

2022 CHEMISTRY PAPER 3 MARKING SCHEME KCSE

QUESTION 1

Procedure I (a)

Table 1

Colours

Yellow / Orange $\frac{1}{2}$

Red / Pink $\frac{1}{2}$

I

Statement form

Colour change from yellow/orange to Red/pink $\frac{1}{2}$ I
i.e.

- From Colour Correctly mentioned in Solution B to the Colour correctly mentioned in C1 of the Table 1 for 1 Mk. Otherwise penalise fully

Procedure II (a)

a) Table 2 ----- 5 Marks.

Award a total of 5 marks distributed as follows:

A. COMPLETE TABLE ----- 1 Mark.

(i) Complete table with 3 titrations done --- 1 Mk.

(ii) Incomplete table with 2 titrations done --- $\frac{1}{2}$ Mk.

(iii) Incomplete table with 1 titration done --- 0 Mk.

Penalties

(i) Wrong arithmetics/subtraction

(ii) Inverted table

(iii) Burette readings beyond 50.0 cm^3 unless explained

(iv) Unrealistic values (titre) i.e. too low (below 1.0 cm^3) or too high (greater than 100 cm^3)

NB:

Penalise $\frac{1}{2}$ mk each of the above mistakes to a maximum of $\frac{1}{2}$ Mk.

i.e., Penalise $\frac{1}{2}$ Mk once.

B. USE OF DECIMALS ----- 1 Mk.

(Tied to the first and second Rows Only).

Conditions:

Answer (i) Accept 1 or 2 decimal places used consistently

- for 1 mk. Otherwise Penalise FULLY, ie award 0 mk
- (ii) If 2 d.p are used, then the 2nd d.p must be a '0' or '5'. Otherwise penalise FULLY, ie, award 0mk.
- (iii) Accept inconsistency in the use of zero as the initial burette reading ie 0, 0.0, 0.00, 00.0, 00.00

C. ACCURACY - - - - - 1 Mk.

Compare the candidates correct titre values with the School value (S.V).

Conditions

- (i) If at least one titre value is within $\pm 0.1 \text{ cm}^3$ of S.V award 1 Mk.
- (ii) If no value (titre) is within $\pm 0.1 \text{ cm}^3$ but at least one is within $\pm 0.2 \text{ cm}^3$ of S.V award $\frac{1}{2}$ Mk.
- (iii) If none of the titre values is within $\pm 0.2 \text{ cm}^3$ of S.V award 0 Mk.

NOTE

- (1) If there is wrong arithmetic subtraction in the table, compare the SV with the worked out correct titre/s and award accordingly.
- (ii) If no S.V is given by the teacher or the School value can not be worked out from the teacher's value (titres) using Principles of Averaging then:
- Write down all the candidates' correct average titres per session and sample those that are close and average them to get the S.V.
 - If the candidate's correct average titres are too varied then use KNEC values of 13.60/13.72/13.73
- iii) Where there are two possible S.Vs from the Teachers' titre values, both should be written on the candidate's script and the one closer to the candidate's value be used for awarding accuracy and Final Accuracy.

eg: 24.9 25.0 25.2

$$S.V \quad \frac{24.9 + 25.0}{2} = 24.95 \text{ cm}^3 \quad \text{OR} \quad \frac{25.0 + 25.2}{2} = 25.1 \text{ cm}^3$$

iv) Tick (✓) the candidates' chosen ~~value~~ titre on the table if it earns a mark before pasting the mark.

D. PRINCIPLES OF AVERAGING ----- 1 Mk.

Conditions

- (i) Values averaged must be shown and be within $\pm 0.2 \text{ cm}^3$ units of each other
- (ii) If three consistent titrations are done and averaged award 1 Mk.
- (iii) If three titrations are done but only two are consistent and averaged 1 Mk.
- (iv) If only two titrations are done, are consistent ~~but~~ and averaged ----- 1 Mk.
- (v) If three titrations are done, are consistent but only two are averaged --- 0 Mk.
- (vi) If ~~only two~~ ^{three} inconsistent titrations are done and averaged award ----- 0 Mk.
- (vii) If only two inconsistent titrations are done and averaged award ----- 0 Mk.
- (viii) If only one titration is done award ----- 0 Mk.

