

EXTERNAL SUMMATIVE ASSESSMENT TEST SPECIFICATION «CHEMISTRY»

Grade 12

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1 Purpose

The purpose of assessment is to identify learners' knowledge and abilities acquired in the process of learning as well as their abilities to apply high order thinking skills.

1.1 Relationship with International Standards

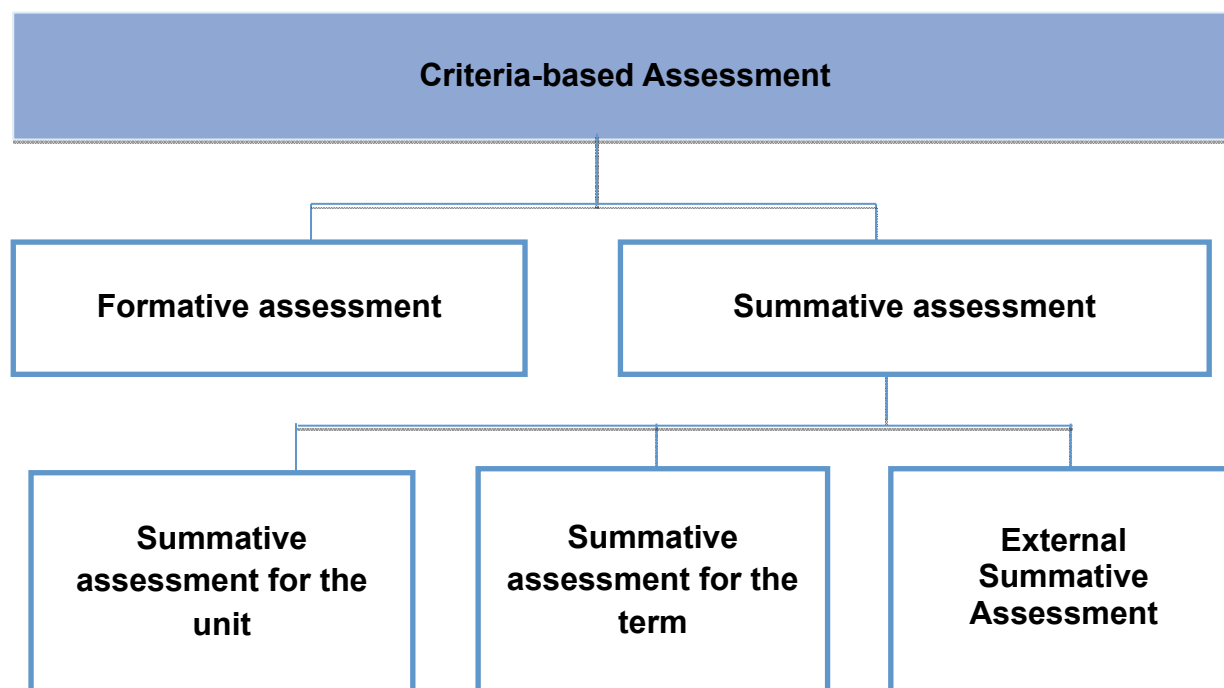
The Grade 12 Chemistry External Summative Assessment is designed to be comparable to the Cambridge International A-Level standard.

1.2 Relationship with Subject Programme

The Grade 12 External Summative Assessment will assess the content of AEO «Nazarbayev Intellectual Schools» Educational Programme – NIS-Programme for Grade 11 and Grade 12. The level of knowledge and abilities, as well as skills, will be defined by the expected outcomes within the Chemistry Subject Programme.

1.3 Relationship with Criteria-based Assessment System

The External Summative Assessment forms one part of the *Criteria-based Assessment System* which also consists of Formative Assessment and Summative Assessment for the unit and the term.



2 External Summative Assessment Overview

Paper 1	60 minutes
All questions are compulsory. Learners answer 40 multiple-choice questions. Each question has four options, from which learners will choose correct one. The questions assess the learners' knowledge, understanding, and their ability of applying and evaluating information. Calculators are allowed.	

