Rewarding Learning

ADVANCED
General Certificate of Education
2019

Chemistry

Assessment Unit A2 1
assessing
Further Physical and Organic Chemistry

[ACH12]

TUESDAY 4 JUNE, AFTERNOON

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 C

2 C

3 B

4 B

5 C

6 C

7 D

8 B

9 B

10 C

[1] for each correct answer [10] 10

Section A **10**

Section B

AVAILABLE MARKS

11 **(a)** A measure of disorder [1]

(b) (131 + 102.5) – (189) = 233.5 – 189 = 44.5 J K^{-1} (mol^{-1}) [1]

(c) The entropy change would be larger [1] as liquid water has lower entropy value than gaseous water [1] (liquid water is less disordered than gaseous water) [2]

(d) (A reaction for which) $\Delta G < 0$ [1]

(e) $0 = \Delta H - \frac{T\Delta S}{1000}$

$$\Delta H = \frac{5440\ (44.5)}{(1000)} = \frac{242\,080}{1000}$$

$$= 242.08\ \text{kJ}\ (\text{mol}^{-1})$$

$$= 242\ \text{kJ}\ (\text{mol}^{-1})$$ [2]

7

12 **(a)** **(i)** 1,3,5-trinitrobenzene [1]

(ii)
- Take sample from the reaction mixture at different times/intervals
- Quench reaction with ice
- Titrate against standard sodium hydroxide solution with phenolphthalein/methyl orange indicator
- Plot a graph of concentration against time
- Take tangents and measure the gradient
- Plot a graph of rate against concentration. Determine order from the shape of this graph.

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 satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates use a minimum of 1 point 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]

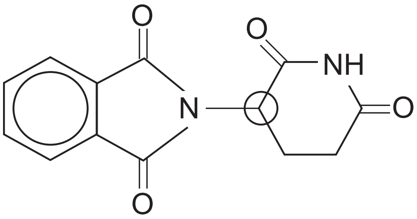
AVAILABLE MARKS

(b) **(i)** First order [1]

(ii) Rate constant $= 2.40 \times 10^{-6}/2.50 \times 10^{-4}$
$= 2.40/2.50 \times 10^{-2}$
$= 0.960 \times 10^{-2}$
$= 0.00960\ \mathrm{min^{-1}}/9.60 \times 10^{-3}\ \mathrm{min^{-1}}$ [2]

(iii) Greater proportion of successful collisions as greater fraction of molecules will have $E > E_A$ (increases the constant in the rate equation) [1] 11

13 **(a)**



[1]

(b) Molecules which exist as non-superimposable mirror images. [1]

(c) The receptor sites are stereospecific [1]

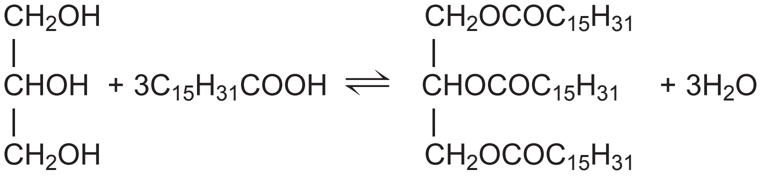
(d) A 50:50 mixture of two optical isomers [1]
The effects of each isomer (being equal and opposite) cancel each other out [1] [2] 5

14 **(a)** Advantage – more precise/quantitative value/easier to discern pH [1]
Disadvantage – must be stored properly/time to set up/more expensive [1]

(b) Vertical section passes through the (pH) range in which both indicators change colour [1]

