A2 LEVEL CHEMISTRY

5.1.3 ACIDS, BASES AND BUFFERS

TEST

Answer all questions

Max 50 marks

Name	……..
Mark	……../50 …….....% Grade ……

1. A student carried out an investigation with aqueous solutions of nitric acid, sodium hydroxide, ethanoic acid and water.

Nitric acid, HNO_3, is a strong Brønsted-Lowry acid.

(a) Explain what is meant by a *strong acid* and a *Brønsted-Lowry acid*.

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.....

[2]

(b) What is the conjugate base formed from HNO_3?

.....

[1]

(c) The student diluted 0.015 mol dm^{-3} nitric acid with an equal volume of water and measured the pH of the diluted acid at 25 °C.

(i) Calculate the pH of 0.015 mol dm^{-3} nitric acid.

[2]

(ii) Calculate the pH of the diluted acid.

[1]

[Total 6 marks]

2. Phenol, C_6H_5OH, is a powerful disinfectant and antiseptic.

Phenol is a weak Brønsted–Lowry acid.

$$C_6H_5OH(aq) \rightleftharpoons H^+(aq) + C_6H_5O^-(aq) \qquad K_a = 1.3 \times 10^{-10} \text{ mol dm}^{-3}$$

(a) Define the following terms:

(i) A Brønsted–Lowry acid,

.....

[1]

(ii) A *weak* acid.

.....

[1]

(b) When phenol is mixed with aqueous sodium hydroxide, an acid-base reaction takes place.

$C_6H_5OH(aq)$	+	$OH^-(aq)$	$\rightleftharpoons$	$C_6H_5O^-(aq)$	+ $H_2O(l)$
.....		.....		.....	.....

In the spaces above,

- label one **conjugate acid-base pair** as acid 1 and base 1,
- label the other **conjugate acid-base pair** as acid 2 and base 2.

[2]

(c) A solution of phenol in water has a concentration of 38 g dm^{-3}.
The acid dissociation constant, K_a, of phenol is 1.3×10^{-10} mol dm^{-3}.

(i) Write an expression for the acid dissociation constant, K_a, of phenol.

[1]

(ii) Calculate the pH of this solution.

answer.....

[5]

(d) As part of an investigation, a student needed to prepare a buffer solution with a pH value of 8.71. From the K_a value of phenol, the student thought that a mixture of phenol and sodium phenoxide could be used to prepare this buffer solution.

The student decided to use a 0.200 mol dm^{-3} solution of phenol, mixed with an equal volume of sodium phenoxide.

Use your knowledge of buffer solutions to determine the concentration of sodium phenoxide solution that the student would need to mix with the 0.200 mol dm^{-3} phenol solution.

[3]

[Total 13 marks]

3. A student prepared two solutions.

- Solution **A** was made by mixing together 25 cm^3 0.010 mol dm^{-3} aqueous sodium hydroxide with 50 cm^3 0.010 mol dm^{-3} ethanoic acid, CH_3COOH. Solution **A** is a buffer solution.

- Solution **B** was made by mixing together 25 cm^3 0.020 mol dm^{-3} aqueous sodium hydroxide with 50 cm^3 0.010 mol dm^{-3} ethanoic acid, CH_3COOH. Solution **B** is **not** a buffer solution.

(i) What is meant by a *buffer solution*?

.....

.....

[1]

(ii) Explain why Solution **A** is a buffer solution whereas Solution **B** is **not**.

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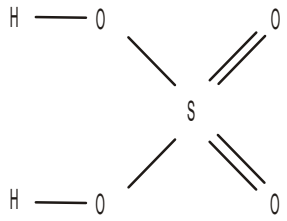
[4]

[Total 5 marks]

4. In order to obtain full marks in this question, you must show **all** your working clearly.

In its reactions, sulphuric acid, H_2SO_4, can behave as an acid, an oxidising agent and as a dehydrating agent.

The displayed formula of pure sulphuric acid is shown below.



Dilute sulphuric acid takes part in the typical acid reactions, reacting with metals, carbonates and bases.

Write balanced equations for the reaction of sulphuric acid with

a metal, ...

a carbonate, ...

a base. .....

[Total 3 marks]

5. Compound **B** is an organic base. A student analysed this base by the procedure below.

He first prepared a solution of **B** by dissolving 4.32 g of **B** in water and making the solution up to 250 cm^3. The student then carried out a titration in which 25.00 cm^3 of this solution of **B** were neutralised by exactly 23.20 cm^3 of 0.200 mol dm^{-3} HC*l*.

