IB · DP · Chemistry

2 hours 14 questions

Structured Questions: Paper 2

8.2 More About Acids

8.2.1 Acid-base Titrations / 8.2.2 pH & [H^+] / 8.2.3 Interpreting pH / 8.2.4 The Ionic Product of Water / 8.2.5 Acid-Base Calculations / 8.2.6 pH Meters & Universal Indicator / 8.2.7 Strong & Weak Acids & Bases / 8.2.8 Comparing Strong & Weak Acids

Easy (5 questions)	/27
Medium (5 questions)	/43
Hard (4 questions)	/31
Total Marks	**/101**

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Easy Questions

1 (a) Using section 22 of the data booklet, identify an indicator that would show a yellow colour in ammonia solution?

.....

(1 mark)

(b) Suggest **two** characteristics that make a good indicator for a titration?

.....

.....

(2 marks)

(c) A typical set of acid-base titration results in shown in the table.

	Rough	Run 1	Run 2
Initial burette reading /±0.05 mL	0.00	0.30	0.60
Final burette reading/ ±0.05 mL	24.15	22.55	22.95

Determine the mean volume from these results.

.....

(1 mark)

(d) What is the recorded uncertainty on the mean volume calculated in part c)?

.....

(1 mark)

2 (a) State the relationship between pH and hydrogen ion concentration.

.....

(1 mark)

(b) Determine the pH of 0.200 mol dm^{-3} hydrochloric acid.

.....

(1 mark)

(c) Determine the hydrogen ion concentration in a sample of lake water of pH 5.60.

.....

(1 mark)

(d) The table below shows the hydrogen ion concentration in three solutions:

	P	Q	R
$[H^+]$	0.001	1×10^{-5}	1.00

List the three solutions in order from low pH to high pH

.....

(1 mark)

3 (a) State what is meant by the ionic product of water.

.....

(1 mark)

(b) Calculate the concentration of $[H^+]$ in a solution of sodium hydroxide, NaOH, whose concentration is 0.001 mol dm^{-3}.

.....

(1 mark)

(c) Calculate the pH of 0.001 mol dm^{-3} NaOH solution.

.....

(1 mark)

(d) The ionic product of water is 2.916×10^{-14} mol^2 dm^{-6} at 313 K. What is the pH of water at this temperature?

.....

(1 mark)

4 (a) State one **advantage** and one **disadvantage** of using a pH meter instead of universal indicator to measure pH.

.....

.....

(2 marks)

(b) State the name and formula of a strong alkali and a weak alkali.

.....

.....

(2 marks)

(c) State the meaning of the term *dissociation* as applied to acids and bases

.....

(1 mark)

(d) Write equations for the dissociation of:

Nitric acid, HNO_3: .....

Methanoic acid, HCOOH: .....

.....

.....

(2 marks)

(e) Identify the formula of the weakest conjugate base produced in the two acids in part d).

.....

(1 mark)

5 (a) Explain the difference between the terms *strong* acid and *weak* acid.

.....

.....

(2 marks)

(b) Other than measuring the pH, describe how you could distinguish between dilute solutions of the same concentration of hydrochloric acid and ethanoic acid.

.....

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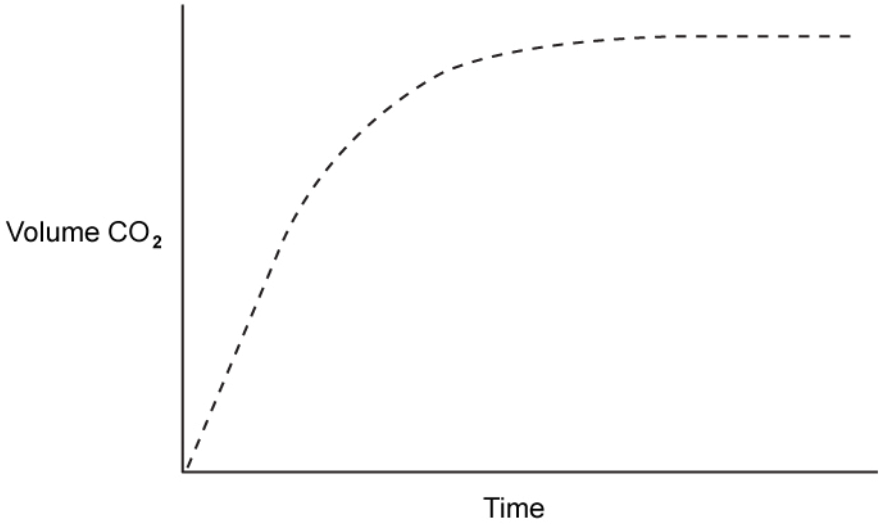
(2 marks)

(c) A solution of 2.00 mol dm^{-3} hydrochloric acid was added to marble chips and the volume of carbon dioxide recorded. A graph of the result is shown below:



On the same graph, sketch the result of repeating the experiment with 2.00 mol dm^{-3} ethanoic acid.

