Important Instructions for this Exam:

- This exam has **3 problems**.
- Before the start of the practical exam, the **READ** signal is given. You have **15 minutes** to read the exam booklet. You may only read during this time. **Do not write or use the calculator. Do not work on any problem or interact with any equipment.**
- You may begin working when the **START** signal is given. You have **5 hours** to complete the exam. You may complete the tasks in any order, but **note that P1 and P3 contain waiting times of 1 h and 20 min**, respectively.
- For questions requiring you to tick the correct box(es), **to change your initial answer, shade the check box completely and draw a new box next to it**. Tick the box corresponding to your intended answer.
- When necessary, **wash your glassware at your workspace** with distilled water from a wash bottle **into the liquid waste container.** The **sinks must not be used** for washing glassware.
- You **must follow the safety rules** given in the IChO regulations below. **Any safety rule violation can result in your dismissal from the laboratory and the nullification of your practical examination work.**

Safety Rules

Students must obey the following safety rules. Any student who fails to comply will leave the practical exam and may receive a score of zero for the practical exam.

- Do not eat or drink in the lab. Chewing gum is not allowed.
- Work only in the designated area. Keep your work area and the common work areas tidy.
- No unauthorised experiments are allowed. No modification of the experiments is allowed.
- Vials and screw capped bottles must be kept closed whenever possible.
- Do not pipette with your mouth. Always use a pipette filler bulb.
- Immediately inform your lab assistant about spills, broken glassware, or any accidents.
- All waste must be properly disposed to prevent contamination or injury. Discard the solutions in the containers with the correct labels. Inform your lab assistant when any of the containers are full.
- Contact lenses are prohibited in the laboratory. Students needing vision correction must wear glasses.

In the practical exam hall, students are required to wear:

- full length trousers or other clothing covering their whole legs
- closed-end shoes
- a lab coat
- safety goggles
- gloves when handling harmful or unknown solutions and substances
- tied back any long hair and/or beards.

Experiment

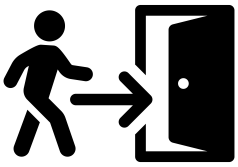
58th International Chemistry Olympiad Uzbekistan 2026

G0-2

English (Official)

General Instructions

- All results and answers must be clearly written in pen **in their designed areas on the answer sheets**. Answers written outside the answer boxes will not be graded. Some figures are reproduced in your question sheets for draft work. They will not be graded. **Make sure to copy your final answer to your answer sheets**.
- **Write only** with the pen provided in the Answer Sheets. Do not use the permanent marker provided for your answers and do not write in pencil. The permanent marker is only for labelling lab equipment. **Use only** the calculator provided.
- **Write** relevant calculations where needed. Full marks will be given only for answers showing the correct work.
- The official English version is available upon request for clarification.
- Chemicals and labware, unless otherwise stated, will be refilled or replaced without penalty only once (one item). Each further replacement will result in the deduction of 1 point from your 40 practical exam points.
- You are not allowed to leave your working place without permission. If you need any assistance, **raise** the corresponding non-verbal communication card (see table below for meanings).
- **Keep** all items within the marked out area of your bench.
- The lab assistants will announce a **30-minute** notice before the **STOP** signal.
- You must stop your work immediately when the **STOP** signal is announced. Failure to stop working or writing can lead to nullification of your practical examination work.
- After the **STOP** signal, the lab assistant will come to sign your answer sheet.
- After both you and the lab assistant sign, place **all sheets with the cover sheet on top** back into the envelope. **Do not seal** the envelope.

		
I need a toilet break.	I need refill or replacement item, or have questions.	I need to grab a snack, or take a break.

Non-verbal communication cards.

GOOD LUCK!

