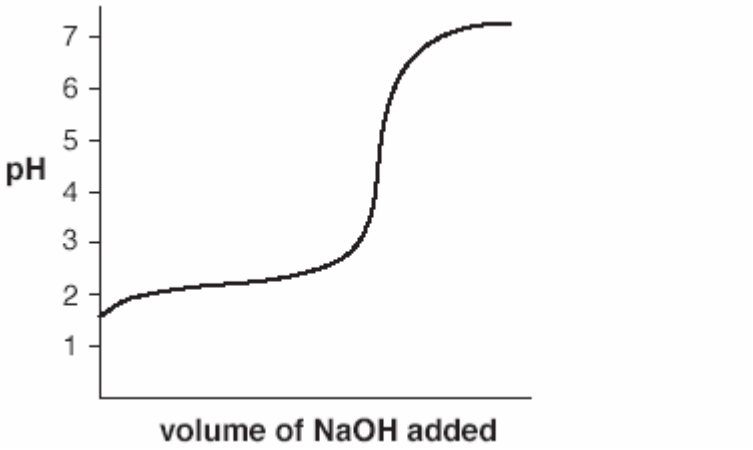
$K_a(H_2CO_3) = 4.5 \times 10^{-7}$ $\quad pK_a = 6.35$

Question 3 (Bursary 2000 Question 10)

Titration of phosphoric acid

The graph below shows how the pH of phosphoric acid solution changes on gradual addition of NaOH from a burette. The change in pH shown is due to the reaction given by the equation below.

$$NaOH(aq) + H_3PO_4(aq) \rightleftharpoons NaH_2PO_4(aq) + H_2O(l)$$



a Circle the number below that is closest to the pK_a value for the $H_3PO_4/H_2PO_4^-$ acid-base conjugate pair.

1.6 **2.1** **4.6** A

Justify your answer. M

_____

_____

The $H_2PO_4^-$ ion can react with water as either an acid or a base.

b Complete equations for the reaction of $H_2PO_4^-$ with water A

i as an acid: $H_2PO_4^- + H_2O \rightleftharpoons$

ii as a base: $H_2PO_4^- + H_2O \rightleftharpoons$

The pH at the equivalence point on the graph shown is 4.6. The major species determining the pH at equivalence is $H_2PO_4^-$.

c Circle the word in brackets that correctly completes the following sentence:

The acid strength of $H_2PO_4^-$ is (higher / lower) than its base strength. A

Justify your answer. M

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_____

d Circle the indicator below that can be used to detect this equivalence point. The pK_a value for each indicator is given in brackets after its name. A

thymol blue (1.7) bromocresol green (4.7) phenolphthalein (9.4)

The graph shown represents the titration of 10 mL of 0.100 mol L^{-1} H_3PO_4 with 0.100 mol L^{-1} NaOH.

e What volume of NaOH has been added at the equivalence point shown on the graph? A

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f Calculate the concentration of $H_2PO_4^-$ at the equivalence point. A M

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