Rewarding Learning

ADVANCED
General Certificate of Education
2023

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

[ACH24]

MONDAY 12 JUNE, 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 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 this 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 B	
3 C	
4 B	
5 D	
6 B	
7 A	
8 B	
9 A	
10 D	
[1] for each correct answer [10]	10
Section A	**10**

Section B

AVAILABLE MARKS

11 (a) (i) hexane-1,6-diamine/1,6-diaminohexane [1]
hexanedioic acid/hexanedioyl (di)chloride [1] [2]

(ii) condensation [1]
polyamide [1] [2]

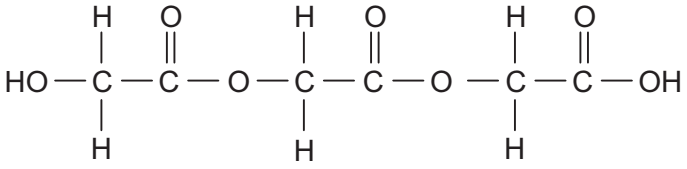
(iii) 6 carbon atoms in each of the monomers [1]

(iv) 226 × 240 = 54 240 [1]

(v) (a polymer which) can be hydrolysed by the action of micro-organisms [1]
amide group can be hydrolysed [1] [2]

(vi) hydrogen bonds/permanent dipole-dipole attractions between nylon molecules [1]
hydrogen bonds are stronger than van der Waals' forces between polythene molecules [1] [2]

(b) (i)



[2]

(ii) ester [1] 13

12 (a) (i) $Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$ [1]

(ii) $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ [1]
white precipitate is $BaSO_4$ [1]
$Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2$ [1]
blue precipitate is $Cu(OH)_2$ [1] [4]

(b) (i) white precipitate = AgCl [1]
gas = CO_2 [1]
green precipitate = $Ni(OH)_2$ [1]
yellow solution = $[Co(NH_3)_6]^{2+}$ [1] [4]

(ii) **A** = nickel(II) chloride/$NiCl_2$ [1]
B = cobalt(II) iodide/CoI_2 [1] [2]

(iii) **C** = any soluble carbonate or hydrogencarbonate, e.g. Na_2CO_3; $NaHCO_3$; K_2CO_3; $KHCO_3$; $(NH_4)_2CO_3$ [1]
any correct test: flame test/ammonium ion test using NaOH(aq)/gas tested using limewater [1] [2] 13

AVAILABLE MARKS

13 (a) (i) $2VO_2^+ + 4H^+ + 2I^- \rightarrow 2VO^{2+} + I_2 + 2H_2O$ [2]

(ii) emf = +0.46 V [1]

(b) (i)

Vanadium compound	Colour
$(VO_2)_2SO_4(aq)$	yellow
$VSO_4(aq)$	violet
$V_2(SO_4)_3(aq)$	green

[3]

(ii) moles of $(VO_2)_2SO_4 = \frac{0.131}{262} = 5.00 \times 10^{-4}$

moles of $VSO_4 = \frac{0.441}{147} = 3.00 \times 10^{-3}$

limiting reactant = $(VO_2)_2SO_4$

moles of $V_2(SO_4)_3 = 1.50 \times 10^{-3}$

mass of $V_2(SO_4)_3 = 1.50 \times 10^{-3} \times 390 = 585$ (mg) [4]

(iii) iodine/I_2/$Cu^{2+}(aq)$ [1]

(c) Indicative content

- H_2 gas 100 kPa
- 1 mol dm^{-3} H^+ with platinum electrode
- 298 K
- salt bridge
- external circuit with (high resistance) voltmeter
- (copper electrode with) 1 mol dm^{-3} Cu^{2+}
- Cu electrode

Band	Response	Mark
A	Candidates must use appropriate specialist terms including a minimum of 6 points of indicative content. They use good spelling, punctuation and grammar and the form and style are of a high standard.	[5]–[6]
B	Candidates must use appropriate specialist terms including a minimum of 4 points of indicative content. They use satisfactory spelling, punctuation and grammar and the form and style are of a satisfactory standard.	[3]–[4]
C	Candidates' brief and partial response includes a minimum of 2 points of indicative content. They use limited spelling, punctuation and grammar and they have made little use of specialist terms. The form and style are of a limited standard.	[1]–[2]
D	Response not worthy of credit	[0]

[6]

(d) (i) electrode 1 as lower $E^{\ominus}$/oxidation occurs [1]

(ii) +1.23 V [1]

(iii) $2H_2 + O_2 \rightarrow 2H_2O$ [1]

(iv) Pt (s) | $H_2(g)$ | $OH^-(aq)$, $H_2O(l)$ || $O_2(g)$ | $H_2O(l)$, $OH^-(aq)$ | Pt (s) [2]

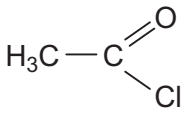
(v) non-polluting/no CO_2/only product is water [1]

23

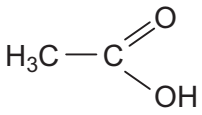
14 **(a)** 2-hydroxybenzoic acid [1]

AVAILABLE MARKS

(b) ethanoyl chloride or ethanoic acid [1]



