AQA

A-level
Chemistry
(7405/3)
Paper 3

Specimen 2015 v0.5 Session 2 hours

Materials
For this paper you must have:
- the Data Booklet, provided as an insert
- a ruler
- a calculator.

Instructions
- Answer **all** questions.
- Show **all** your working.

Information
- The maximum mark for this paper is 90.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname

Forename(s)

Candidate signature _____

Section A

Answer **all** questions in this section.

1 Ethanol can be oxidised by acidified potassium dichromate(VI) to ethanoic acid in a two-step process.

ethanol ⟶ ethanal ⟶ ethanoic acid

0 1 . 1 In order to ensure that the oxidation to ethanoic acid is complete, the reaction is carried out under reflux.

Describe what happens when a reaction mixture is refluxed and why it is necessary, in this case, for complete oxidation to ethanoic acid.

[3 marks]

0 1 . 2 Write a half-equation for the overall oxidation of ethanol into ethanoic acid.

[1 mark]

0 1 . 3 The boiling points of the organic compounds in a reaction mixture are shown in **Table 1**.

Table 1

Compound	ethanol	ethanal	ethanoic acid
Boiling point / °C	78	21	118

Use these data to describe how you would obtain a sample of ethanal from a mixture of these three compounds. Include in your answer a description of the apparatus you would use and how you would minimise the loss of ethanal. Your description of the apparatus can be either a description in words or a labelled sketch.

[5 marks]

Question 1 continues on the next page

0 1 . 4 Use your knowledge of structure and bonding to explain why it is possible to separate ethanal in this way.

[2 marks]

0 1 . 5 A student obtained a sample of a liquid using the apparatus in Question **1.3**.

Describe how the student could use chemical tests to confirm that the liquid contained ethanal and did **not** contain ethanoic acid.

[5 marks]

2 Ethanol and ethanoic acid react reversibly to form ethyl ethanoate and water according to the equation:

$$CH_3COOH + CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$$

A mixture of 8.00×10^{-2} mol of ethanoic acid and 1.20×10^{-1} mol of ethanol is allowed to reach equilibrium at 20 °C.

- The equilibrium mixture is placed in a graduated flask and the volume made up to 250 cm^3 with distilled water.
- A 10.0 cm^3 sample of this equilibrium mixture is titrated with sodium hydroxide added from a burette.
- The ethanoic acid in this sample reacts with 3.20 cm^3 of 2.00×10^{-1} mol dm^{-3} sodium hydroxide solution.

0 2 . 1 Calculate the value for K_c for the reaction of ethanoic acid and ethanol at 20 °C. Give your answer to the appropriate number of significant figures.

[6 marks]

K_c = _____

Question 2 continues on the next page

A student obtained the titration results given in **Table 2**.

Table 2

	Rough	**1**	**2**	**3**
Final burette reading / cm^3	4.60	8.65	12.85	16.80
Initial burette reading / cm^3	0.10	4.65	8.65	12.85
Titre / cm^3				

0 2 . 2 Complete **Table 2**.

[1 mark]

0 2 . 3 Calculate the mean titre and justify your choice of titres.

[2 marks]

Calculation

Mean titre = _____ cm^3

Justification _____

_____

0 2 . 4 The pH ranges of three indicators are shown in **Table 3**.

Table 3

Indicator	**pH range**
Bromocresol green	3.8–5.4
Bromothymol blue	6.0–7.6
Thymol blue	8.0–9.6

Select from **Table 3** a suitable indicator for the titration of ethanoic acid with sodium hydroxide.

[1 mark]

_____

0 2 . 5 The uncertainty in the mean titre for this experiment is ±0.15 cm^3.

Calculate the percentage uncertainty in this mean titre.

[1 mark]

Percentage uncertainty = _____ %

0 2 . 6 Suggest how, using the same mass of ethanoic acid, the experiment could be improved to reduce the percentage uncertainty.

[2 marks]

_____

_____

_____

_____

_____

Turn over for the next question

3 A peptide is hydrolysed to form a solution containing a mixture of amino acids. This mixture is then analysed by silica gel thin-layer chromatography (TLC) using a toxic solvent. The individual amino acids are identified from their R_f values.

Part of the practical procedure is given below.

1. **Wearing plastic gloves to hold a TLC plate**, draw a pencil line 1.5 cm from the bottom of the plate.
2. Use a capillary tube to apply a very small drop of the solution of amino acids to the mid-point of the pencil line.
3. Allow the spot to dry completely.
4. In the developing tank, add the developing solvent to **a depth of not more than 1 cm**.
5. Place your TLC plate in the developing tank.
6. Allow the developing solvent to rise up the plate **to the top**.
7. Remove the plate and quickly mark the position of the solvent front with a pencil.
8. Allow the plate to dry **in a fume cupboard**.

