AEO «Nazarbayev Intellectual Schools»
Center for Pedagogical Measurements

NIS
Nazarbayev
Intellectual
Schools

EXTERNAL SUMMATIVE ASSESSMENT
TEST SPECIFICATION
«CHEMISTRY»

Grade 12

Астана, 2024

Contents

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

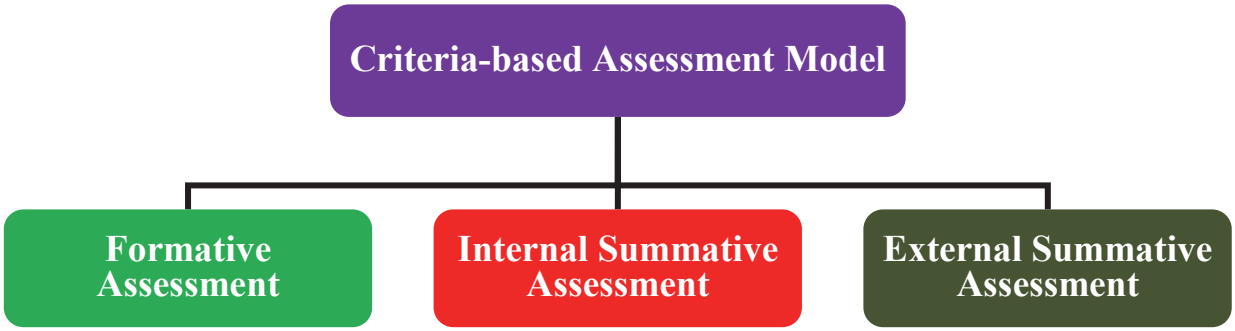
The Grade 12 Chemistry External Summative Assessment is designed to be comparable to the Cambridge International A-Level standard.

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 Model (CBAM)

The External Summative Assessment forms one part of the *Criteria-based Assessment Model* which also consists of Formative Assessment and Internal Summative Assessment.



2 External Summative Assessment Overview

Paper 1	**60 minutes**
All questions are compulsory. Learners answer 40 multiple-choice questions. Each question will have four options, from which learners will choose correct one. The questions will 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 will 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 will 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; • 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 will be provided for use by learners in the exams. This will contain a periodic table, important constants and other relevant information. Qualitative analysis data will be provided for Paper 3.

3. Description of papers

All learners complete all 3 papers. Papers 1 and 2 will require demonstrating knowledge and understanding of Chemistry, ability of handling, applying and evaluating information (in accordance with AO1 and AO2). Paper 3 will assess 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;
- preparation of appropriate classrooms for written examinations.

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 learner's syllabus Grade will be calculated directly from the total of their marks on the components that they took (weighted in accordance with the set specifications), not from the component Grades.

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 will depend 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.

Instruction on marking Chemistry:

M mark is awarded for applying the correct method and is not deducted for arithmetic errors;

A mark is awarded for the correct answer and depends on the previous mark of M, so when M0, A1 is not awarded;

B mark is awarded regardless of the M mark and is awarded for the correct intermediate result or correct answer;

Ft in the mark scheme, which states "follows from ...", the mark can be added for the learner's actions, which follow from the answer to the previous question, whether it is correct or not.

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 $^{7}_{3}\text{Li} + {}^{1}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + {}^{0}_{-1}\text{e}$

B $^{14}_{7}\text{N} + {}^{1}_{0}\text{n} \rightarrow {}^{14}_{6}\text{C} + {}^{1}_{1}\text{H}$

C $^{23}_{11}\text{Na} + {}^{4}_{2}\text{He} \rightarrow {}^{27}_{10}\text{Ne} + {}^{1}_{1}\text{H}$

D $^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{144}_{56}\text{Ba} + {}^{89}_{36}\text{Kr}$

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.

$$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

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.

$3K_2MnO_4 + 2H_2O \rightarrow MnO_2 + 2KMnO_4 + 4KOH$

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. Their structures are shown.

rhombic sulphur monoclinic 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.

$SO_2(g)$ ⟶ $SO_3(g)$ ⟶ $H_2S_2O_7(l)$ ⟶ $H_2SO_4(l)$

step **1** step **2** step **3**

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 SO_2 to O_2.

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.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

A sample of 300 cm^3 of 1.00 mol dm^{-3} NaOH(aq) is added to 100 cm^3 of 1.00 mol dm^{-3} $H_2SO_4(aq)$.

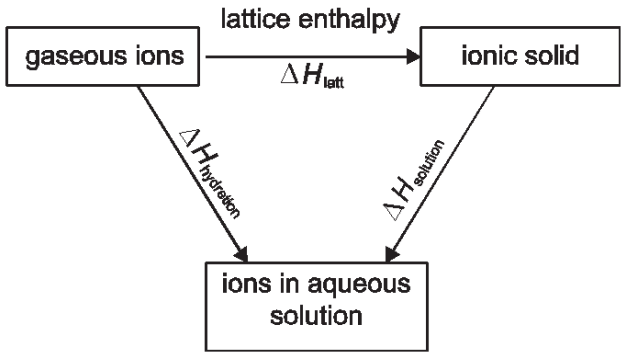
Calculate the pH of the solution formed after the addition. Give your answer to **one** decimal place.