Penalties

- (i) Penalise $\frac{1}{2}$ Mk for wrong arithmetics in the answer if the error is outside ± 2 ^{units} in the 2nd d.p.
- (ii) Penalise $\frac{1}{2}$ Mk if no working is shown but correct answer is given
- (iii) Penalise fully i.e. award 0 Mk if no working is shown and the answer given is wrong.
- (iv) For wrong working with correct answer award 0 mark. Eg:

$$25 + 25 + 25 = 75 / 3 = 25$$

$$\frac{25 + 25 + 25}{3} = 25 \quad (\text{The dotted dots should not be assumed to be division})$$

NOTE: (i) Accept answer if it work out exactly to a whole No., or 1 dp and award FULLY

(ii) The working of average value must be marked before the mark for principle of averaging is pasted to the table 2.

(iii) Accept rounding off / truncation of answer to 2 d.p. eg: 24.666 as 24.66 or 24.67 otherwise penalise $\frac{1}{2}$ Mk

if answer is rounded off / truncated to 1 dp or whole number
 (iv) Units may or may not be given, but when given MUST be correct, otherwise penalise $\frac{1}{2}$ Mk for wrong units attached.

E: FINAL ACCURACY ----- 1 Mk.

(Tied to the correct average Titre)

Compare the Candidates average titre with the S.V and award as follows:

Conditions

(i) if within $\pm 0.10 \text{ cm}^3$ of S.V award 1 Mk.

(ii) if not within $\pm 0.10 \text{ cm}^3$ of S.V but within $\pm 0.2 \text{ cm}^3$ of S.V $\frac{1}{2}$ Mk.

(iii) if beyond $\pm 0.20 \text{ cm}^3$ of S.V award 0 Mk.

NOTE: (i) Where there are two possible average titres use the one which is closer to the S.V and award accordingly.

(ii) If wrong titre values are averaged by the candidate pick the correct titre values if any following the principles of Averaging, average and award accordingly.

EG: 23.8 24.0 24.0

Candidates' Working: $\frac{24.0 + 24.0}{2} = 24.0 \text{ cm}^3$

Examiner's Working: $\frac{23.8 + 24.0 + 24.0}{3} = 23.93 \text{ cm}^3$

Table 2	
1	1
1	1
1	1
5	5

CALCULATIONS

ii Moles of Compound B used:

$$\frac{0.05 \times 25}{1000} \times \frac{1}{2} \quad \text{OR} \quad \frac{0.05}{40} \times \frac{1}{2} \quad \text{OR} \quad 0.05 \times 0.025$$

$$= 0.00125 \times \frac{1}{2}$$

Conditions:

0.05 Must be transferred intact otherwise penalise FULLY

for any strange figure used other than 0.05

$$\begin{aligned} \text{iii) Moles of HCl in } C_2 &= 2 \times 0.00125 \sqrt{2} \\ &= 2 \times \text{Ans (ii) above } \sqrt{2} \\ &= \text{Correct Ans } \sqrt{2} \end{aligned} \quad \left\| \begin{aligned} &= 2 \times 0.00125 \sqrt{2} \\ &= 0.0025 \sqrt{2} \end{aligned} \right.$$

iv) Concentration of HCl in C_2 in moles per litre

$$= \frac{\text{Ans (iii) above} \times 1000}{\text{Average titre / ans (i)}} \sqrt{2}$$