/CH_3COCl



/CH_3COOH [1]

when comparing with ethanoyl chloride:
reaction of ethanoic anhydride is less vigorous/does not produce HCl/ethanoic anhydride is cheaper/easier to store/less hazardous/less reactive
or
when comparing to ethanoic acid:
reaction with ethanoic anhydride is faster/gives a higher yield/goes further or to completion/ethanoic anhydride is more reactive [1] [3]

(c) CH_3CO^+ [1]

(d) chemical shifts of 0.5 – 2.0 and 10.0 – 12.0 [1]
integration = 3:1 [1]
two singlets [1] [3]

(e) **(i)** $HOC_6H_4COOH \rightleftharpoons {}^-OC_6H_4COO^- + 2H^+$ [1]

(ii) $[Fe(H_2O)_6]^{3+} + {}^-OC_6H_4COO^- \rightarrow [Fe(H_2O)_4(OC_6H_4COO)]^+ + 2H_2O$ [1]

(iii) co-ordination number = 6 [1]
shape = octahedral [1] [2]

(f) **(i)** $MnO_4^- + e^- \rightarrow MnO_4^{2-}$ [1]

(ii) oxidation [1]

(iii) **indicative content**

- draw a base line using a pencil close to bottom of TLC plate
- spot sample onto the TLC plate using a capillary tube
- place TLC plate in a tank containing a shallow amount of solvent/ethyl ethanoate and allow solvent to run up (over the spots) until almost at top of TLC plate
- mark the solvent front and allow to dry
- place in alkaline potassium manganate(VII) solution and heat strongly/develop
- calculate R_f values using $R_f = \frac{\text{distance moved by spot}}{\text{distance moved by solvent}}$
- if spot with R_f of salicylic acid not present/0.315, reaction complete

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D	Response not worthy of credit	[0]

[6]

(g) **(i)** pink to colourless [1]

(ii) hydrolysis [1]
neutralisation [1] [2]

(iii) moles of HCl = moles of NaOH remaining in 25.0 cm^3
$= \frac{14.3 \times 0.140}{1000} = 2.002 \times 10^{-3}$
moles of NaOH in 250 cm^3 = 0.02002
moles of NaOH added initially = $\frac{40.0 \times 1.25}{1000} = 0.05$
moles of NaOH which reacted with aspirin = 0.05 – 0.02002 = 0.02998
moles of aspirin = $\frac{0.02998}{2} = 0.01499$
mass of aspirin = 0.01499 × 180 = 2.70 (g) [5]

(iv) % aspirin = $\frac{2.70}{4.50} \times 100 = 60.0$ (%) [1]

(v) not all hydrolysed [1]

(h) **(i)** 2,5-dihydroxybenzoic acid [1]

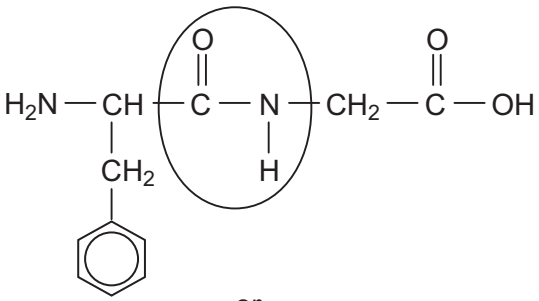
(ii) more OH groups [1]
greater ability to form hydrogen bonds with water [1] [2]

AVAILABLE MARKS

33

15 **(a)** 2-amino-3-phenylpropanoic acid [2]

(b)



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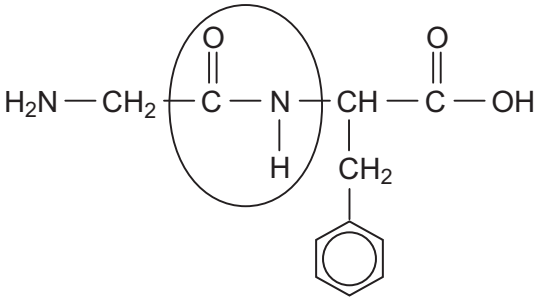

[3]

(c) **(i)** sodium nitrite and hydrochloric acid [1]

(ii)

$C_6H_5CH_2CH(NH_2)COOH + HNO_2 \rightarrow C_6H_5CH_2CH(OH)COOH + N_2 + H_2O$ [2]

(iii) bubbles of gas/effervescence [1]

(d) **(i)** removal of a carboxyl group [1]

(ii) carbon dioxide [1]

(e) **(i)** does not have an atom with 4 different groups bonded/no chiral or asymmetric centre/does not exist as non-superimposable mirror image [1]

(ii) $2C_6H_3(OH)_2CH_2CH_2NH_2 + H_2SO_4 \rightarrow (C_6H_3(OH)_2CH_2CH_2NH_3)_2SO_4$ [2]

(f)

Step	Reagent(s)	Type of reaction
2	phosphorus pentoxide/ phosphorus(V) oxide/ P_4O_{10}	dehydration
3	lithium tetrahydridoaluminate(III) /lithal/$LiAlH_4$	reduction

[4] 18

Section B **100**

Total **110**

AVAILABLE MARKS