Show your working.

[5]

[Total: 15]

Question	Answer	Mark	Additional guidance
1 (a) (i)	$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$	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 $6{,}02*10^{23}$ 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)	$MnO_4^{2-} + H_2O \rightarrow MnO_2 + MnO_4^- + OH^-$ $3MnO_4^{2-} + 2H_2O \rightarrow MnO_2 + 2MnO_4^- + 4OH^-$	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 gaseous ions is dissolved to form dilute solution/ in lots of water.	1 **[1]**	
1 (c) (ii)	$K^+(g) \rightarrow K^+(aq)$ $MnO_4^-(g) \rightarrow MnO_4^-(aq)$	1 1 **[2]**	**Accept** $K^+(g) + aq \rightarrow K^+(aq)$ $MnO_4^-(g) + aq \rightarrow MnO_4^-(aq)$

1 (c) (iii)		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)	*Similarity*: they are both S8 / both have eight sulfur atoms in the molecule/ they're both yellow in colour, have single bonds and are in a ring. *Difference:* 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. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ 2. $SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$ 3. $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$ / $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(aq)$	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. $SO_2(g) + 1/2O_2(g) \rightleftharpoons SO_3(g)$
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_2SO_4) 0.30 moles (NaOH) (after the addition) 0.1 mole NaOH (0.1/0.4) / 0.25 mol dm^{-3} NaOH pH = 13.4	1 1 1 1 1 **[5]**	**Accept** **ecf** for third marking point e.g. moles NaOH-2x moles H_2SO_4 **ecf** for fourth marking point e.g. moles after addition/0.4 **ecf** for fifth marking point answer 13.0-13.5

7.3 Paper 3

1. A student wants to find the value of **x** in hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot \mathbf{x}H_2O$, by titration with an aqueous solution of iodine, I_2.

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

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

The iodine will be formed by the reaction between aqueous potassium iodate(V), KIO_3, and aqueous potassium iodide, KI.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

(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 ($Na_2S_2O_3 \cdot \mathbf{x}H_2O$ and container)/g	mass of empty container/g	mass of $Na_2S_2O_3 \cdot \mathbf{x}H_2O$/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 cm^3 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 cm^3 of KIO_3 (aq) 0.0200 mol dm^{-3} was transferred into a conical flask.

Using a graduated cylinder, 20 cm^3 of sulfuric acid, 1.00 mol dm^{-3}, and then 10 cm^3 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 = ... cm^3 [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 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 $Na_2S_2O_3 \bullet \mathbf{x}H_2O$.

relative formula mass = ... [1]

(v) Hence calculate the value of **x** in the formula $Na_2S_2O_3 \bullet \mathbf{x}H_2O$.

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.

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

The results of the experiment are given in the table:

time / s	temperature / °C
0	23.0
30	23.0
60	23.0
90	23.0
120	23.0
150	23.0
180	
210	47.0
240	47.0
270	46.0
300	46.0

time / s	temperature / °C
330	45.0
360	44.0
390	43.5
420	42.0
450	40.0
480	39.5
510	39.0
540	38.5
570	37.0
600	36.0

(a) List of equipment and materials:

- 1×40 cm^3 of 1.0 mol dm^{-3} copper(II) sulfate, $CuSO_4(aq)$ labelled **copper (II) sulfate, $CuSO_4(aq)$**
- 1×1 g of zinc powder.
- $1 \times$ **X**
- 1×250 cm^3 glass beaker
- 1×25 cm^3 measuring cylinder
- $1 \times$ plastic cup that fits into the glass beaker
- $1 \times$ **Y**
- $1 \times$ funnel
- $1 \times$ 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 cm^3 aqueous solution of copper(II) sulfate, $CuSO_4$ (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.

.....

.....