= Correct answer $\sqrt{2}$ OR

Concentration of HCl in C_2

$$= \frac{0.05 \times 25 \times 2}{\text{Average titre / ans (i)}} \sqrt{2}$$

= Correct answer $\sqrt{2}$

v) Concentration of HCl in C_1

Moles of HCl in 250 cm³ of C_1

$$\frac{\text{Ans (iv)} \times 250}{1000} \quad \text{or} \quad \frac{250 \times \text{Ans (iii)}}{\text{Average titre}} = Y \text{ (intermediate answer)}$$

Same as ^{moles} 250 cm³ of C_1 (Y)

$$\text{Concentration in } C_1 = \frac{Y \times 1000}{250000}$$

= Correct answer $\sqrt{2}$

OR

$$\text{Concentration of } C_1 = \frac{250 \times \text{ans (ii)} \times 1000}{\text{average titre} \times 25} \sqrt{2}$$

= Correct answer $\sqrt{2}$

OR

$$\text{Concentration of } C_1 = M_{C_1} V_1 = M_{C_2} V_2 \quad M_{C_1} V_{C_1} = M_{C_2} V_{C_2}$$

$$= M_{C_2}$$

$$M_{C_1} = \frac{M_{C_2} V_{C_2}}{V_{C_1}}$$

$$\frac{\text{Ans (v)} \times 250}{25} \sqrt{\frac{1}{2}} \text{ or } \text{Ans (iv)} \times 10$$

= Correct ans $\sqrt{\frac{1}{2}}$

General Notes

- (i) Answer (ii) and answer (iii) MUST be at least 4 d.p unless it work out exactly to less than 4 d.p. Otherwise Penalise $\frac{1}{2}$ Mk for rounding off or truncating to less than 4 d.p
- (ii) For answer (ii) and (iii) penalise $\frac{1}{2}$ Mk On the answer if the error is outside ± 2 units in the 4th d.p
- (iii) Transferred answers in ~~(ii)~~ (iii) to (v) must be intact. Otherwise penalise $\frac{1}{2}$ Mk for wrong transfer but penalise FULLY for strange figure used.
- (iv) Answers (iv) and (v) MUST be at least 3 d.p unless they work out exactly to less than 3 d.p. Otherwise Penalise $\frac{1}{2}$ Mk for rounding off / truncating to less than 3 d.p.
- (v) Penalise $\frac{1}{2}$ Mk for arithmetic error in answer (iv) and (v) if error is outside ± 2 units in the 3rd d.p.
- (vi) For answer (ii) to (v), units may or may not be given but if given MUST be correct otherwise penalise $\frac{1}{2}$ Mk for wrong units attached.
 M, moles / litre, moles/dm³, moles/1000cm³, mol/litre
 mol l⁻¹
- (vii) Ans (v) MUST be within the range of 1.3 to 2.3. Otherwise penalise $\frac{1}{2}$ Mk on the answer.

Procedure 1(b)

Table 3 ----- 2 Mks

Award a total of 2 Marks distributed as follows.

A \otimes COMPLETE TABLE ----- 1 Mk.

Penalties

- (i) Where initial temperature reading is lower than the final temperature reading
- (ii) Unrealistic temperature reading (below 9.0°C and above 40°C)
- (iii) Wrong arithmetics / subtraction / Missing ΔT
- (iv) Giving more than 1 set of temperature readings or entries

NOTE:

(i) Penalise $\frac{1}{2}$ Mk for each of the above mistakes to a maximum of $\frac{1}{2}$ Mk
ie penalise $\frac{1}{2}$ Mk ONCE

~~(ii) In 1 b (i) correct units must be shown~~

(ii) Award 0 mk for complete table if final temperature reading is equal to the initial temperature reading or where final or initial temperature is missing

(iii) Ignore the sign of ΔT

B. USE OF DECIMALS ----- $\frac{1}{2}$ MK
Tied to 1st and 2nd Rows Only

Conditions

- (i) All temperature readings MUST be recorded consistently as whole numbers or 1 d.p or 2 d.p. Otherwise.
Penalise FULLY.