40 marks are 23% of total amount of marks	
Paper 2	120 minutes
All questions are compulsory. Learners answer between 8 and 12 questions, which may be broken into subparts. The questions assess the learners' knowledge and their ability of handling, applying and evaluating information. Calculators are allowed.	
100 marks are 59% of total amount of marks	
Paper 3	90 minutes
All questions are compulsory. This paper consists of two or three theoretical experiments. The experiments assess the learners' knowledge, their practical skills of planning, analysis and evaluation. Calculators are allowed.	
30 Marks are 18% of total amount of marks	

2.1 Assessment Objectives

AO1	Knowledge with Understanding Learners should be able to demonstrate knowledge and understanding in relation to: - scientific phenomena, facts, laws, definitions, concepts and theories; - scientific vocabulary, terminology and conventions (including symbols, quantities and units); - operating principle of scientific instruments and apparatus, including techniques of operation and aspects of safety; - scientific quantities and their determination; - scientific and technological applications with their social, economic and environmental implications; - presenting reasoned explanations for phenomena, patterns and relationships.
AO2	Handling, Applying and Evaluating Information Learners should be able to: - locate, select, organise and present information from a variety of sources; - translate information from one form to another; - manipulate numerical and other data; - analyse and evaluate information to identify patterns, report trends and draw conclusions; - make predictions and put forward hypotheses; - find arguments in support of hypotheses or to assess the course of action; - apply knowledge, including principles, to new situations; - evaluate information and hypotheses;
AO3	Planning, Analysis and Evaluation Learners should be able to: - Identify a problem; design and plan investigations; - Identify independent, dependent and controlled variables; - Analyse and process data. - Interpret and evaluate observations and experimental data;

- | | |
|--|--|
| | <ul style="list-style-type: none">• Make conclusions based on evidence obtained from an investigation. |
|--|--|

2.2 Use of calculators

Scientific calculators are allowed in all papers.

Calculators must be:

- of a size suitable for use on the desk;
- either battery or solar powered;
- free of lids, cases and covers which have printed instructions or formulas.

Calculators must not contain any of these facilities:

- symbolic algebra manipulation;
- symbolic differentiation or integration;
- communication with other machines or the internet.

Calculators may not contain any retrievable information including:

- databanks;
- dictionaries;
- mathematical formulas;
- text.

2.3 Formulae and Data

A Data Booklet is provided for use by learners in the exams. It contains a periodic table, important constants and other relevant information. Qualitative analysis data is provided for Paper 3.

3. Description of papers

All learners complete all 3 papers. Papers 1 and 2 require demonstrating knowledge and understanding of Chemistry, ability of handling, applying and evaluating information (in accordance with AO1 and AO2). Paper 3 assesses learners' planning, analysis and evaluation skills (in accordance with AO2 and AO3).

3.1 Paper 1

60 minutes

Calculators and Data Booklets are allowed.
Paper 1 consists of 40 multiple choice questions.
All questions are compulsory.
Total 40 marks.

3.2 Paper 2

120 minutes

Calculators and Data Booklets are allowed to use.
Paper 2 consists of 8-12 structured questions, which require short or extended answers.
Learners may use ruler, pencil and eraser.
All questions are compulsory.
Total 100 marks.

3.3 Paper 3

90 minutes

Calculators and Qualitative analysis data are allowed to use.
Paper 3 consists of structured questions related to two or three theoretical experiments.
Learners may use ruler, pencil and eraser.

All questions are compulsory.
Total 30 marks.

3.4 Balance of marks

The balance of marks for the assessment objectives is shown in the table below:

Assessment Objectives	Paper 1	Paper 2	Paper 3	TOTAL
AO1	16	40	0	56
AO2	24	60	6	90
AO3	0	0	24	24
Total	40	100	30	170

3.5 Language of assessment

The language of assessment is English.

4. Administration

All assessments must be conducted in compliance with all security measures in accordance with Instruction on arranging and conducting External Summative Assessment of academic achievements of Nazarbayev Intellectual Schools' learners. Instruction contains the following main points:

- examination materials and their safety;
- duties of teachers, invigilators and examination administrators;
- preparation of classrooms and materials for the examination.

5. The Marking process

Marking is carried out by the Attestation Committee, which includes the Principal Examiner, Team Leaders and Examiners. To mark each examination work, groups of Examiners are formed, led by Team Leaders.

During the marking, all Examiners use the same version of the Mark Scheme. The Principal Examiner and the Team Leaders check selectively papers marked by Examiners to ensure the correct application of the Mark Scheme and the objectivity of the evaluation.