Experiment

58th International Chemistry Olympiad Uzbekistan 2026

G0-3

English (Official)

Problems and Grading Information

	Title	Question Pages	Answer Pages	Total Points	Percentage
1	Synthesise and Analyse	6	3	33	14
2	Atlas of Enzymes	6	3	108	11
3	The Adventures of Hodja Nasreddin	4	8	87	15
				Total	**40**

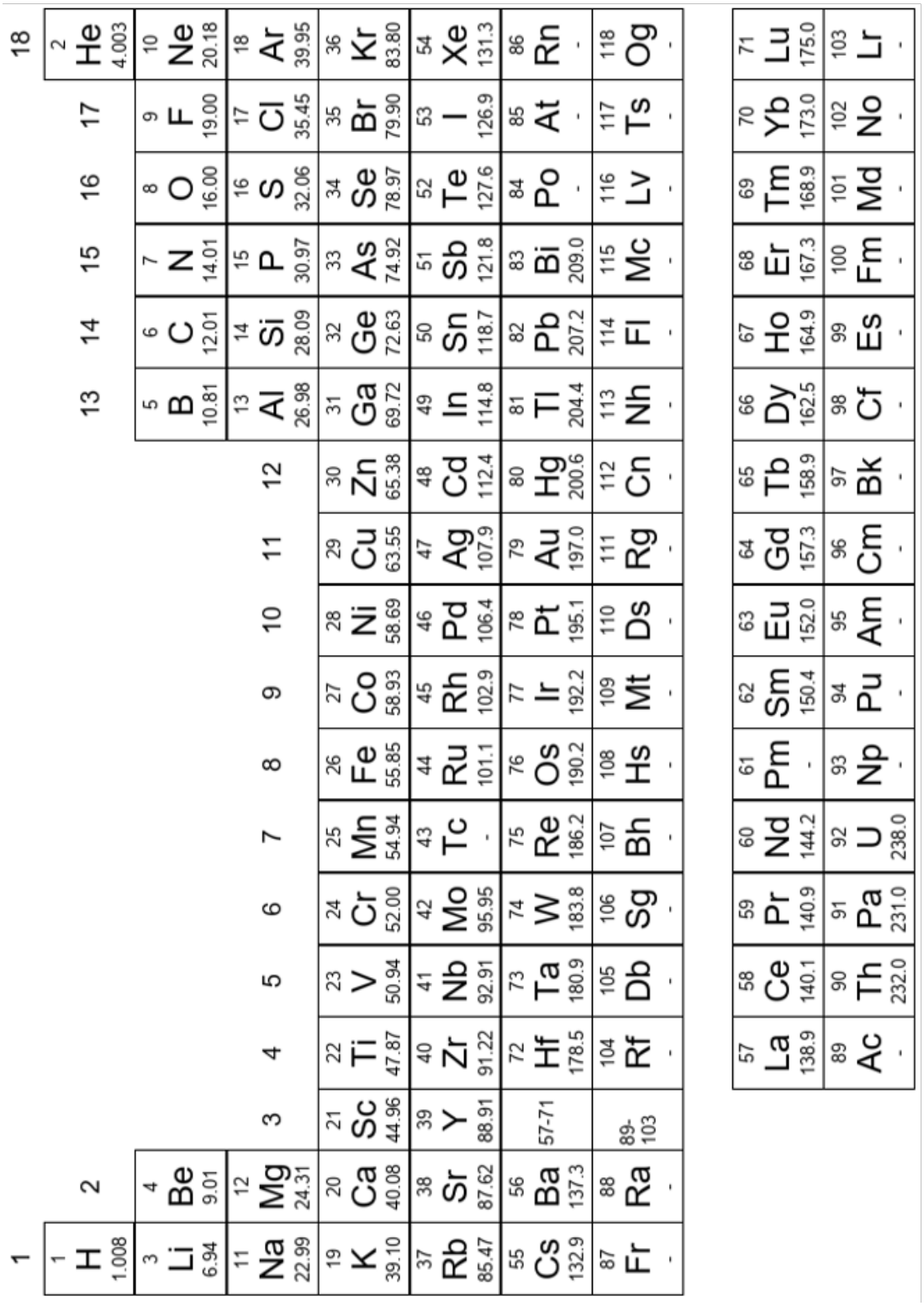
Experiment

58th International Chemistry Olympiad Uzbekistan 2026

G0-4

English (Official)