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(1 mark)

(d) The same experiment in part c) can be carried out by measuring how the mass of the reaction flask changes with time.
Sketch a graph of the expected result.

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(1 mark)

Medium Questions

1 (a) The equilibrium constant for the first dissociation of formic acid is 1.8×10^{-4} mol dm^{-3}.

State, with a reason, the strength of formic acid.

.....

.....

(2 marks)

(b) Outline **one** laboratory method used to distinguish between equimolar solutions of formic acid and hydrochloric acid, giving the expected observations.

.....

(1 mark)

(c) Formic acid has the chemical formula HCOOH. Identify the conjugate base of formic acid and state whether it is a weak or strong conjugate base.

.....

.....

(2 marks)

(d) Draw the structure of formic acid and give its systematic IUPAC name.

.....

.....

(2 marks)

2 (a) The pH of an aqueous solution of salicylic acid at 298 K is 3.85. Determine the concentration of hydroxide ions in the solution, using Section 2 of the Data booklet.

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(2 marks)

(b) **A** and **B** are two solutions of the same concentrations that have pH values of 3 and 6 respectively.

i) Identify which is the stronger acid and calculate the concentration of hydrogen ions in each solution.

ii) Calculate the ratio of the hydrogen ion concentrations in both **A** and **B**.

.....

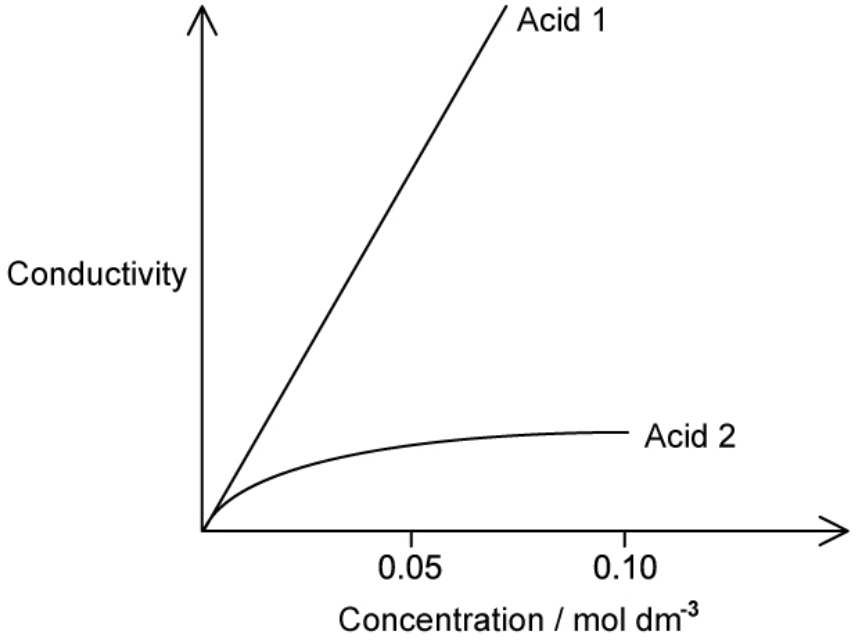
.....

.....

(3 marks)

(c) The variation of conductivity and concentration of a strong and weak monoprotic acid are shown in **Figure 1**.

Identify the strong and weak acid from the information given and justify your choices.



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(3 marks)

(d) For acid 1 and acid 2 in part (c) compare the volume of 0.2 mol dm^{-3} NaOH required to neutralise 20 cm^3 of 0.1 mol dm^{-3} solutions of the acids.

.....

(1 mark)

3 (a) The concentrations of solutions of weak acids can be determined by titration against standard solutions of alkalis, such as sodium hydroxide.

i) Explain what is meant by the term *standard solution*.

ii) State the name of the indicator which should be used for this titration and what would be observed at the equivalence point of the reaction if the sodium hydroxide is placed in the burette.

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.....

(3 marks)

(b) A solution of 25.0 cm^3 ethanoic acid was titrated against 0.150 mol dm^{-3} NaOH (aq) and it was found that 22.35 cm^3 of the NaOH was needed for complete neutralisation.

Write an equation for the reaction and determine the concentration of the ethanoic acid.

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.....

(3 marks)

(c) A solution of 0.1 mol dm^{-3} ammonia has a pH of approximately 11. Predict how the pH value of 0.1 mol dm^{-3} sodium hydroxide solution would compare and calculate its value.