6. The Grading Process

The results of the assessment will be reported in the form of a grades A*, A, B, C, D and E, where A* is the highest grade and E is the lowest passing grade.

Grade U ('ungraded') will not represent a pass in a syllabus.

A student's academic achievement in the subject is calculated directly from the total of their marks across all examination papers, rather than from the grades of individual papers.

The test specification contains A, C, and E Grades descriptors. The Attestation Committee sets the thresholds for these grades based on professional judgment and the results of learners. The thresholds of the grades A *, B and D are established by arithmetic means.

Grades A *, A, B, C, D and E are transferred into the final grades.

6.1 Grade Descriptions

Key Grade Descriptions are provided to give a general indication of the standards of achievement likely to have been shown by learners awarded particular grades. The grade awarded depends in practice upon the extent to which the learner has met the assessment objectives overall.

Grade	Grade Description
Grade A	Demonstrates a wide and detailed knowledge of the subject with very few omissions, and has a clear understanding of the principles on which the subject is based and the manner in which it functions. The principles can be applied in both familiar and unfamiliar situations. Has a good ability to evaluate hypotheses. Answers given are well-expressed, direct and relevant and complex calculations are accurate and correctly set out. Writes accurate equations for most chemical reactions. Solves problems in situations involving a wide range of variables. Is able to generate a hypothesis to explain theories and phenomena, whilst making predictions and putting forward new hypotheses after evaluating available information effectively. Can competently design and plan investigations using suitable methods. Once completed, interprets and evaluates observations and experimental data, presenting evidence in a range of appropriate ways, can evaluate and suggest improvements to ensure precision and accuracy. From this will draw a precise set of conclusions, including next steps where necessary.
Grade C	Demonstrates a sound knowledge in many areas of the subject with some omissions, and has an understanding of many of the principles on which the subject is based and the manner in which it functions. The principles can be applied most effectively in familiar and occasionally unfamiliar situations. Has a reasonable ability to evaluate information and hypotheses. Answers given are often well-expressed, relevant and calculations frequently produce the correct answer. Writes equations for a reasonable number of chemical reactions. Solves problems involving more than one step but with a limited range of

	variables. Is able to generate a simple hypothesis to test a theory and make a prediction. Can generate a simple hypothesis to explain a given set of facts and data. Is able to plan a scientific task, such as a practical procedure, to test an idea, answer a question, or solve a problem and will present evidence in an appropriate way. From this can draw conclusions consistent with the evidence collected.
Grade E	Demonstrates a basic knowledge of the simple areas of the subject with some important omissions, and has a limited understanding of the principles on which the subject is based and the manner in which it functions. The principles are generally only applied effectively in familiar situations. Has some ability to evaluate information and hypotheses. Answers given often include relevant points but can be confused with irrelevant additions. Simple calculations are sometimes accurate but more complicated calculations have a tendency to generate error and can become unclear. Writes equations for some straightforward chemical reactions. Can solve a problem involving one step where only a minor manipulation of data is needed. Will recognise a hypothesis that explains a set of facts or data. Can plan a scientific task, such as a practical procedure, to test a basic idea, answer a simple question, or solve a straightforward problem. Can draw simple conclusions consistent with the evidence collected and present evidence as charts, tables or graphs.

7 Sample questions

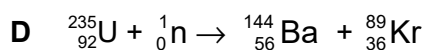
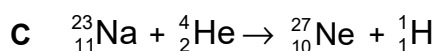
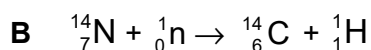
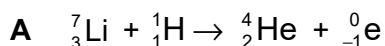
At the end of each question in square brackets [1] the mark available is indicated.

As a guidance, mark schemes are provided, which clearly indicate the number of marks awarded for each question.

7.1 Paper 1

- 1 In a nuclear reaction the number of each type of subatomic particle in the reactants is the same as in the products.

Which equation correctly shows a nuclear reaction?



A ☐ B ☐ C ☐ D ☐

[1]

- 2 What is the number of molecules in 15.4 g of oxygen?

A 9.28×10^{24}

B 1.16×10^{24}

C 2.90×10^{23}

D 5.80×10^{23}

A ☐ B ☐ C ☐ D ☐

[1]

Question	Answer	Mark	Additional Guidance
1	B	[1]	
2	C	[1]	

7.2 Paper 2

- 1 This question is about the use of balanced equations.