1 mole of **B** reacts with 1 mole of HC*l*.

Use this information to calculate the molar mass of base **B** and suggest its identity.

[Total 6 marks]

6. In sewage plants, biological activity can be reduced by increasing the pH of the water. This is achieved by adding small amounts of solid calcium hydroxide, $Ca(OH)_2$, to the sewage water.

In all parts of this question, assume that measurements have been made at 25 °C.

(a) The pH of aqueous solutions is determined by K_w.

K_w has a value of 1.0×10^{-14} mol^2 dm^{-6} at 25 °C.

(i) What name is given to K_w?

.....

[1]

(ii) Write the expression for K_w.

.....

[1]

(b) A chemist checked the concentration of aqueous calcium hydroxide, $Ca(OH)_2$, in the sewage water by titration with 5.00×10^{-3} mol dm^{-3} hydrochloric acid.

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

The chemist titrated 25.0 cm^3 of the sewage water with 21.35 cm^3 of HCl to reach the endpoint of the titration.

Calculate the concentration, in mol dm^{-3}, of the calcium hydroxide in the sewage water.

concentration = ... mol dm^{-3}

[3]

(c) The chemist analysed a sample of water from another part of the sewage works and he found that the calcium hydroxide concentration was 2.7×10^{-3} mol dm^{-3}.

When solid calcium hydroxide dissolves in water, its ions completely dissociate.

$$Ca(OH)_2(s) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$$

Calculate the pH of this sample.

[3]

(d) After further treatment, the water could be used for drinking. In the drinking water produced, the OH^- concentration was 100 times greater than the H^+ concentration.

What was the pH of this drinking water?

[1]

[Total 9 marks]

7. A student titrated the 1.50×10^{-2} mol dm^{-3} methanoic acid with aqueous sodium hydroxide.

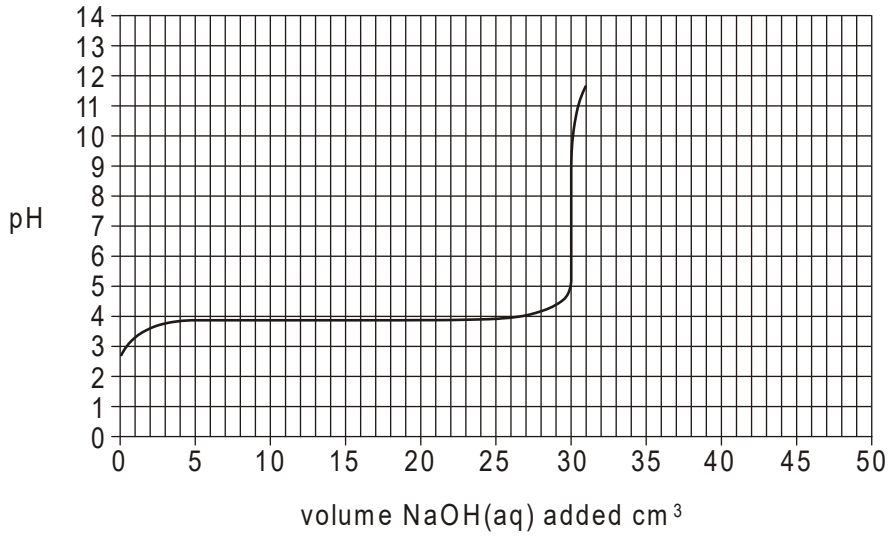
A 25.00 cm^3 sample of the HCOOH(aq) was placed in a conical flask and the NaOH(aq) was added from a burette until the pH no longer changed.

(i) Write a balanced equation for the reaction between HCOOH(aq) and NaOH(aq).

.....

[1]

(ii) Part of the pH curve for this titration is shown below.



Calculate the concentration, in mol dm^{-3}, of the aqueous sodium hydroxide.

concentration = ...mol dm^{-3}

[3]

(iii) Calculate the pH of the aqueous sodium hydroxide.
$K_w = 1.00 \times 10^{-14}$ mol dm^{-3}

pH = ...

[2]

(iv) The pH ranges in which colour changes for three acid-base indicators are shown below.

indicator	pH range
metacresol purple	7.4 – 9.0
2,4,6-trinitrotoluene	11.5 – 13.0
ethyl orange	3.4 – 4.8

Explain which of the three indicators is suitable for this titration.

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[2]

[Total 8 marks]