0 3 . 1 Parts of the procedure are in bold text.

For each of these parts, consider whether it is essential and justify your answer.

[4 marks]

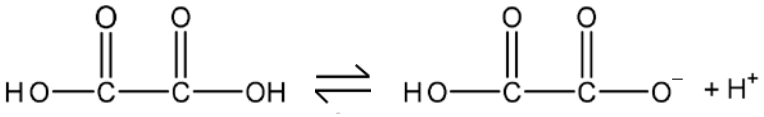
0 3 . 2 Outline the steps needed to locate the positions of the amino acids on the TLC plate and to determine their R_f values.

[4 marks]

0 3 . 3 Explain why different amino acids have different R_f values.

[2 marks]

4 Ethanedioic acid is a weak acid.
Ethanedioic acid acts, initially, as a monoprotic acid.



0 4 . 1 Use the concept of electronegativity to justify why the acid strengths of ethanedioic acid and ethanoic acid are different.

[6 marks]

0 4 . 2 A buffer solution is made by adding 6.00×10^{-2} mol of sodium hydroxide to a solution containing 1.00×10^{-1} mol of ethanedioic acid ($H_2C_2O_4$).
Assume that the sodium hydroxide reacts as shown in the following equation and that in this buffer solution, the ethanedioic acid behaves as a monoprotic acid.

$$H_2C_2O_4(aq) + OH^-(aq) \longrightarrow HC_2O_4^-(aq) + H_2O(l)$$

The dissociation constant K_a for ethanedioic acid is 5.89×10^{-2} mol dm^{-3}.

Calculate a value for the pH of the buffer solution.
Give your answer to the appropriate number of significant figures.

[5 marks]

pH = _____

Question 4 continues on the next page

0 4 . 3 In a titration, the end point was reached when 25.0 cm^3 of an acidified solution containing ethanedioic acid reacted with 20.20 cm^3 of 2.00 $\times 10^{-2}$ mol dm^{-3} potassium manganate(VII) solution.

Deduce an equation for the reaction that occurs and use it to calculate the original concentration of the ethanedioic acid solution.

[4 marks]

Equation _____

Calculation

Original concentration = _____ mol dm^{-3}

5 A sample of ethanedioic acid was treated with an excess of an unknown alcohol in the presence of a strong acid catalyst. The products of the reaction were separated and analysed in a time of flight (TOF) mass spectrometer. Two peaks were observed at m/z = 104 and 118.

0 5 . 1 Identify the species responsible for the two peaks.

[2 marks]

0 5 . 2 Outline how the TOF mass spectrometer is able to separate these two species to give two peaks.

[4 marks]

Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

0 6 Which change requires the largest amount of energy?

[1 mark]

A $He^{+}(g) \longrightarrow He^{2+}(g) + e^{-}$ ⬭

B $Li(g) \longrightarrow Li^{+}(g) + e^{-}$ ⬭

C $Mg^{+}(g) \longrightarrow Mg^{2+}(g) + e^{-}$ ⬭

D $N(g) \longrightarrow N^{+}(g) + e^{-}$ ⬭

0 7 A sample of 2.18 g of oxygen gas has a volume of 1870 cm^3 at a pressure of 101 kPa.

What is the temperature of the gas?
The gas constant is $R = 8.31$ J K^{-1} mol^{-1}.

[1 mark]

A 167 K ⬭

B 334 K ⬭

C 668 K ⬭

D 334 000 K ⬭

0 8 An ester is hydrolysed as shown by the following equation.

$$RCOOR' + H_2O \longrightarrow RCOOH + R'OH$$

What is the percentage yield of RCOOH when 0.50 g of RCOOH (M_r = 100) is obtained from 1.0 g of RCOOR′ (M_r = 150)?

[1 mark]

A 33% ⬭

B 50% ⬭

C 67% ⬭

D 75% ⬭

0 9 A saturated aqueous solution of magnesium hydroxide contains 1.17×10^{-3} g of $Mg(OH)_2$ in 100 cm^3 of solution. In this solution, the magnesium hydroxide is fully dissociated into ions.

What is the concentration of $Mg^{2+}(aq)$ ions in this solution?

[1 mark]

A 2.82×10^{-2} mol dm^{-3} ⬭

B 2.01×10^{-3} mol dm^{-3} ⬭

C 2.82×10^{-3} mol dm^{-3} ⬭

D 2.01×10^{-4} mol dm^{-3} ⬭

Turn over for the next question

1 0 The rate equation for the hydrogenation of ethene

$$C_2H_4(g) + H_2(g) \longrightarrow C_2H_6(g)$$

is $Rate = k[C_2H_4][H_2]$

At a fixed temperature, the reaction mixture is compressed to triple the original pressure.