(a) (i) Copper reacts with concentrated sulfuric acid.

Copper(II) sulfate, sulfur dioxide and water are the products of the reaction.

Construct the balanced equation for this reaction.

..... [2]

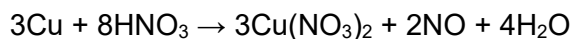
- (ii) The mole is used in chemical calculations.

Define the term *mole*.

.....
..... [1]

- (iii) A sample of 192 g of copper reacts with dilute nitric acid.

The equation for the reaction is shown.



Calculate the amount in moles of copper(II) ions / nitrate ions in the copper(II) nitrate formed in this reaction.

Show your working.

amount of copper(II) ion mol
amount of nitrate ion mol [3]

- (b) The equation for a redox reaction is shown.



Write the ionic equation for this redox reaction indicating state symbols.

..... [2]

- (c) The enthalpy change of solution of potassium manganate(VII) depends on the lattice energy and the enthalpy change of hydration.

- (i) Define the term *enthalpy change of hydration*.

.....
..... [1]

- (ii) Write equations for the enthalpy change of hydration for a potassium ion, K^+ , and a manganate(VII) ion, MnO_4^- .

Include state symbols in your equations.

enthalpy change of hydration for K^+

enthalpy change of hydration for MnO_4^- [2]

(iii) Draw the energy diagram for the enthalpy change of solution for potassium manganate(VII).

In your diagram, use lattice enthalpy of KMnO_4 , enthalpy of hydration of KMnO_4 and enthalpy of solution of KMnO_4 .

[3]

[Total: 14]

2 Elemental sulfur is found widespread in nature.

(a) State one source of sulfur in nature.

..... [1]

(b) Sulfur has several allotropes.

(i) Define the term *allotropes*.

.....
..... [1]

Two allotropes of sulfur are monoclinic sulfur and rhombic sulfur.

(ii) Identify one similarity and one difference between these two allotropes.

similarity
..... [1]

difference
..... [1]

(c) In Kazakhstan sulfuric acid is produced from the waste gases from the extraction of non-ferrous metals.

(i) The flow chart shows the steps involved in the formation of sulfuric acid.



Write equations for each of the steps. Include state symbols.

(ii)

step 1
step 2
step 3 [3]

Step 1 is an exothermic equilibrium reaction.

The compromise conditions for step 1 are 400 to 450 °C, 1 atmosphere pressure and a 1:1 mole ratio of SO₂ to O₂.

Explain how these three parameters affect the position of the equilibrium and the rate of reaction.

temperature

.....

pressure

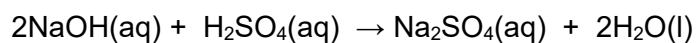
.....

mole ratio

.....

[3]

(d) Sodium hydroxide reacts with sulfuric acid as shown in the equation.



A sample of 300 cm³ of 1.00 mol dm⁻³ NaOH(aq) is added to 100 cm³ of 1.00 mol dm⁻³ H₂SO₄(aq).

Calculate the pH of the solution formed after the addition. Give your answer to **one** decimal place.

Show your working.

[5]

[Total: 15]

Question	Answer	Mark	Additional guidance
1 (a) (i)	$\text{Cu} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{SO}_2 + 2\text{H}_2\text{O}$	1 1 [2]	Correct formulae Balancing – dependent on correct formulae
1 (a) (ii)	Amount of substance that contains Avogadro's number of specified particles	1 [1]	Accept The relative atomic mass/relative formula mass in grams of any element/compound $6,02 \times 10^{23}$ molecules/ions/atoms
1 (a) (iii)	192 / 63.5 = 3.0 moles Cu 1:1 (from the equation of reaction) 3 moles Cu^{2+} and 6 moles NO_3^-	1 1 1 [3]	Accept ecf for third marking point from moles of copper e.g. if moles of Cu=2 then answer should be 2 moles Cu^{2+} and 4 moles NO_3^-
1 (b)	$\text{MnO}_4^{2-} + \text{H}_2\text{O} \rightarrow \text{MnO}_2 + \text{MnO}_4^- + \text{OH}^-$ $3\text{MnO}_4^{2-} + 2\text{H}_2\text{O} \rightarrow \text{MnO}_2 + 2\text{MnO}_4^- + 4\text{OH}^-$	1 1 [2]	Note one mark for the correct ionic species in the equation even if K^+ is shown one mark for the balanced ionic equation
1 (c) (i)	(heat changes when) 1 mole of <u>gaseous ions</u> is dissolved to form dilute solution/ in lots of water.	1 [1]	
1 (c) (ii)	$\text{K}^+(\text{g}) \rightarrow \text{K}^+(\text{aq})$ $\text{MnO}_4^-(\text{g}) \rightarrow \text{MnO}_4^-(\text{aq})$	1 1 [2]	Accept $\text{K}^+(\text{g}) + \text{aq} \rightarrow \text{K}^+(\text{aq})$ $\text{MnO}_4^-(\text{g}) + \text{aq} \rightarrow \text{MnO}_4^-(\text{aq})$

