Gateways School

**Acids & bases**

**Revision PPQ**

76 marks

**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_**

**Q1.**

A student was given a task to determine the percentage purity of a sample of salicylic acid. The method used by the student to prepare a solution of salicylic acid is described below.

•        0.500 g of an impure sample of salicylic acid was placed in a weighing bottle.

•        The contents were tipped into a beaker and 100 cm3 of distilled water were added.

•        Salicylic acid does not dissolve well in cold water so the beaker and its contents were heated gently until all the solid had dissolved.

•        The solution was poured into a 250 cm3 graduated flask and made up to the mark with distilled water.

(a)     Give **two** additional instructions that would improve this method for making up the salicylic acid solution.

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**(2)**

(b)     The pH of this solution was measured and a value of 2.50 was obtained.
Calculate the concentration of salicylic acid in this solution.
Assume that salicylic acid is the only acid in this solution. The *K*a for salicylic acid
is 1.07 × 10–3 mol dm–3. You may represent salicylic acid as HA.
Show your working.

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**(3)**

(c)     Use your answer to part (b) to calculate the mass of salicylic acid (*M*r = 138.0) present in the original sample.
(If you were unable to complete the calculation in part (b), assume that the concentration of salicylic acid is 8.50 × 10–3 mol dm–3. This is **not** the correct answer.)

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**(2)**

(d)     Use your answer to part (c) to calculate the percentage purity of the salicylic acid used to make the solution.
(If you were unable to complete the calculation in part (c), assume that the mass of salicylic acid is 0.347 g. This is **not** the correct answer.)

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**(1)**

**(Total 8 marks)**

**Q2.**

Titration curves labelled **A**, **B**, **C** and **D** for combinations of different aqueous solutions of acids and bases are shown below.
All solutions have a concentration of 0.1 mol dm–3.



(a)     In this part of the question write the appropriate letter in each box.

From the curves **A**, **B**, **C** and **D**, choose the curve produced by the addition of

|  |  |
| --- | --- |
| ammonia to 25 cm3 of hydrochloric acid |   |
| sodium hydroxide to 25 cm3 of ethanoic acid |   |
| nitric acid to 25 cm3 of potassium hydroxide |   |

**(3)**

(b)     A table of acid.base indicators is shown below.
The pH ranges over which the indicators change colour and their colours in acid and alkali are also shown.

|  |
| --- |
| **Indicator                       pH range            Colour in acid          Colour in alkali** |
| Trapaeolin                     1.3 – 3.0                       red                            yellowBromocresol green        3.8 – 5.4                    yellow                           blueCresol purple                 7.6 – 9.2                    yellow                          purpleAlizarin yellow              10.1 – 12.0                  yellow                         orange |

(i)      Select from the table an indicator that could be used in the titration that produces curve **B** but **not** in the titration that produces curve **A**.

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**(1)**

(ii)     Give the colour change at the end point of the titration that produces curve **D** when cresol purple is used as the indicator.

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**(1)**

**(Total 5 marks)**

**Q3.**

In order to obtain a pH curve, you are provided with a conical flask containing 25.0 cm3 of a 0.100 mol dm–3 carboxylic acid solution and a burette filled with 0.100 mol dm–3 sodium hydroxide solution. You are also provided with a calibrated pH meter.

(a)     State why calibrating a pH meter just before it is used improves the accuracy of the pH measurement.

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**(1)**

(b)     Describe how you would obtain the pH curve for the titration.

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**(5)**

**(Total 6 marks)**

**Q4.**

This question is about several Brønsted–Lowry acids and bases.

(a)     Define the term *Brønsted–Lowry* acid.

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**(1)**

(b)     Three equilibria are shown below. For each reaction, indicate whether the substance immediately **above** the box is acting as a Brønsted–Lowry acid (**A**) or a Brønsted–Lowry base (**B**) by writing **A** or **B** in each of the six boxes.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   (i) | CH3COOH | + | H2O  |  | CH3COO–  | + | H3O+ |

**(1)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   (ii) | CH3NH2 | + | H2O  |  | CH3NH3+  | + | OH– |

**(1)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   (iii) |    HNO3 | + | H2SO4 |  | H2NO3+  | + | HSO4 – |

**(1)**

(c)     A 25.0 cm3 sample of 0.0850 mol dm–3 hydrochloric acid was placed in a beaker.
Distilled water was added until the pH of the solution was 1.25.

Calculate the total volume of the solution formed. State the units.

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**(3)**

(d)     At 298 K, the value of the acid dissociation constant (*K*a) for the weak acid HX in aqueous solution is 3.01 × 10–5 mol dm–3.

(i)      Calculate the value of p*K*a for HX at this temperature.
Give your answer to 2 decimal places.

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**(1)**

(ii)     Write an expression for the acid dissociation constant (*K*a) for the weak acid HX.

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**(1)**

(iii)     Calculate the pH of a 0.174 mol dm–3 solution of HX at this temperature.
Give your answer to 2 decimal places.

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**(3)**

(e)     An acidic buffer solution is formed when 10.0 cm3 of 0.125 mol dm–3 aqueous sodium hydroxide are added to 15.0 cm3 of 0.174 mol dm–3 aqueous HX.
The value of Ka for the weak acid HX is 3.01 × 10–5 mol dm–3.

Calculate the pH of this buffer solution at 298 K.
Give your answer to 2 decimal places.