Periodic Table of Elements



GHS Statements

Hazard Code	Hazard Statement
H225	Highly flammable liquid and vapour
H226	Flammable liquid and vapour
H272	May intensify fire; oxidiser
H290	May be corrosive to metals
H301	Toxic if swallowed
H302	Harmful if swallowed
H311	Toxic in contact with skin
H312	Harmful in contact with skin
H314	Causes severe skin burns and eye damage
H315	Causes skin irritation
H317	May cause an allergic skin reaction
H318	Causes serious eye damage
H319	Causes serious eye irritation
H331	Toxic if inhaled
H332	Harmful if inhaled
H335	May cause respiratory irritation
H336	May cause drowsiness or dizziness
H341	Suspected of causing genetic defects
H351	Suspected of causing cancer
H361	Suspected of damaging fertility or the unborn child
H372	Causes damage to organs through prolonged or repeated exposure
H373	May cause damage to organs through prolonged or repeated exposure
H400	Very toxic to aquatic life
H402	Harmful to aquatic life
H410	Very toxic to aquatic life with long lasting effects
H411	Toxic to aquatic life with long lasting effects
H412	Harmful to aquatic life with long lasting effects

Chemicals:	
Ammonia buffer, pH 10	H314, H335, H412
Copper(II) sulfate solution	H319, H411
Dichloromethane	H351
Dithizone	H315, H319, H335
Eriochrome Black T indicator	H315, H319, H335, H411, H412
Ethanol	H225
Ethylenediaminetetraacetic acid disodium salt	H332, H373
Iron(III) nitrate solution	H314, H318
Hydrochloric acid	H314, H331
Pyridine in ethanol solution	H225, H302, H312, H332
Sliced red cabbage	no hazards
Sodium hydroxide	H314
Solution **Y1**	H302, H312, H315, H319, H332, H335
Solutions **E1**-**E5**	H301, H302, H311, H312, H314, H315, H318, H319, H331, H335, H341, H373, H400, H402, H410, H412
Solutions **M1**-**M3**	no hazards
Solutions **S1**-**S10**	no hazards
Solutions **W1**-**W7**	H302, H312, H315, H317, H318, H319, H332, H334, H341, H361, H372, H400, H410, H411
Solutions **X3**-**X6**	H226, H290, H302, H314, H318, H331
Unknown solution **R1**	H272, H302, H315, H318, H319, H335, H400, H410, H411
Unknown solution **R2**	H302, H312, H318, H319, H332, H400, H412
Unknown solvent	H225, H319, H336

Common Equipments and Chemicals

Equipment

Item	Quantity	Label
Shared on the table of common use:		
Nitrile gloves (S, M, L)	as needed	
Paper tissues refill	as needed	
Wash bottles with distilled water	as needed	
For each student:		
Safety goggles	1	
Hotplate stirrer	1	
Burette, 25.00 mL	2	
Laboratory stand with clamp and double burette clamp	1	
3-Valve Bulb	1	
Funnel for burette	2	
Permanent marker	1	
Ruler	1	
Pen	1	
Pack of paper tissues	1	
Container for disposal of liquid waste	1	**Liquid waste**
Container for disposal of solid waste	1	**Solid waste**

Chemicals

Name	State	Concentration	Quantity	Placed in	Label
For each student:					
Distilled water	l	-	500 mL	Wash bottle, 500 mL	**H_2O**
Sodium hydroxide	aq	0.0100 M	200 mL	Plastic bottle, 250 mL	**NaOH 0.01 M**

Extra equipment and chemicals

Item	Penalty	Student signature	Assistant signature
	Free		
	$1/40$ practical exam points		
	$1/40$ practical exam points		
	$1/40$ practical exam points		
	$1/40$ practical exam points		
	$1/40$ practical exam points		

Safety violations

Type of violation	Penalty	Student signature	Assistant signature
	Warning		
	Disqualification (40 Points)		

P1. Synthesise and analyse (A new complex problem)

Equipment

Item	Quantity	Label
Part A		
Magnetic stirrer bar	1	
Steel spatula	1	
Sintered funnel	1	
Round bottom flask with ground-glass joint	1	
Vacuum pump with hose connected to a bubbler at the back	1	
Glass beaker, 100 mL	1	
Pre-weighed glass vial with cap for product	1	**A + student code**
Measuring cylinder, 10 mL	1	
Magnetic rod	1	
Yellow paper for product transfer	1	
Part B		
Graduated pipette, 10.0 mL	1	
Glass beaker, 50 mL	2	
Erlenmeyer flask, 100 mL	2	
Measuring cylinder, 10 mL	1	
Part C		
Plastic Pasteur pipette, 3 mL	12	
Eppendorf tube, 0.5 mL	15	