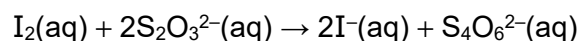
1 (c) (iii)	<pre> graph TD GI[gaseous ions] -- "lattice enthalpy ΔH_{latt}" --> IS[ionic solid] GI -- "ΔH_{hydration}" --> IAS[ions in aqueous solution] IS -- "ΔH_{solution}" --> IAS </pre>	3 [3]	Note 1 mark for lattice enthalpy change and correct direction arrow 1 mark for change of enthalpy of hydration correct direction arrow 1 mark for change of enthalpy of solution correct direction arrow
2 (a)	Sulfur found in nature as brimstone/ /coal/crude oil/volcanoes	1 [1]	Ignore Minerals and salts
2 (b) (i)	Being the same element, it has different forms in the same state	1 [1]	Accept Different crystal or molecular lattices of the same element
2 (b) (ii)	<i>Similarity:</i> they are both S ₈ / both have eight sulfur atoms in the molecule/ they're both yellow in colour, have single bonds and are in a ring. <i>Difference:</i> Monoclinic Sulphur is unstable at temperatures below 96°C/ β-sulfur, non-stable, the puckered ring/ prismatical	1 1 [2]	Accept Must have a comment about both rhombic and monoclinic sulfur
2 (c) (i)	1. 2SO ₂ (g) + O ₂ (g) ⇌ 2SO ₃ (g) 2. SO ₃ (g) + H ₂ SO ₄ (l) → H ₂ S ₂ O ₇ (l) 3. H ₂ S ₂ O ₇ (l) + H ₂ O(l) → 2H ₂ SO ₄ (l) / H ₂ S ₂ O ₇ (l) + H ₂ O(l) → 2H ₂ SO ₄ (aq)	1 1 1 [3]	Do not accept unbalanced equations Accept Reaction arrow in step 1 2 marks for 3 correct reactions without state symbols Correct multiples including fractions e.g. SO ₂ (g) + 1/2O ₂ (g) ⇌ SO ₃ (g)
2 (c)(ii)	to increase the rate of reaction without shifting an equilibrium too far to the left pressure high enough to have the position of the equilibrium on the right/product to shift the position of an equilibrium to the right	1 1 1 [3]	Accept owtte owtte Accept the equilibrium will shift towards the left/reactants owtte

2 (d)	0.10 moles (H ₂ SO ₄)	1	Accept ecf for third marking point e.g. moles NaOH-2x moles H ₂ SO ₄ ecf for fourth marking point e.g. moles after addition/0.4 ecf for fifth marking point answer 13.0-13.5
	0.30 moles (NaOH)	1	
	(after the addition) 0.1 mole NaOH	1	
	(0.1/0.4) / 0.25 mol dm ⁻³ NaOH	1	
	pH = 13.4	[5]	

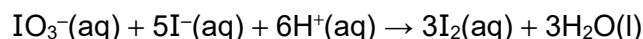
7.3 Paper 3

1. A student wants to find the value of **x** in hydrated sodium thiosulfate, Na₂S₂O₃ • **x**H₂O, by titration with an aqueous solution of iodine, I₂.

The ionic equation for the reaction between thiosulfate ions and iodine is shown.



The iodine will be formed by the reaction between aqueous potassium iodate(V), KIO₃, and aqueous potassium iodide, KI.