.....

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(2 marks)

(d) Write an equation for the reaction between ammonia and water and use it to classify each product as a Brønsted–Lowry acid or base.

.....

.....

(2 marks)

4 (a) Glycolic acid, $C_2H_4O_3$, is an organic acid sometimes used to remove limescale, $CaCO_3$, from electric kettles and coffee machines.

Predict, with a reason, a difference in the reaction between the same concentration of sulfuric acid and glycolic acid with samples of calcium carbonate.

.....

.....

(2 marks)

(b) Another acid that is sometimes used to descale kettles is sulfamic acid, NH_2SO_3H. Sulfamic is classed as a *strong monoprotic* acid.

i) Explain the meaning of the term *strong monoprotic acid*.

ii) Calculate the pH of a 0.136 mol dm^{-3} solution of sulfamic acid and determine the concentration of hydroxide ions in the solution at 298 K.

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.....

(3 marks)

(c) A solution of hydrochloric acid has a pH of 1 and a solution of carbonic acid has a pH of 5. Determine the ratio of hydrogen ion concentrations of hydrochloric acid to carbonic acid.

.....

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(2 marks)

(d) Outline two ways, apart from using pH, which could allow you to distinguish between two solutions of carbonic acid and hydrochloric acid that have the same concentration.

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(4 marks)

5 (a) Four solutions of acids with identical concentrations are prepared. The equilibrium constants of these acids are given in **Table 1**.

Table 1

Acid	K_c mol dm^{-3} at 298 K
HCN	4.9×10^{-10}
HF	6.8×10^{-4}
CH_3COOH	1.7×10^{-5}
HCl	1.3×10^{6}

Write down the acid dissociation equation for HCN.

.....

(1 mark)

(b) Use the information in part (a) to complete this question.

i) Write down the list of acids in part (a) in order of **decreasing** pH.

ii) Write down the list of acids in order of **increasing** concentration of molecules of the acid present in the solution.

.....

.....

(2 marks)

(c) State the name and formula of all the chemical species present in the solution of CH_3COOH.

.....

.....

(2 marks)

(d) Write the name and formula of the conjugate base of HF.

.....

(1 mark)

Hard Questions

1 (a) A solution of hydrochloric acid of concentration 0.001 mol dm^{-3} has a pH value of 3. Suggest, giving a reason, the pH of the following solutions of acids:

i) 0.01 mol dm^{-3} hydrochloric acid

[2]

ii) 0.01 mol dm^{-3} ethanoic acid

[2]

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(4 marks)

(b) A solution of 0.01 mol dm^{-3} ethanoic acid has a concentration of hydrogen ion of 1 x 10^{-4} mol dm^{-3}. Determine the percentage of ethanoic acid molecules that have dissociated.

.....

(1 mark)

(c) Two separate titrations are carried out using 25.00 cm^3 of 0.01 mol dm^{-3} solutions of hydrochloric acid followed by ethanoic acid, against 0.01 mol dm^{-3} sodium hydroxide.

State what difference(s) would be observed in the two titrations.

.....

(1 mark)

(d) Suggest a suitable indicator for the titration of hydrochloric acid and sodium hydroxide in part c), and state the colour changes observed.

.....

.....

(2 marks)

2 (a) Show how the ionic product for water is derived from the dissociation of water and give it units.

(3 marks)

(b) Determine the pH of 0.001 mol dm^{-3} sodium hydroxide.

(1 mark)

(c) Suggest, with a reason, how the magnitude of K_w changes with increasing temperature.

(4 marks)

3 (a) Malonic acid is a weak dibasic carboxylic acid with the formula $C_3H_4O_4$. Draw the displayed structure of malonic acid.

.....

(1 mark)

(b) Suggest, with a reason, which of the two acids, ethanoic or malonic, has a higher pH?

.....

.....

(2 marks)

(c) Apart from testing the pH, suggest how equimolar solutions of malonic acid and ethanoic acid may be distinguished.

.....

(1 mark)

(d) Write the formulas of two conjugate bases that can be formed from malonic acid.

.....

.....

(2 marks)

4 (a) Marble chips are added separately to solutions of the same concentration of ethanoic acid and hydrochloric acid. State **one** similarity and **one** difference you would expect to observe in the reactions.

.....

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(2 marks)

(b) Write an equation for the reaction between marble chips and ethanoic acid.

.....

(1 mark)

(c) Determine the volume, in cm^3, of 2.25 mol dm^{-3} ethanoic acid needed to completely react with 1.50 g of marble chips.

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(3 marks)

(d) Determine the volume of CO_2, in cm^3, produced at 273 K and 101 kPa in part c).

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(3 marks)