What is the factor by which the rate of reaction changes?

[1 mark]

A 6 ⬭

B 9 ⬭

C 12 ⬭

D 27 ⬭

1 1 When one mole of ammonia is heated to a given temperature, 50% of the compound dissociates and the following equilibrium is established.

$$NH_3(g) \rightleftharpoons \tfrac{1}{2}N_2(g) + \tfrac{3}{2}H_2(g)$$

What is the total number of moles of gas present in this equilibrium mixture?

[1 mark]

A 1.5 ⬭

B 2.0 ⬭

C 2.5 ⬭

D 3.0 ⬭

1 2 Which change would alter the value of the equilibrium constant (K_p) for this reaction?

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

[1 mark]

A Increasing the total pressure of the system. ⬭

B Increasing the concentration of sulfur trioxide. ⬭

C Increasing the concentration of sulfur dioxide. ⬭

D Increasing the temperature. ⬭

1 3 What is the pH of a 0.020 mol dm^{-3} solution of a diprotic acid which is completely dissociated?

[1 mark]

A 1.00 ⬭

B 1.40 ⬭

C 1.70 ⬭

D 4.00 ⬭

1 4 The acid dissociation constant, K_a, of a weak acid HA has the value 2.56×10^{-4} mol dm^{-3}

What is the pH of a 4.25×10^{-3} mol dm^{-3} solution of HA?

[1 mark]

A 5.96 ⬭

B 3.59 ⬭

C 2.98 ⬭

D 2.37 ⬭

1 5 Magnesium reacts with hydrochloric acid according to the following equation.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

A student calculated the minimum volume of 2.56 mol dm^{-3} hydrochloric acid required to react with an excess of magnesium to form 5.46 g of magnesium chloride (M_r = 95.3).

Which of the following uses the correct standard form and the appropriate number of significant figures to give the correct result of the calculation?

[1 mark]

A 4.476×10^{-2} dm^3 ⬭

B 4.48×10^{-2} dm^3 ⬭

C 4.50×10^{-2} dm^3 ⬭

D 44.8×10^{-3} dm^3 ⬭

1 6 In which reaction is hydrogen acting as an oxidising agent?

[1 mark]

A $Cl_2 + H_2 \longrightarrow 2HCl$ ⬭

B $(CH_3)_2CO + H_2 \longrightarrow (CH_3)_2CHOH$ ⬭

C $N_2 + 3H_2 \longrightarrow 2NH_3$ ⬭

D $2Na + H_2 \longrightarrow 2NaH$ ⬭

1 7 In which reaction is the metal oxidised?

[1 mark]

A $2Cu^{2+} + 4I^- \longrightarrow 2CuI + I_2$ ⬭

B $[Fe(H_2O)_6]^{3+} + Cl^- \longrightarrow [Fe(H_2O)_5(Cl)]^{2+} + H_2O$ ⬭

C $[CoCl_4]^{2-} + 6H_2O \longrightarrow [Co(H_2O)_6]^{2+} + 4Cl^-$ ⬭

D $Mg + S \longrightarrow MgS$ ⬭

1 8 The following cell has an EMF of +0.46 V.

$$Cu \mid Cu^{2+} \,||\, Ag^+ \mid Ag$$

Which statement is correct about the operation of the cell?

[1 mark]

A Metallic copper is oxidised by Ag^+ ions. ⬭

B The silver electrode has a negative polarity. ⬭

C The silver electrode gradually dissolves to form Ag^+ ions. ⬭

D Electrons flow from the silver electrode to the copper electrode via an external circuit. ⬭

1 9 In an experiment to identify a Group 2 metal (X), 0.102 g of X reacts with an excess of aqueous hydrochloric acid according to the following equation.

$$X + 2HCl \longrightarrow XCl_2 + H_2$$

The volume of hydrogen gas given off is 65 cm^3 at 99 kPa pressure and 303 K. The gas constant is $R = 8.31$ J K^{-1} mol^{-1}.

Which is X?

[1 mark]

A Barium ⬭

B Calcium ⬭

C Magnesium ⬭

D Strontium ⬭

2 0 What forms when a solution of sodium carbonate is added to a solution of gallium(III) nitrate?

[1 mark]

A A white precipitate of gallium(III) carbonate. ⬭

B A white precipitate of gallium(III) hydroxide. ⬭

C A white precipitate of gallium(III) carbonate and bubbles of carbon dioxide. ⬭

D A white precipitate of gallium(III) hydroxide and bubbles of carbon dioxide. ⬭

2 1 Which compound gives a colourless solution when an excess of dilute aqueous ammonia is added?