(a) The student:

- measures the mass of an empty container
- puts some solid hydrated sodium thiosulfate into the container
- measures the mass of the container and hydrated sodium thiosulfate

Look at the table of results.

mass (Na ₂ S ₂ O ₃ • x H ₂ O and container)/g	mass of empty container/g	mass of Na ₂ S ₂ O ₃ • x H ₂ O/r
107,6	100,0	

(i) Complete the table by calculating the mass of hydrated sodium thiosulfate.

[1]

(ii) Write the names of the equipment the student used to determine the mass of sodium thiosulfate

..... [1]

- (iii) The student prepared 250 cm³ of a solution from a sample of hydrated sodium thiosulfate.

Make a plan for the preparation of sodium thiosulfate solution.

.....

 [3]

- (b) The burette was filled with sodium thiosulfate solution. The initial reading of the solution in the burette is recorded.

Using a pipette, 25.0 cm³ of KIO₃ (aq) 0.0200 mol dm⁻³ was transferred into a conical flask.

Using a graduated cylinder, 20 cm³ of sulfuric acid, 1.00 mol dm⁻³, and then 10 cm³ of KI (aq) were added to a conical flask.

A brown iodine solution was formed.

The iodine formed was titrated with sodium thiosulfate solution.

When the solution in the conical flask was light yellow, three drops of starch solution were added.

- (i) Indicate why the starch solution was added.

..... [1]

The titration results are given in the table

titration number	1	2	3	4
initial (burette) reading / cm ³	0.00	0.00	24.00	0.00
final (burette) reading / cm ³	24.75	24.00	48.40	24.20
titre / cm ³	- difference is too large	24.00	24.40	24.20

- (ii) Calculate the mean titre of sodium thiosulfate solution added.

mean titre = cm³ [1]

(iii) Calculate the percentage error of the second titration result.

[1]

(c) (i) Calculate the amount, in moles, of I_2 formed from the 25.0 cm^3 of $0.0200\text{ mol dm}^{-3}$ KIO_3 .

.....mol [1]

(iii) Hence calculate the amount, in moles, of $S_2O_3^{2-}$ that reacted with the iodine formed in (c)(i).

.....mol [1]

(iii) Use the mean titre of hydrated sodium thiosulfate to calculate the amount, in moles, of $S_2O_3^{2-}$ in the 250 cm^3 graduated flask.

.....mol [1]

(iv) Calculate the relative formula mass for $Na_2S_2O_3 \cdot xH_2O$.

relative formula mass = [1]

(v) Hence calculate the value of x in the formula $\text{Na}_2\text{S}_2\text{O}_3 \cdot x\text{H}_2\text{O}$.

$x =$ [1]

(d) Propose one possible problem that may arise with the student's titration practice and suggest ways to improve it.

problem

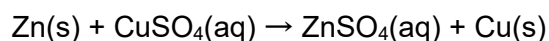
..... [1]

way to improve it:

..... [1]

[Total: 15]

- 2 The student performed an experiment to determine enthalpy change of the reaction between zinc powder and an aqueous solution of copper(II) sulfate.



The results of the experiment are given in the table:

time / s	temperature / °C	time / s	temperature / °C
0	23.0	330	45.0
30	23.0	360	44.0
60	23.0	390	43.5
90	23.0	420	42.0
120	23.0	450	40.0
150	23.0	480	39.5
180		510	39.0
210	47.0	540	38.5
240	47.0	570	37.0
270	46.0	600	36.0
300	46.0		

(a) List of equipment and materials:

- 1 × 40 cm³ of 1.0 mol dm⁻³ copper(II) sulfate, CuSO₄(aq) labelled **copper (II) sulfate, CuSO₄(aq)**
- 1 × 1 g of zinc powder.
- 1 × **X**
- 1 × 250 cm³ glass beaker
- 1 × 25 cm³ measuring cylinder
- 1 × plastic cup that fits into the glass beaker
- 1 × **Y**
- 1 × funnel
- 1 × teat pipette

(i) Identify equipment **X** and equipment **Y**.

X

Y [1]

- (ii) You are to plan an experiment to determine the enthalpy of the reaction between zinc powder and aqueous copper (II) sulfate.