- (ii) If readings are recorded to 1 dp, then the decimal should be $\cdot 0$ or $\cdot 5$ otherwise penalise FULLY.
- (iii) If readings are recorded to 2 d.p.s, then should be $\cdot 00, \cdot 25, \cdot 50, \cdot 75$ otherwise penalise FULLY.
- (iv) To award for decimal the initial and Final temperature readings MUST be shown

C. ACCURACY. - - - - - $\frac{1}{2}$ Mk

Compare the Candidate's initial temperature reading to the S.V (Teacher's initial temperature reading) and award $\frac{1}{2}$ Mk if within ± 2 units of school value. Otherwise award 0mk for accuracy.

NOTE: (i) If Candidate's Value earns a mark tick (\checkmark) the reading in the table.

(ii) If no school value is given by the teacher or where the value is unrealistic, record all values. Sample close ones and average the Candidate's initial temperature readings per session

(iii) If Candidates values are too varied then use the KYEC value of 23.5 as the S.V

(iv) S.V Must be written on top of each Candidates' table 3.

(v) Where there are more than one set of temperature readings for accuracy, Marking Point, use the set whose ΔT is used in calculation 1 b(i). However where ΔT is not used in 1 b(i) then ALL sets MUST meet the criteria for accuracy

Table 3	1
	$\frac{1}{2}$
	$\frac{1}{2}$
	$\frac{1}{2}$
	<u>2</u>

CALCULATIONS

$$1b(i) \text{ Heat change} = 30 \times 4.2 \times \Delta T \quad \checkmark_2$$

= Correct answer J \checkmark_2

OR

$$= \frac{30}{1000} \times 4.2 \times \Delta T \quad \checkmark_2$$

= Correct ans kJ \checkmark_2

$$1b(ii) \text{ Moles} = \frac{2.5}{84} \quad \checkmark_2$$

$$= 0.02976 \quad \checkmark_2$$

$$1b(iii) \Delta H_f = \frac{\text{Ans } 1b(i) \text{ J} \times 1000}{\text{Ans } 1b(ii)} \quad \checkmark_2$$

= Correct ans \checkmark_2

OR

$$\text{Ans} = \frac{\text{Ans } 1b(i) \text{ kJ}}{\text{Ans } 1b(ii)} \quad \checkmark_2$$

= Correct ans \checkmark_2

General Notes

(i) In 1b(i) to 1b(iii) if the expressions are not shown but the answer given is correct award $\frac{1}{2}$ mk for the answer.

(ii) In 1b(i) correct units MUST be shown otherwise penalise $\frac{1}{2}$ mk for missing or wrong units attached.

Correct units are: J, j, kJ, joules or kilojoules

(iii) In 1b(i) accept an error of 2 units in the 4th digit if in joules (J) or on 3rd d.p if in kJ. Otherwise penalise $\frac{1}{2}$ mk on the answer

(iv) In 1b(i) ignore the sign in the answer

(v) In 1b(ii) 2.5 MUST be transferred intact, otherwise penalise FULLY for any strange value used.

(vi) In 1b(ii) penalise $\frac{1}{2}$ mk for wrong answer if arithmetic error is outside ± 2 units in the 4th d.p

(vii) In 1b(iii) accept an error of ± 2 units 3rd d.p on the answer. Otherwise penalise $\frac{1}{2}$ mk

- (viii) In 1b(ii) Penalise $\frac{1}{2}$ mk on the answer if a +ve sign is missing
- (ix) 1b(i) and 1b(iii) units may or may not be shown but if written MUST be correct. Otherwise penalise $\frac{1}{2}$ Mk on the answer
- (x) From 1b(i) to 1b(iii) formulae are not a must but penalise $\frac{1}{2}$ mk if wrong formulae shown

R

Reject

$$\text{Moles} = \frac{\text{Mass given}}{\text{RFM}} \quad || \quad \Delta H = MCT$$

Accept

$$\text{Moles} = \frac{\text{Mass}}{\text{Molar Mass / Formula Mass}} \quad || \quad \begin{aligned} \Delta H &= MC\Delta T \\ \Delta H &= MC\Theta \\ \Delta H &= MC\Delta\Theta \\ Q &= MC\Delta T \end{aligned}$$

- (xi) In 1b(i) and 1b(iii) accept correct transfer of values even if rejected earlier. Otherwise penalise $\frac{1}{2}$ Mk for wrong transfer but penalise FULLY for strange value used.