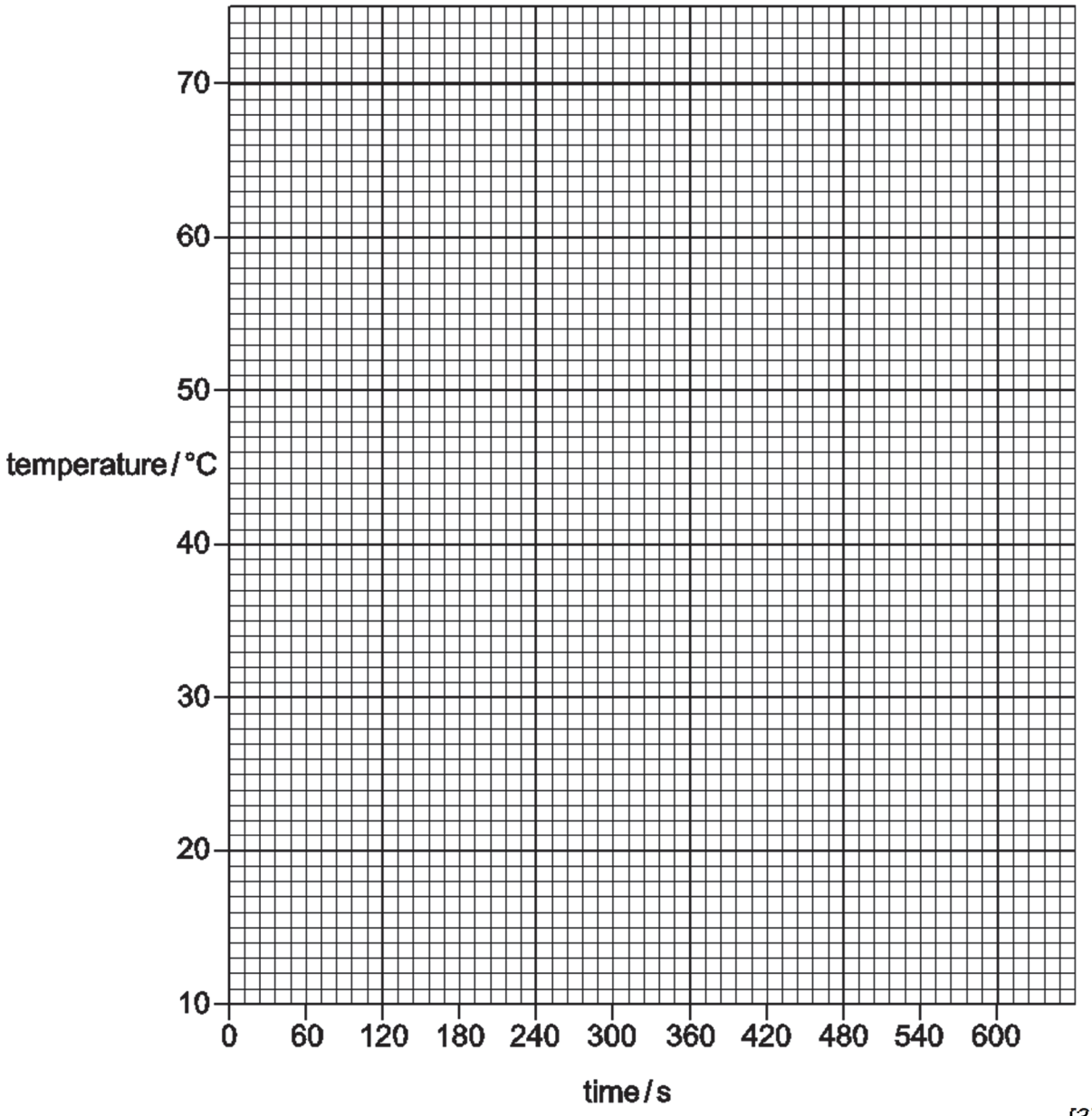
.....

.....

.....

..... [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 cm^3 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 cm^3 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]**	AO2	
1(b)(ii)	$(24.00 + 24.40 + 24.20)/3 = 24.20$	1 **[1]**	AO2	
1(b)(iii)	[(0.05 x 2) / 24.00] × 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 $S_2O_3^{2-}$ = 0.003	1 **[1]**	AO2	**efc**
1(c)(iii)	moles of $S_2O_3^{2-} = 0.003 \times \frac{250}{24.20} = 0{,}031$	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 ± half a square
2(b)(ii)	correct best fit line, extrapolation and temperature to within ±0.5°C	1 **[1]**	AO3	
2(b)(iii)	correct best fit curve correct maximum temperature to within ±0.5°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 $26 \times 4.18 \times$ **(c)(i)**	1 **[1]**	AO3	

Question	Answer	Mark	AO	Additional Guidance
2(c)(iii)	correct calculation of **(c)(ii)** ÷ 0.0025 correct conversion to kJ by ÷ 1000	1 1 **[2]**	AO3	 **accept ecf** for conversion to kJ
2(d)	**any from** use two people so you can measure the temperature at time of addition use a pipette to measure the volume so it is more accurate use a data-logger so that the temperature can be measured continuously / reduce time intervals between temperature readings so the temperature can be measured more frequently use a lid to reduce heat loss use extra insulation around the plastic cup to reduce heat loss use the heat capacity of the plastic cup to measure heat absorbed by the plastic use more zinc so heat is released faster / reaction happens more quickly	 1 **[1]**	AO3	M1 mark answer wherever it appears but must have a way **and** an explanation **ignore** human error **ignore** repeat experiments **allow** using a magnetic stirrer to ensure consistent temperature throughout the mixture **ignore** use less zinc