(c) Neutral as it is the salt of a strong acid and base [1] 4

15 **(a)**



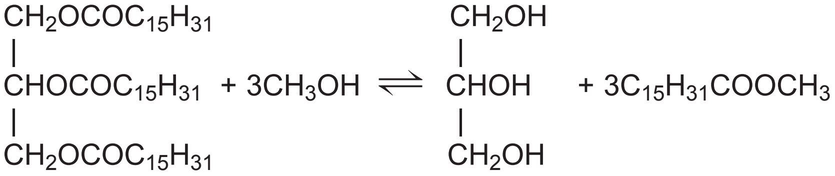
$$\begin{array}{l} \mathrm{CH_2OH} \\ | \\ \mathrm{CHOH} \\ | \\ \mathrm{CH_2OH} \end{array} + 3\mathrm{C_{15}H_{31}COOH} \rightleftharpoons \begin{array}{l} \mathrm{CH_2OCOC_{15}H_{31}} \\ | \\ \mathrm{CHOCOC_{15}H_{31}} \\ | \\ \mathrm{CH_2OCOC_{15}H_{31}} \end{array} + 3\mathrm{H_2O}$$

[2]

(b) Saturated [1] $C_{15}H_{31}$ is C_nH_{2n+1} [1] [2]
Second mark dependent on the first

(c) A reaction where the alkyl group of an ester is exchanged with the alkyl group of an alcohol/carboxylic acid [2]

(d)

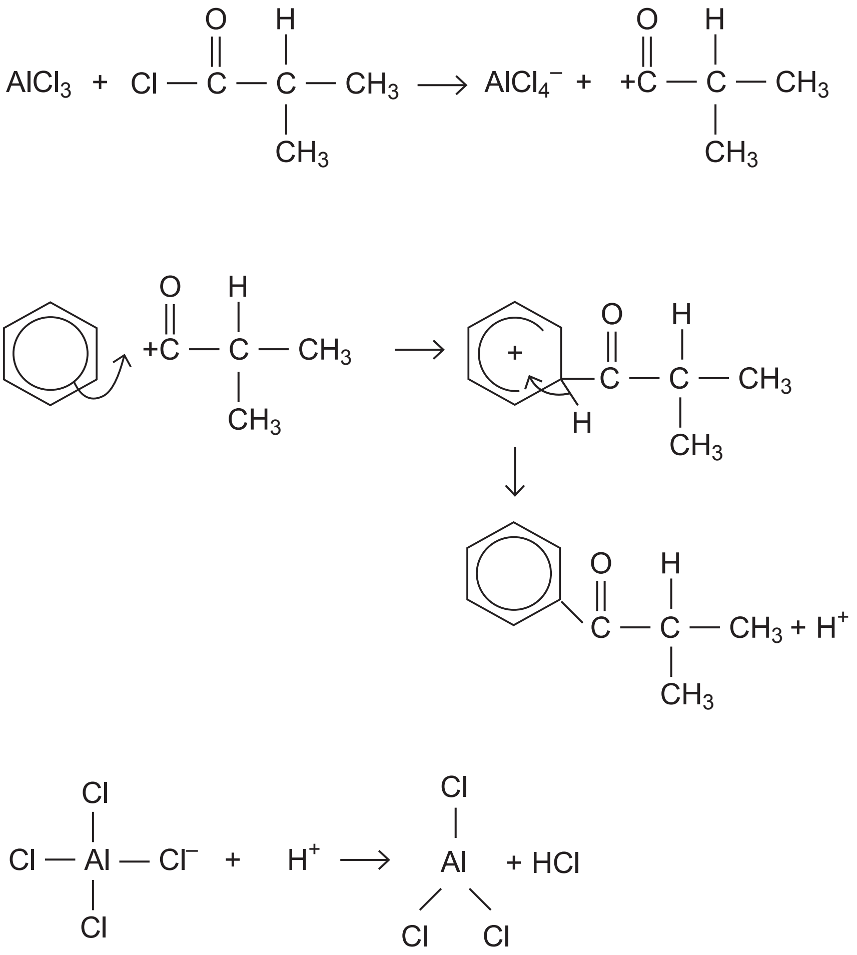


$$\begin{array}{l} \mathrm{CH_2OCOC_{15}H_{31}} \\ | \\ \mathrm{CHOCOC_{15}H_{31}} \\ | \\ \mathrm{CH_2OCOC_{15}H_{31}} \end{array} + 3\mathrm{CH_3OH} \rightleftharpoons \begin{array}{l} \mathrm{CH_2OH} \\ | \\ \mathrm{CHOH} \\ | \\ \mathrm{CH_2OH} \end{array} + 3\mathrm{C_{15}H_{31}COOCH_3}$$