PROCEDURE 11(b)

Table 4 ----- 2 Mk
 Mark as table 3 but ^{for} KNEC value use 24.0°C .

CALCULATIONS

- (x) 1b(i) Mark as 1b(i) but use ΔT of table 4
 1b(ii) Mark as 1b(ii)

General notes:

Apply the general notes of procedure 1b

1b(iii) Heat change $\Delta H_{\text{g}} = \Delta H_2 - \Delta H_1$ ✓

$$\begin{aligned} \text{Heat change} &= \text{Ans 11 b (i)} - 1b(iii) \quad \checkmark \quad] \\ &= \text{correct ans} \quad \checkmark \end{aligned}$$

Conditions | Penalties

- (1) Penalise $\frac{1}{2}$ mk on the answer if +ve sign or/and correct

Units is or are missing

(ii) Accept ^{correct} transfer of answer 1 b(iii) and 11 b(ii) even if rejected earlier but penalise fully for any strange value used.

(iii) If the expression is missing but the answer is correct award $\frac{1}{2}$ mk for the correct answer.

(iv) The ans should be as expected. Otherwise penalise $\frac{1}{2}$ mk on the answer.

(21)

QUESTION 2. ORGANIC

a) ^{Burn in a spatula} Observations
 Solid burn with a yellow / sooty / smoky
 Luminous flame
 Reject golden yellow on its own

Inferences
 >C=C< / $\text{-C}\equiv\text{C-}$ present 2
 NOTE:
 Accept any of the following statements for full credit
 (i) Unsaturated organic compound
 (ii) Organic compound with high C:H ratio
 (iii) Long chain organic compound
 (iv) Aromatic organic compound
 (v) Carbon-carbon double / triple bond present in words
 Ignore
 (i) Alkene / Alkyne present
 (ii) Long chain hydrocarbon

b(i) Add 3 drops of acidified Potassium dichromate (VI) and Warm

Observations
 Orange potassium dichromate VI
 does not change to green ✓
 NOTE
 Accept for full credit

- (i) Orange colour of potassium dichromate (VI) persists / is retained / remains / does not change.
- (ii) Orange colour does not change / persists / retained / remains

Inferences
 ROH absent ✓ 2
 Accept for 1/2 mark
 Alcohol / Alkanol absent in words but reject -OH

b(ii) Add three drops of bromine water

Observations
 Bromine water is not decolourised ✓
 Yellow / orange colour of bromine water is retained
 / persists / does not change
 Colour of bromine water remains the same

Inferences
 >C=C< / $\text{-C}\equiv\text{C-}$ absent 2
 NOTE
 Accept for 1/2 mark
 (i) Unsaturated organic compound absent
 (ii) Carbon-carbon double bond / triple bond

Reject

i) Colour of bromine water as brown/red

ii) colour of the solution remains the same

iii) The colour remains the same

In words as absent

Ignore

i) Alkenes and alkynes absent in words

ii) Presence of a single bond present, i.e. $-C-C-$ absent present

b(iii) Add Na_2CO_3 and test the gas using a burning splint

Observation

Effervescence/bubbles/fizzing
Colourless gas evolved that extinguishes a burning splint

Reject:

i) Hissing/fizzing/sizzling

ii) Colourless gas on its own

Inferences

$RCOOH$ / $R-\overset{\overset{O}{\parallel}}{C}-OH$ / $-COOH$ 2

Present

(Tied to effervescence/bubbles/fizzing)

NOTE
Accept for $\frac{1}{2}$ mk

i) Carboxylic/alkanoic acid present in words

ii) Solution is acidic

iii) H^+ / H_3O^+ present

Reject

i) $-COOH$

ii) Solid M is acidic/an acid

GENERAL NOTES

For tests a, b(i), b(ii) and b(iii) Penalise FULLY for any the inferences if any contradictory functional groups are mentioned.

