# 2.9 A-Level Chemistry: Required Practicals and Practical Skills: 30-minute Pack

Total Marks

AQA 7405 · Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

**Answer ALL questions. Show all your working.**

**1** An unknown colourless organic liquid Y was analysed using the tests below.

Test 1: A few drops of Y were added to Brady's reagent (2,4-dinitrophenylhydrazine dissolved in methanol and sulfuric acid). Observation: an orange precipitate formed immediately.

Test 2: A sample of Y was warmed gently with Tollens' reagent (ammoniacal silver nitrate) in a test tube. Observation: a silver mirror formed on the inside of the tube.

Test 3: A separate sample of Y was warmed with acidified potassium dichromate(VI) solution. Observation: the solution changed from orange to green.

Test 4: A few drops of Y were added to bromine water and shaken. Observation: no change was seen; the bromine water remained orange.

**(a)** Identify the functional group shown to be present by the result of Test 1, and state the type(s) of compound this test alone cannot distinguish between. **(2)**

**(b)** Use the result of Test 2 to identify whether Y is an aldehyde or a ketone. Write a balanced equation for the oxidation of Y (represented as RCHO) by the diamminesilver(I) ion, $[Ag(NH_3)_2]^+$, in Tollens' reagent, giving the organic product formed. **(3)**

**(c)** State the colour change observed in Test 3 and explain this observation in terms of the change in oxidation state of chromium. **(3)**


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**(d)** Explain what the result of Test 4 indicates about the structure of Y. **(2)**

**(e)** Using all four test results, identify the class of organic compound Y belongs to, and suggest a molecular formula consistent with a compound of this class containing three carbon atoms. **(2)**

**(f)** Describe an alternative test, using Fehling's solution, that could be used instead of Test 2 to confirm that Y is an aldehyde. State the reagent's colour before the test and the observation that would confirm a positive result. **(2)**

**(Total for Question 1 is 14 marks)**


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**2** A 0.100 mol dm-3 solution of NaOH(aq) was added from a burette to 25.0 $cm^3$ of a solution of ethanoic acid, $CH_3COOH(aq)$, of unknown concentration, with the pH recorded continuously using a pH meter. Selected data points from the titration curve are shown below.

| Volume of NaOH added / cm3 | pH |
|---|---|
| 0.0 | 2.87 |
| 12.5 | 4.76 |
| 24.0 | 6.24 |
| 24.9 | 7.50 |
| 25.0 (equivalence point) | 8.72 |
| 25.1 | 9.90 |
| 26.0 | 11.40 |
| 30.0 | 12.10 |

| Indicator | pH range over which colour change occurs |
|---|---|
| Methyl orange | 3.1 - 4.4 |
| Phenolphthalein | 8.2 - 10.0 |

**(a)** Calculate the concentration, in mol dm-3, of the original ethanoic acid solution. **(3)**

**(b)** Using the pH data given, identify a suitable indicator for this titration and explain your choice. **(2)**

**(c)** State the pH at the half-equivalence point (12.5 $cm^3$) and use this value to calculate the acid dissociation constant, Ka, for ethanoic acid. **(3)**

**(d)** Explain, in terms of the relative concentrations of $CH_3COOH$ and $CH_3COO^-$ present, why the pH at the half-equivalence point is equal to pKa. **(2)**

**(e)** Explain why the initial pH of the ethanoic acid solution (2.87) is higher than the pH of a strong monoprotic acid of the same concentration (0.100 mol dm-3) would be. **(2)**

**(Total for Question 2 is 12 marks)**


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# Mark scheme · 2.9 A-Level Chemistry: Required Practicals and Practical Skills: 30-minute Pack

## Question 1

(a) a carbonyl group, C=O, is present **B1**

(a) cannot distinguish between an aldehyde and a ketone (2,4-DNPH/Brady's reagent gives a positive result with both) **B1**

**(a) Answer: Carbonyl group (C=O); does not distinguish aldehyde from ketone.**

(b) Y is an aldehyde (only aldehydes are oxidised by Tollens' reagent to give a silver mirror; ketones give no reaction) **B1**

(b) attempt at a balanced equation showing RCHO oxidised and $Ag^+$ reduced to Ag **M1**