[1]

(e) $C_{15}H_{31}COOCH_3$ [1] 8

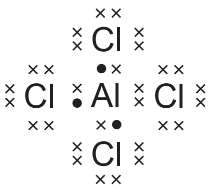
16 (a)



[5]

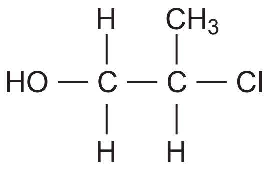
or $AlCl_4^- + H^+ \longrightarrow AlCl_3 + HCl$

(b)



[1]

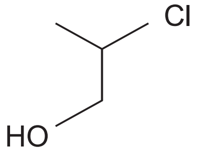
(c)



$$\begin{array}{ccccccc} & & \mathrm{H} & & \mathrm{CH_3} & & \\ & & | & & | & & \\ \mathrm{HO} & - & \mathrm{C} & - & \mathrm{C} & - & \mathrm{Cl} \\ & & | & & | & & \\ & & \mathrm{H} & & \mathrm{H} & & \end{array}$$

or $CH_2OHCH(CH_3)Cl$

or



[1]

(d) Addition reactions would remove stability [1]

AVAILABLE MARKS

8

17 (a) (i) $K_w = [H^+][OH^-]$
or $K_w = [H^+(aq)]\ [OH^-(aq)]$
or $K_w = [H_3O^+][OH^-]$
or $K_w = [H_3O^+(aq)]\ [OH^-(aq)]$ [1]

(ii) $[H_2O]$ is effectively constant/$[H_2O]$ is incorporated into the value of K_w i.e. $K_w = [H_3O^+ (aq)]\ [OH^- (aq)]\ [H_2O]$ [1]

(b) (i) $9.3 \times 10^{-14} = [H^+(aq)]^2$
$[H^+(aq)] = 3.05 \times 10^{-7}$
pH = 6.52 [2]

(ii) Neutral [1] as H^+/H_3O^+ and OH^- form in equal amounts [1] [2]
Second mark is dependent on the first

(iii) $Ba(OH)_2$ RFM = 137 + 2 × (16 + 1) = 171
256.5/171 = 1.497 = 1.5 mol
moles = 1.5
$[OH^-] = 2 \times 1.5/0.5 = 6$
$[H^+(aq)][OH^-(aq)] = 9.3 \times 10^{-14}$
$[H^+(aq)] \times 6 = 9.3 \times 10^{-14}$
$[H^+(aq)] = 9.3 \times 10^{-14}/6 = 1.55 \times 10^{-14}$
pH =13.81 [4]

(c) (i) $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

moles of acid $\frac{25.0}{1000} \times 0.18 = 0.0045$

moles of alkali $\frac{10.0}{1000} \times 0.12 = 0.0012$

excess acid = 0.0033 moles

moles of salt = 0.0012 moles

$K_a = 10^{-4.76} = 1.74 \times 10^{-5}\ mol\,dm^{-3}$

$K_a = \frac{[H^+]\ [salt]}{[acid]} \quad [H^+] = \frac{K_a\,[acid]}{[salt]}$

$[H^+] = \frac{(1.74 \times 10^{-5})(0.0033)}{(0.0012)}$

$[H^+] = 4.78 \times 10^{-5}\ mol\,dm^{-3}$
pH = 4.32 [4]

(ii) $CH_3COO^- + H^+ \rightleftharpoons CH_3COOH$ [1]
H^+ removed by salt, $[H^+(aq)]$ remains constant, pH unchanged [1] [2] 16
Second mark is dependent on the first

18 **(a)** 1–2 atm pressure [1], vanadium pentoxide catalyst [1] [2]

