Rewarding Learning

ADVANCED
General Certificate of Education
2024

Chemistry

Assessment Unit A2 1

assessing

Further Physical and Organic Chemistry

[ACH14]

TUESDAY 28 MAY, MORNING

MARK SCHEME

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes, teachers and students will be able to see what the examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather, with rewarding students for what they do know.

The purpose of mark schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins, a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. The document published represents the final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example where there is no absolute correct response – all teachers will be familiar with making such judgements.

Section A

	AVAILABLE MARKS
1 B	
2 B	
3 D	
4 C	
5 C	
6 A	
7 C	
8 C	
9 A	
10 C	
[1] for each correct answer [10]	10
Section A	**10**

Section B

AVAILABLE MARKS

11 (a) (i) moles of $CH_3COOH = \frac{17.2 \times 0.525}{1000} = 9.03 \times 10^{-3}$

moles of NaOH in 25 $cm^3 = 9.03 \times 10^{-3}$

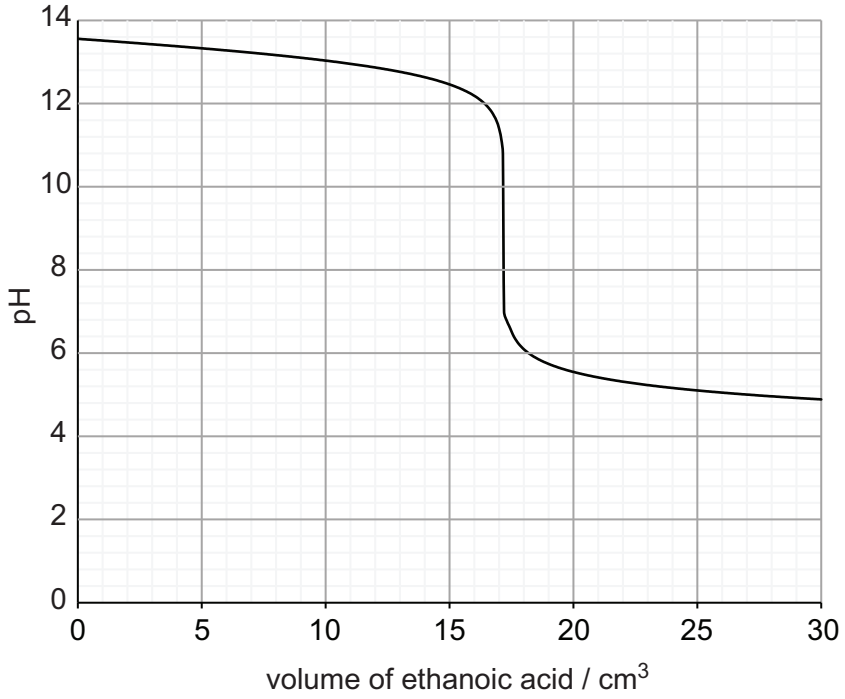
$[NaOH] = 9.03 \times 10^{-3} \times 40 = 0.361$ (mol dm^{-3}) [2]

(ii) $[OH^-] = 0.361$ (mol dm^{-3})

$[H^+] = \frac{1.00 \times 10^{-14}}{0.361} = 2.77 \times 10^{-14}$ (mol dm^{-3})

$pH = -\log_{10}(2.77 \times 10^{-14}) = 13.56$ [2]

(iii)



starts at 13.5 [1]
vertical region from around 11 – 6.5 [1]
vertical region at 17.2 cm^3 [1] [3]

(iv) phenolphthalein [1]
colour change of the indicator is in the pH range within the vertical region of the titration curve/weak acid-strong base titration [1] [2]

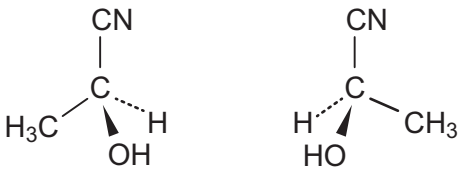
(b) (i) vertical region at lower volume [1]
vertical region from around 11 – 3 [1] [2]

(ii) moles of $H_2SO_4 = \frac{20.0 \times 0.525}{1000} = 0.0105$
moles of $H^+ = 0.021$

new volume = 250.0 cm^3

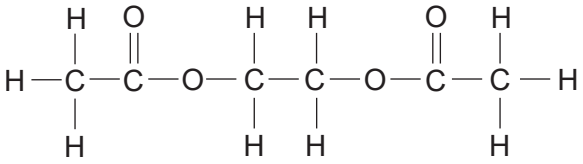
$[H^+] = 0.021 \times 4 = 0.084$ mol dm^{-3}