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**(6)**

**(Total 18 marks)**

**Q5.**

In this question, give all values of pH to 2 decimal places.

(a)     The ionic product of water has the symbol *K*w

(i)      Write an expression for the ionic product of water.

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**(1)**

(ii)     At 42°C, the value of *K*w is 3.46 × 10−14 mol2 dm−6.

Calculate the pH of pure water at this temperature.

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**(2)**

(iii)    At 75 °C, a 0.0470 mol dm–3 solution of sodium hydroxide has a pH of 11.36.
Calculate a value for *K*w at this temperature.

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**(2)**

(b)     Methanoic acid (HCOOH) dissociates slightly in aqueous solution.

(i)      Write an equation for this dissociation.

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**(1)**

(ii)     Write an expression for the acid dissociation constant *K*a for methanoic acid.

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**(1)**

(iii)    The value of *K*a for methanoic acid is 1.78 × 10−4 mol dm−3 at 25 °C.
Calculate the pH of a 0.0560 mol dm−3 solution of methanoic acid.

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**(3)**

(iv)    The dissociation of methanoic acid in aqueous solution is endothermic.

Deduce whether the pH of a solution of methanoic acid will increase, decrease or stay the same if the solution is heated. Explain your answer.

Effect on pH \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Explanation \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

(c)     The value of *K*a for methanoic acid is 1.78 × 10−4 mol dm−3 at 25°C.
A buffer solution is prepared containing 2.35 × 10−2 mol of methanoic acid and
1.84 × 10−2 mol of sodium methanoate in 1.00 dm3 of solution.

(i)      Calculate the pH of this buffer solution at 25°C.

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**(3)**

(ii)     A 5.00 cm3 sample of 0.100 mol dm−3 hydrochloric acid is added to the buffer solution in part (c)(i).

Calculate the pH of the buffer solution after this addition.

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**(4)**

**(Total 20 marks)**

**Q6.**

In this question, give all values of pH to two decimal places.

Calculating the pH of aqueous solutions can involve the use of equilibrium constants such as *K*w and *K*a

*K*w is the ionic product of water. The value of *K*w is 5.48 × 10–14 mol2 dm–6 at 50 °C.

(a)     (i)      Write an expression for pH.

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**(1)**

(ii)     Write an expression for *K*w

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**(1)**

(b)(i)      Calculate the pH of pure water at 50 °C.

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**(2)**

(ii)Suggest why this pure water is **not** acidic.

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**(1)**

(iii)Calculate the pH of 0.140 mol dm–3 aqueous sodium hydroxide at 50 °C.

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**(3)**

(c)Calculate the pH of the solution formed when 25.0 cm3 of 0.150 mol dm–3 aqueous sulfuric acid are added to 30.0 cm3 of 0.200 mol dm–3 aqueous potassium hydroxide at 25 °C. Assume that the sulfuric acid is fully dissociated.

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**(6)**

**(Total 14 marks)**

**Q7.**

A weak acid HA dissociates in aqueous solution as shown below

  HA(aq) **⇌** H+(aq) + A−(aq)                         ∆*H* = +20 kJ mol−1

Which one of the following changes will result in a decrease in the pH of an aqueous solution of the acid?

**A**       addition of a little aqueous sodium hydroxide solution

**B**       raising the temperature of the solution

**C**       dissolving a little of the sodium salt, NaA, in the solution

**D**       adding a platinum catalyst to the solution

**(Total 1 mark)**

**Q8.**

A solution of sodium ethanoate has a pH of 8.91 at 25 °C. The hydrogen ion and hydroxide ion concentrations in this solution are

**A**       [H+] = 1.00 × 10−9 mol dm−3 [OH−] = 1.00 × 10−5 mol dm−3

**B**       [H+] = 1.00 × 10−9 mol dm−3 [OH−] = 8.13 × 10−6 mol dm−3

**C**       [H+] = 1.23 × 10−9 mol dm−3 [OH−] = 1.00 × 10−5 mol dm−3

**D**       [H+] = 1.23 × 10−9 mol dm−3 [OH−] = 8.13 × 10−6 mol dm−3

**(Total 1 mark)**

**Q9.**

An aqueous solution contains 4.0 g of sodium hydroxide in 250 cm3 of solution.
(*K*w = 1.00 × 10−14 mol2 dm−6)

The pH of the solution is

**A**       13.0

**B**       13.3

**C**       13.6

**D**       13.9

**(Total 1 mark)**

**Q10.**

Addition of which one of the following to 10 cm3 of 1.0 M NaOH would result in the pH being halved?

**A**       10 cm3 of water

**B**       100 cm3 of water

**C**       5 cm3 of 1.0 M HCl

**D**       10 cm3 of 1.0 M HCl

**(Total 1 mark)**

**Q11.**

Use the information below to answer this question.

A saturated solution of magnesium hydroxide, Mg(OH)2, contains 0.1166 g of Mg(OH)2 in 10.00 dm3 of solution. In this solution the magnesium hydroxide is fully dissociated into ions.

Which one of the following is the pH of a solution of magnesium hydroxide containing 4.0 × 10−5 mol dm−3 of hydroxide ions at 298 K?
(*K*w = 1.0 × 10−14 mol2 dm−6 at 298 K)

**A**       9.6

**B**       9.5

**C**       8.6

**D**       8.3

**(Total 1 mark)**