(b) Lower temperatures give a better yield but are slower [1] (or converse)
450 °C is a compromise between yield and rate [1] [2]

(c) $K_c = \dfrac{[SO_3]^2}{[SO_2]^2\,[O_2]}$ [1]

(d) $K_c = \dfrac{\left(\frac{10}{20}\right)^2}{\left(\frac{8}{20}\right)^2\left(\frac{x}{20}\right)} = \dfrac{0.25}{(0.16)(0.05x)} = 27.9$

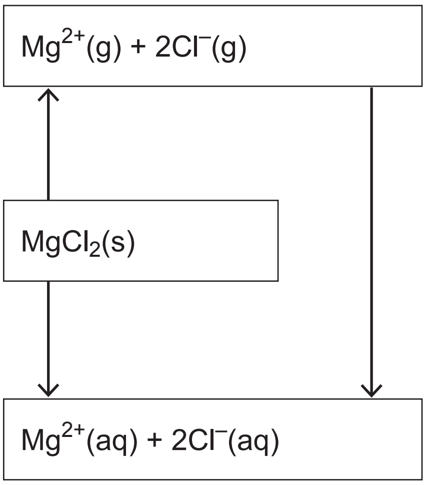
$= \dfrac{0.25}{0.008x} = 27.9$

$0.25 = (27.9 \times 0.008x)$
$0.25 = 0.2232x$
$1.12 = x$
$1.1 = x$ [4] 9

19 **(a)** **(i)** $CaCl_2(s) \rightarrow Ca^{2+}(g) + 2Cl^-(g)$ [2]

(ii) Mg^{2+} has a higher charge density than Ca^{2+}/smaller ion than Ca^{2+} [1]

(b) **(i)**



[1]

[1] [2]

(ii) $-155 = 2493 + x + 2(-364)$
$x = -1920\ kJ\ mol^{-1}$ [2] 7

20 **(a)** **(i)** E isomer [1] high priority groups on opposite sides of C=C [1] [2]
Second mark dependent on the first

(ii)
- Place (5 cm^3) of 2,4-dinitrophenylhydrazine solution in a test tube/suitable container. Add some drops of the test liquid/(pale yellow) oil.
- Cool (the mixture in iced water).
- Filter off the crystals using suction filtration.
- Dry by sucking air over the crystals in the Buchner or in a low temperature oven/dessicator
- Determine the melting point.
- Compare to data book

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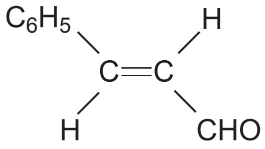
[6]

(b)



+ 2[H] → $C_6H_5CH{=}CHCH_2OH$

[1]

(c) Intermolecular forces between cinnamic acid molecules are van der Waals' and hydrogen bonds [1]

Intermolecular forces between cinnamaldehyde molecules are van der Waals' and permanent dipole–dipole [1]

More energy required to break hydrogen bonds [1] [3]

12

AVAILABLE MARKS

21 **(a)** $CH_3COCl + H_2O \rightarrow CH_3COOH + HCl$ [1]

(b) Hold over a glass rod which has been dipped in concentrated ammonia solution [1] white smoke [1] [2]

(c) **(i)** $(CH_2OH)_2 + 2CH_3COCl \rightarrow (CH_2OOCCH_3)_2 + 2HCl$ [2]

(ii) Moles ethane-1,2-diol = 31/62 = 0.5
$(CH_2OOCCH_3)_2 = (C_3H_5O_2)_2 = C_6H_{10}O_4$
$M_r = 72 + 10 + 64 = 146$
Theoretical yield = 0.5 × 146 = 73 g
% yield = 49/73 × 100 = 67.1%
= 67% [3]

(d) No catalyst needed [1]
Goes to completion/higher yield [1]
Less purification [1] [3]

(e) Phosphorus(V) chloride, PCl_5/phosphorus(III) chloride, PCl_3/thionyl chloride, $SOCl_2$ [2] 13

Section B **100**

Total **110**