$pH = -\log_{10}(0.084) = 1.08$ [3]

				AVAILABLE MARKS
	(c)	**(i)**	$2NaOH + H_3PO_4 \rightarrow Na_2HPO_4 + 2H_2O$ [1]	
		(ii)	$HPO_4^{2-} + H_2O \rightarrow PO_4^{3-} + H_3O^+ / HPO_4^{2-} \rightarrow H^+ + PO_4^{3-}$ [1] $HPO_4^{2-} + H_2O \rightarrow H_2PO_4^- + OH^- / HPO_4^{2-} + H^+ \rightarrow H_2PO_4^-$ [1] [2]	
		(iii)	salt of a strong base and a weak acid [1]	18
12	**(a)**	**(i)**	donates one proton per molecule [1]	
		(ii)	straight chain [1] stronger/more van der Waals' forces between molecules [1] [2]	
		(iii)	base = $CH_3CH_2CH_2COOH$ [1] conjugate acid = $CH_3CH_2CH_2COOH_2^+$ [1] [2]	
		(iv)	$[H^+] = 10^{(-2.40)} = 3.98 \times 10^{-3}$ $[\text{acid}] = \frac{(3.98 \times 10^{-3})^2}{1.38 \times 10^{-4}} = 0.1148 \text{ mol dm}^{-3}$ moles = $0.1148 \times 0.250 = 0.0287$ mass = $0.0287 \times 90 = 2.58$ (g) [4]	
	(b)	**(i)**	$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$ [1]	
		(ii)	2-hydroxypropanenitrile [1]	
		(iii)	nucleophilic addition [1]	
		(iv)	 [2]	
		(v)	molecules which exist as non superimposable mirror images [1]	
		(vi)	$CH_3CH(OH)CN + 2H_2O + HCl \rightarrow CH_3CH(OH)COOH + NH_4Cl$ [2]	
		(vii)	it is a racemic mixture [1]	18

AVAILABLE MARKS

13 (a)



or $CH_3COOCH_2CH_2OOCCH_3$ [1]

(b) (i)

Substance	CH_3COOH	$HOCH_2CH_2OH$	$C_6H_{10}O_4$	H_2O
Initial amount in mixture/mol	0.550	0.205	0	0
Equilibrium amount in mixture/mol	0.260	0.06 [1]	0.145 [1]	0.29 [1]

[3]

(ii) $K_c = \dfrac{[C_6H_{10}O_4][H_2O]^2}{[CH_3COOH]^2[HOCH_2CH_2OH]}$ [1]

(iii) same number of moles on both sides/volumes cancel out in equation/K_c has no units [1]

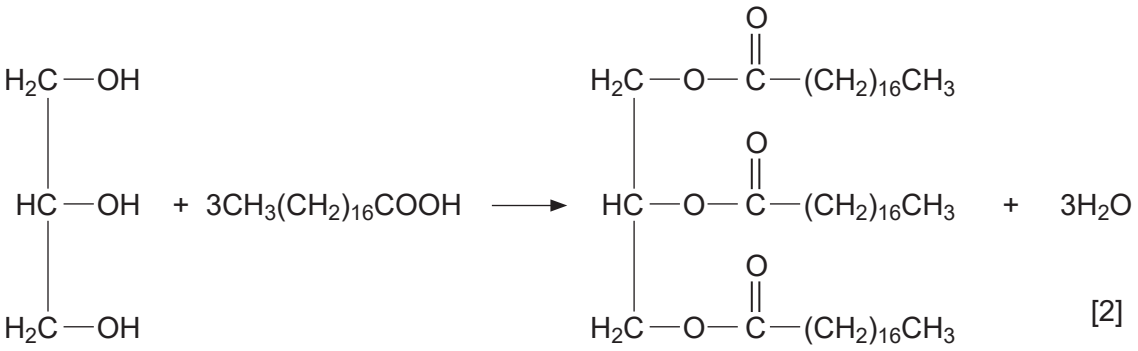
(iv) $K_c = \dfrac{(0.145)(0.29)^2}{(0.26)^2(0.06)} = 3.01$ [2] 8

14 (a) Indicative content

- record the pH at different times using a pH meter
- calculate the concentration of OH^- ions using K_w
- plot a graph of concentration of OH^- against time
- gradient of tangents at different concentrations equals rate
- plot rate against concentration of hydroxide ions
- shape of graph indicates order

Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 3 points of indicative content. They must use appropriate spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates must use a minimum of 2 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

				AVAILABLE MARKS
(b)	**(i)**	order = 1	[1]	
	(ii)	order = 1	[1]	
	(iii)	rate = 24×10^{-4} or 2.4×10^{-3}	[1]	
	(iv)	increases	[1]	
(c)	**(i)**	propane-1,2,3-triol	[1]	
	(ii)	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	[1]	
	(iii)		[2]	14
15	**(a)**	**(i)** $2Rb(s) + \frac{1}{2}O_2(g) \rightarrow Rb_2O(s)$	[1]	
		(ii) C = enthalpy of atomisation of oxygen [1] D = lattice enthalpy of rubidium oxide [1] E = first electron affinity of oxygen [1]	[3]	
		(iii) $\Delta H = +2(+86) +2(+402) + (+249) + (-142) + (+844) - (+2161)$ $\Delta H = -234$ (kJ mol^{-1})	[2]	
	(b)	**(i)** $Rb(s) + \frac{1}{2}I_2(g) \rightarrow RbI(s)$ / $2Rb(s) + I_2(g) \rightarrow 2RbI(s)$	[1]	
		(ii) $\Delta H = (+617) + (-296) + (-308) = +13$ (kJ mol^{-1})	[2]	
	(c)	**(i)** sodium nitrate(III)	[1]	
		(ii) potassium cation larger than sodium cation [1] less polarising effect on the nitrate ion [1]	[2]	
		(iii) $\Delta H = 2(-359) - 2(-467) = +216$ (kJ)	[2]	
		(iv) $\Delta H = T\Delta S$ $968 = \frac{216}{\Delta S}$ $\Delta S = \frac{216}{968} = 0.223$ kJ K^{-1} mol^{-1} $\Delta S = +223$ (J K^{-1} mol^{-1})	[3]	
		(v) $223 = 2(120) + 205 - 2S(NaNO_3)$ $2S(NaNO_3) = 445 - 223 = 222$ $S(NaNO_3) = 111$ (J K^{-1} mol^{-1})	[2]	19

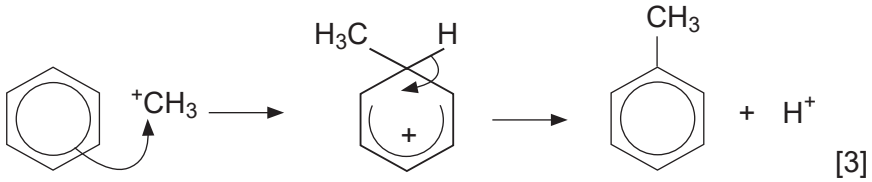
AVAILABLE MARKS

16 (a) (i) catalyst/halogen carrier [1]

(ii) electrophilic substitution [1]

(iii) Step 1: $CH_3Cl + AlCl_3 \rightarrow CH_3^+ + \mathbf{AlCl_4^-}$ [1]

Step 2:



[3]

Step 3: $\mathbf{AlCl_4^-} + \mathbf{H^+} \rightarrow AlCl_3 + \mathbf{HCl}$ [1] [5]

(iv) oxidation [1]

(v) $C_6H_5COOH + PCl_5 \rightarrow C_6H_5COCl + HCl + POCl_3$ [1]

(b) (i) concentrated sulfuric acid [1]

(ii) 1. shake/use a separating funnel with sodium carbonate solution [1]
2. dry the crude product (using anhydrous sodium sulfate) [1]
3. distil (and collect the fraction at 199°C) [1] [3]

(c) (i) concentrated nitric acid [1]
concentrated sulfuric acid [1] [2]

(ii) $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ [2]

(iii) Indicative content

- dissolve some methyl benzoate in concentrated sulfuric acid
- cool the solution in ice
- add the nitrating mixture drop by drop to the solution of methyl benzoate, stirring with a thermometer and keeping the temperature below 10°C
- allow the mixture to stand at room temperature for 15 minutes
- pour the mixture onto crushed ice and stir until all the ice has melted and crystalline methyl 3-nitrobenzoate is formed
- filter the crystals using Büchner filtration
- recrystallise from ethanol
- dry crystals in a desiccator

Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 7 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use appropriate spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates must use a minimum of 3 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6] 23

Section B **100**

Total **110**

AVAILABLE MARKS