You are provided with the following:

- 1 g of zinc powder
- 25 cm³ aqueous solution of copper(II) sulfate, CuSO₄ (aq)
- the reagents and laboratory equipment listed in (i)

Your method should include a change in temperature per unit time. The zinc powder must be added to the aqueous copper(II) sulfate after exactly 180 seconds.

.....

.....

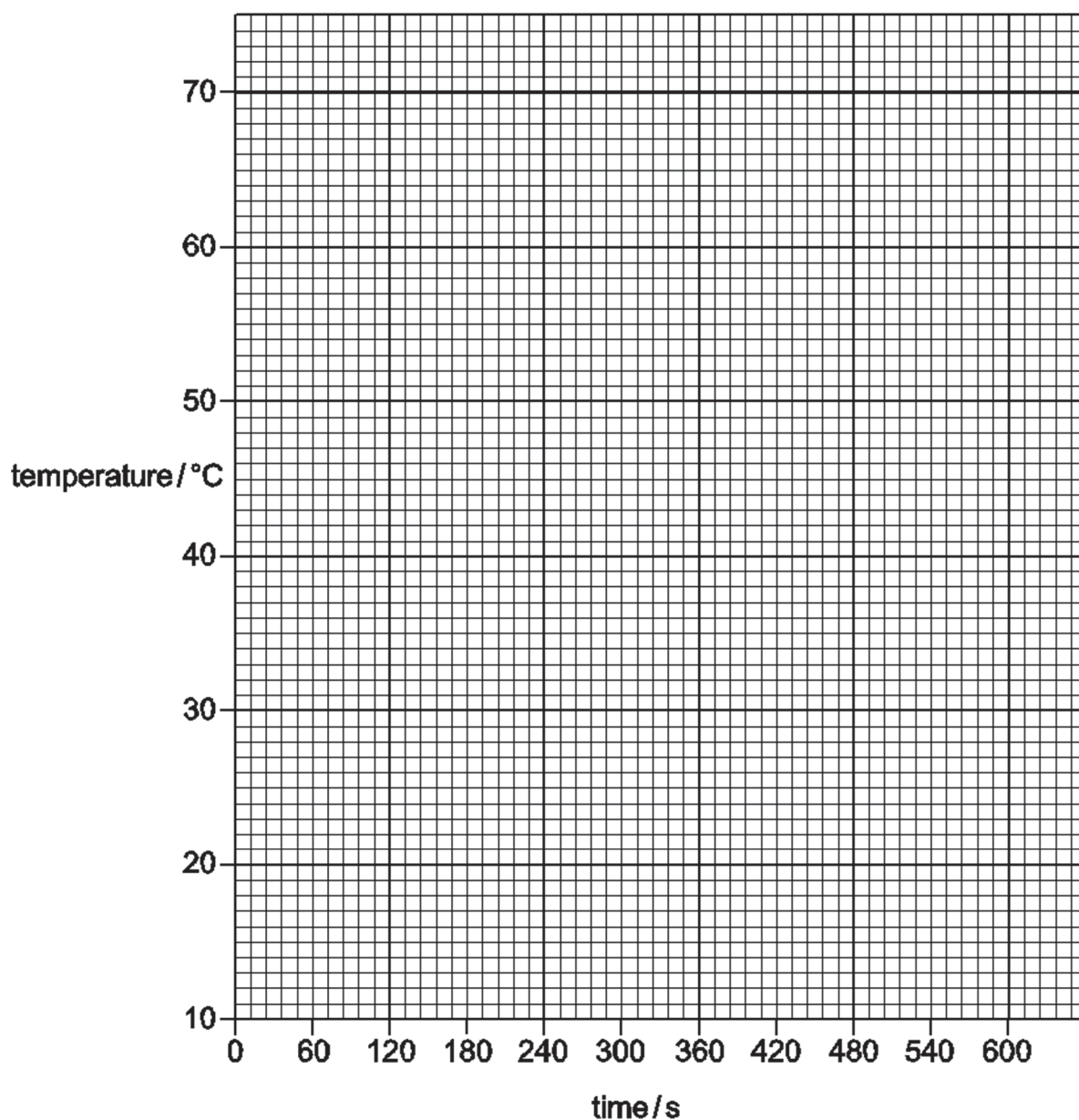
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.....

.....

..... [3]

(b) (i) Plot the temperature of the mixture in the plastic cup against the time.