08

QUESTION 3

3a. Add NaOH dropwise until in excess

Observations

White ppt / solid / suspension $\frac{1}{2}$
 Insoluble in excess. ~~$\frac{1}{2}$~~

Inferences

Ca^{2+} , Mg^{2+} , Ba^{2+} present 2

Award $\frac{1}{2}$ mk each to a maximum of 1 mk.

Accept ions written in words for full credit.

Penalties

Penalise $\frac{1}{2}$ mk for any contradictory ion to a maximum of 1mk.

NOTE

Ignore the mention of Pb^{2+} , Al^{3+} , Zn^{2+} ions absent.

3b. Warm and add $\text{NH}_3(\text{aq})$ dropwise until in excess

Observations

White ppt / solid / suspension $\frac{1}{2}$
 Insoluble in excess

Inferences

Mg^{2+} Present

Accept

Calcium / ~~Ba~~ Ca^{2+} / Ba^{2+} absent 2
 for $\frac{1}{2}$ mk in the absence of Mg^{2+}

NOTE

i) For any ion to earn credit it must have been correctly inferred in 3(a) above

ii) Accept for $\frac{1}{2}$ mk ions mentioned in words

Penalties

Penalise FULLY for any contradictory ion mentioned.

3c. Add 3 drops of $\text{Ba}(\text{NO}_3)_2$ then 1 cm^3 dil $\text{HNO}_3(\text{aq})$

Observations
White PPT / solid / suspension
insoluble on addition of dilute
nitric acid / NO effervesces /
NO bubbles

Reject
White solution / white substance

Inferences

SO_4^{2-} present ✓

Accept for $\frac{1}{2}$ mk

i) SO_3^{2-} and CO_3^{2-} absent

but both must be mentioned.

ii) Accept mention of the ~~two~~ ions in words

Penalties

Penalise FULLY for any contradictory ion/s

2

3d. Place 1 cm^3 of NaOH, Add soln then heat mixture and test the gas

Observations

i) Red litmus paper remains red
or Red litmus paper does not turn
blue

or Red colour of litmus paper
does not change / remains the
same

Accept for 1 mk

i) Red litmus paper remains

ii) No effect on red litmus paper

iii) No change on red litmus
paper

iv) Red litmus paper does not
change to blue

NOTE: But credit FULLY
on the correct inference

Inferences

NH_4^+ $\frac{1}{2}$ absent
Present ✓

1 1/2

3d(ii) Warm the Mixture and add the folded Al_2O_3 , test gas with ^{red} litmus

Observations	Inferences
- Effervescence ^{✓₂} bubbles of a colourless gas	NO_3^- present. ✓
- Red litmus paper ^{✓₂} turns to blue	Tied to red litmus paper turning blue <u>1/2</u>
Pungent smelling gas	Accept
Award $\frac{1}{2}$ mk each to a Maximum of 1 Mk.	Nitrate ion Written in words for $\frac{1}{2}$ Mk

NOTE
~~For 3d(i), 3d(ii) Penalise FULLY for any contradictory ion~~

Identification of the cation and two anions
Cation: Mg^{2+} $\frac{1}{2}$

Anion
 NO_3^- $\frac{1}{2}$, SO_4^{2-} $\frac{1}{2}$

1/2
~~1/2~~
I

Conditions

- (i) ~~For the cations and anions to be awarded they must have~~
- (i) Accept ions given in words for full credit.
 - (ii) For the cations and the anions to be awarded, they must have been correctly inferred in 3b, 3c and 3d(i)
 - (iii) For 3d(i) and 3d(ii) penalise FULLY for any contradictory ion.

11