(b) $RCHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow RCOO^- + 2Ag + 4NH_3 + 2H_2O$ (oe; allow RCOOH as product with adjusted balancing) **A1**

**(b) Answer: Aldehyde; $RCHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow RCOO^- + 2Ag + 4NH_3 + 2H_2O$**

(c) orange (dichromate(VI), $Cr_2O_7^{2-}$) changes to green ($Cr^{3+}$) **B1**

(c) chromium is reduced from oxidation state +6 (in $Cr_2O_7^{2-}$) to +3 (in $Cr^{3+}$) **B1**

(c) as it oxidises the aldehyde, RCHO, to a carboxylic acid, RCOOH **B1**

**(c) Answer: Orange to green; Cr is reduced from +6 to +3 as it oxidises RCHO to RCOOH.**

(d) bromine water is not decolourised, so Y contains no C=C double bond (no alkene present) **B1**

(d) Y is a saturated compound (oe) **B1**

**(d) Answer: No C=C bond present; Y is saturated.**

(e) Y is a saturated aliphatic aldehyde **B1**

(e) $C_3H_6O$ (propanal, $CH_3CH_2CHO$) or any valid saturated aldehyde formula $C_nH_{2n}O$ **B1**

**(e) Answer: Saturated aliphatic aldehyde; $C_3H_6O$ (propanal).**

(f) Fehling's solution is blue before the test **B1**

(f) on warming with an aldehyde, a brick-red (orange-red) precipitate of copper(I) oxide, $Cu_2O$, forms; no change occurs with a ketone **B1**

**(f) Answer: Blue Fehling's solution turns to a brick-red precipitate ($Cu_2O$) on warming with an aldehyde.**

## Question 2

(a) moles NaOH at equivalence = 0.100 x (25.0/1000) = 0.00250 mol **M1**

(a) moles $CH_3COOH$ = moles NaOH = 0.00250 mol (1:1 stoichiometry, $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$) **M1**

(a) concentration = 0.00250/0.0250 = 0.100 mol dm-3 (cao) **A1**

**(a) Answer: 0.100 mol dm-3**

(b) phenolphthalein **B1**

(b) its colour-change range (pH 8.2-10.0) lies within the steep part of the titration curve around the equivalence point (pH rises sharply from about 7.50 to 11.40 between 24.9 and 26.0 $cm^3$), close to the equivalence point pH of 8.72; methyl orange (pH 3.1-4.4) would change colour far too early and is unsuitable **B1**

**(b) Answer: Phenolphthalein, since its colour-change range coincides with the steep part of the curve near the equivalence point (pH 8.72).**

(c) pH = 4.76 **B1**

(c) $[H^+] = 10^{-4.76}$ **M1**

(c) Ka = 1.74 x $10^{-5}$ mol dm-3 (awrt 1.7-1.8 x $10^{-5}$) **A1**

**(c) Answer: Ka = 1.74 x $10^{-5}$ mol dm-3**

(d) at the half-equivalence point, exactly half of the original $CH_3COOH$ has been converted to its conjugate base $CH_3COO^-$ (as sodium ethanoate), so $[CH_3COOH] = [CH_3COO^-]$ **B1**

(d) substituting into $Ka = [H^+][CH_3COO^-]/[CH_3COOH]$: since $[CH_3COO^-] = [CH_3COOH]$, these cancel, giving $Ka = [H^+]$, so $pKa = -\log(Ka) = -\log[H^+] = pH$ **B1**

**(d) Answer: At half-equivalence $[CH_3COOH] = [CH_3COO^-]$, so $Ka = [H^+]$ and hence pKa = pH.**

(e) ethanoic acid is a weak acid and only partially dissociates in water ($CH_3COOH \rightleftharpoons CH_3COO^- + H^+$), an equilibrium that lies well to the left **B1**

(e) so $[H^+]$ produced is much lower than the initial acid concentration, unlike a strong acid which fully dissociates and would give $[H^+]$ = 0.100 mol dm-3 (pH = 1.00), resulting in a higher pH for the weak acid **B1**

**(e) Answer: Ethanoic acid only partially dissociates, giving a much lower $[H^+]$ than a fully dissociated strong acid of the same concentration.**


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