[3]

(ii) Draw a line of best fit for the **first 6** points.

Extrapolate this line to estimate the temperature at 180 s.

temperature = °C [1]

(iii) Draw a curve of best fit for the **last 14** points.

Use your curve to estimate the maximum temperature of this mixture.

maximum temperature = °C [2]

(c) The temperature change of a reaction can be used to calculate the enthalpy change of the reaction.

(i) Use your answers to (b)(ii) and (b)(iii) to calculate the temperature change for the reaction.

..... °C [1]

(ii) The specific heat capacity of the reaction mixture is 4.18 J/g °C.

The mass of the reaction mixture is 26 g.

Calculate the heat released during the reaction.

heat released = J [1]

(iii) During the experiment 0.025 moles of copper (II) sulfate reacted.

Calculate the enthalpy change of the reaction, in kJ mol⁻¹.

.....
.....
..... [2]

(d) Suggest **one** way to improve the experiment and explain how this reduces experimental error.

improvement

explanation

.....
[1]

[Total: 15]

Question	Answer	Mark	AO	Additional Guidance
1(a)(i)	7,6 g	1 [1]	AO2	
1(a)(ii)	balance, spatula	1 [1]	AO2	
1(a)(iii)	Add about 100 cm³ of distilled water to the beaker. Stir the mixture with a stirring rod until all of the sodium thiosulfate has dissolved. Transfer this solution into the 250 cm³ graduated flask. Wash the beaker with small amounts of distilled water and pour this water into the graduated flask. Fill the volumetric flask to the mark with distilled water and close the stopper and shake well.	1 1 1 [3]	AO3	
1(b)(i)	To determine the end point of the titration	1 [1]	AO3	
1(b)(ii)	$(24.00 + 24.40 + 24.20) / 3$ $= 24.20$	1 [1]	AO2	
1(b)(iii)	$[(0.05 \times 2) / 24.00] \times 100\% = 0.41\%$	1 [1]	AO2	efc
1(c)(i)	moles of I ₂ = 0.0015	1 [1]	AO2	efc
1(c)(ii)	moles of S ₂ O ₃ ²⁻ = 0.003	1 [1]	AO2	efc
1(c)(iii)	moles of S ₂ O ₃ ²⁻ = $0.003 \times \frac{250}{24.20} = 0,031$	1 [1]	AO3	efc
1(c)(iv)	$M_r = \frac{7.6}{0.031} = 245.2$	1 [1]	AO3	accept any number of decimal places but must be correctly rounded efc
1(c)(v)	x = 5	1 [1]	AO3	note answer must be a whole number efc

Question	Answer	Mark	AO	Additional Guidance
1(d)	problem titres are not concordant / are too far apart / are 0.5(0) cm^3 apart / difference is too large; improvement repeat until (two) concordant titres have been achieved / two readings within 0.1(0) cm^3 ;	1 1 [2]	AO3	

Question	Answer	Mark	AO	Additional Guidance
2(a)(i)	stopwatch / clock with a second hand, thermometer (0–110 °C).	1 [1]	AO3	in any order
2(a)(ii)	• Insert the plastic cup into the glass beaker • Use of a measuring cylinder for measuring aqueous copper(II) sulfate • Using a thermometer • Record the temperature every 30 seconds for 10 minutes • Add all the zinc powder to the solution in 180 seconds • Continuous mixing of the mixture	3 [3]	AO3	If you write the sequence in full - all 3 points if the general sequence of work is recorded, but 1-2 actions are not recorded - 2 points only some actions correspond to the performance of the work - 1 point
2(b)(i)	first six points plotted correctly last 14 points plotted correctly	1 2 [3]	AO3	accept one mark if 10 of the last 14 points plotted correctly accept plots to within $\pm$ half a square
2(b)(ii)	correct best fit line, extrapolation and temperature to within $\pm 0.5^\circ\text{C}$	1 [1]	AO3	
2(b)(iii)	correct best fit curve correct maximum temperature to within $\pm 0.5^\circ\text{C}$	1 1 [2]	AO3	
2(c)(i)	temperature change using formula (b)(iii) – (b)(ii)	1 [1]	AO3	
2(c)(ii)	correct calculation of $26 \times 4.18 \times (\text{c})(\text{i})$	1 [1]	AO3	