[1 mark]

A $MgCl_2$ ⬭

B AgCl ⬭

C $CuCl_2$ ⬭

D $AlCl_3$ ⬭

2 2 What is the final species produced when an excess of aqueous ammonia is added to aqueous aluminium chloride?

[1 mark]

A $[Al(NH_3)_6]^{3+}$ ⬭

B $[Al(OH)_3(H_2O)_3]$ ⬭

C $[Al(OH)_4(H_2O)_2]^-$ ⬭

D $[Al(OH)(H_2O)_5]^{2+}$ ⬭

2 3 The following equation represents the oxidation of vanadium(IV) ions by manganate(VII) ions in acid solution.

$$5V^{4+} + MnO_4^- + 8H^+ \longrightarrow 5V^{5+} + Mn^{2+} + 4H_2O$$

What volume of 0.020 mol dm^{-3} $KMnO_4$ solution is required to oxidise completely a solution containing 0.010 mol of vanadium(IV) ions?

[1 mark]

A 10 cm^3 ⬭

B 25 cm^3 ⬭

C 50 cm^3 ⬭

D 100 cm^3 ⬭

2 4 How many isomers have the molecular formula C_5H_{12}?

[1 mark]

A 2 ⬭

B 3 ⬭

C 4 ⬭

D 5 ⬭

2 5 Which molecule is **not** produced when ethane reacts with bromine in the presence of ultraviolet light?

[1 mark]

A $C_2H_4Br_2$ ⬭

B HBr ⬭

C H_2 ⬭

D C_4H_{10} ⬭

2 6 How many structural isomers have the molecular formula C_4H_9Br?

[1 mark]

A 2 ⬭

B 3 ⬭

C 4 ⬭

D 5 ⬭

2 7 What is the major product of the reaction between but-1-ene and DBr?
(D is deuterium and represents ^2H)

[1 mark]

A $CH_2DCH_2CH_2CH_2Br$ ⬭

B $CH_2DCH_2CHBrCH_3$ ⬭

C $CH_3CH_2CHBrCH_2D$ ⬭

D $CH_3CH_2CHDCH_2Br$ ⬭

2 8 Why are fluoroalkanes unreactive?

[1 mark]

A Fluorine is highly electronegative. ⬭

B The F^- ion is very stable. ⬭

C They are polar molecules. ⬭

D The C–F bond is very strong. ⬭

2 9 Which alcohol could **not** be produced by the reduction of an aldehyde or a ketone?

[1 mark]

A 2-methylbutan-1-ol ⬭

B 2-methylbutan-2-ol ⬭

C 3-methylbutan-1-ol ⬭

D 3-methylbutan-2-ol ⬭

3 0 Which compound forms optically active compounds on reduction?

[1 mark]

A $CH_3CH_2C(CH_3)=CHCH_3$ ⬭

B $CH_3CH_2C(CH_3)=CH_2$ ⬭

C CH_3COCH_3 ⬭

D $CH_3CH_2COCH_3$ ⬭

3 1 How many secondary amines have the molecular formula $C_4H_{11}N$?

[1 mark]

A 2 ⬭

B 3 ⬭

C 4 ⬭

D 5 ⬭

3 2 Which compound has the highest boiling point?

[1 mark]

A C_2H_4 ⬭

B C_2H_6 ⬭

C CH_3NH_2 ⬭

D CH_3F ⬭

3 3 Which compound can polymerise by reaction with itself?

[1 mark]

A $NH_2CH_2CH_2NH_2$ ⬭

B $CH_3CH_2CONH_2$ ⬭

C $HOOCCH_2COOH$ ⬭

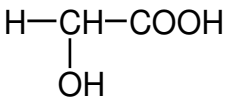
D NH_2CH_2COCl ⬭

3 4 A drug is designed to simulate one of the following molecules that adsorbs onto the active site of an enzyme.

Which molecule requires the design of an optically active drug?

[1 mark]

A



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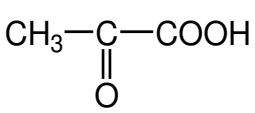
B



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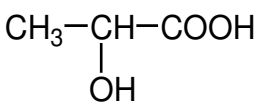
C



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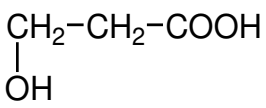
D



⬭

Turn over for the next question

3 5 Which amine has only **three** peaks in its proton NMR spectrum?

[1 mark]

A Methylamine ⬭

B Trimethylamine ⬭

C Diethylamine ⬭

D Propylamine ⬭

END OF QUESTIONS

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