Experiment

58th International Chemistry Olympiad Uzbekistan 2026

Q1-2

English (Official)

Chemicals

Name	State	Concentration	Quantity	Placed in	Label
Part A					
Solution **R1** (synthesis)	aq	To be determined	10.0 mL	Glass vial with cap, 30 mL	**R1-syn**
Solution **R2**	aq	1.03 M	10.0 mL	Glass vial with cap, 30 mL	**R2**
Pyridine in ethanol (synthesis)	sol	8.4 % v/v	10 mL	Plastic tube (15 mL) in plastic cup	**Py**
Part B					
Solution **R1** (analysis)	aq	To be determined	10.0 mL	Volumetric flask, 100 mL	**R1-an**
Ethylenediamine-tetraacetic acid disodium salt	aq	0.0770 M	50 mL	Bottle, 50 mL	**EDTA**
Ammonia buffer	aq	-	40 mL	Bottle, 50 mL	**NH_3 buffer**
Eriochrome Black T	s	1% in NaCl	0.2 g	Sample container	**Eriochrome**

Part C					
Complex **A**	s	-	10 mg	Eppendorf tube, 0.5 mL	**A**
Iron(III) nitrate	aq	0.4 %	0.5 mL	Eppendorf tube, 0.5 mL	**Fe^{3+}**
Copper(II) sulphate	aq	5%	0.5 mL	Eppendorf tube, 0.5 mL	**Cu^{2+}**
Pyridine in ethanol (analysis)	sol	8.4 % v/v	0.5 mL	Eppendorf tube, 0.5 mL	**Py-qual**
X^-	aq	0.1 M	0.5 mL	Eppendorf tube, 0.5 mL	**X^- – qual**
Unknown solvent	l	-	1 mL	Eppendorf tube, 1.5 mL	**Solvent**
Dithizone	s	-	1 mg	Eppendorf tube, 0.5 mL	**Dithiz.**
Dichloromethane	l	-	0.75 mL	Eppendorf tube, 1.5 mL	**CH_2Cl_2**

Experiment

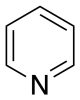
58th International Chemistry Olympiad Uzbekistan 2026

Q1-3

English (Official)

14% of total											
Question	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	**Total**
Total	10	0	10	1	3	1	4	2	1	1	33

In this problem, you will synthesise and analyse complex **A** with molecular formula $[M(Py)_mX_n]$ where:

- M^{k+} is an unknown metal cation; - Py (pyridine); - X^- is either OCN^- or SCN^-; - m = 0, 1, 2, 3, ...; - n = 1, 2, 3, ...	Py = 

Part A. Synthesis

To synthesise complex **A**, solutions **R1-syn** and **R2** are used:

- Solution **R1-syn** contains 10.0 mL of an aqueous solution of a M^{k+} salt with unknown concentration.
- Solution **R2** contains 10.0 mL of an aqueous solution of potassium salt of X^- with a concentration of 1.03 M.

1. **Put** the stirrer bar in the 100 mL beaker.
2. **Transfer** the whole solution **R1-syn** to the same beaker.
3. **Rinse** the vial **R1-syn** with 1 mL of water using a Pasteur pipette and **transfer** the remains to the beaker.
4. **Add dropwise** the whole solution **R2** using a Pasteur pipette while stirring on the magnetic stirrer.
5. **Rinse** the vial **R2** with 1 mL of water using a Pasteur pipette and **transfer** the remains to the beaker.
6. **Add dropwise** the whole pyridine solution (**Py**) using a Pasteur pipette while stirring.
7. **Continue** stirring for 5 minutes.
8. **Connect** sintered funnel to a round bottom flask to assemble the vacuum filtration apparatus.
9. **Filter** the product using vacuum filtration and **wash** it three times with 10 mL portions of water.
10. Once you have finished washing, **ask** the lab assistant to collect the filtrate to avoid spills. For this, **raise** the green card with a question mark, **turn off** the pump and **disconnect** the vacuum hose. **Remove** the filter and **hand** the flask to the lab assistant. The lab assistant will discard the filtrate and **return** the empty flask.
11. **Reassemble** the filtration setup and **let** your product dry for **1 hour** with the vacuum turned on. During the drying, **it is important** to **use** your spatula **to break up** any aggregates of the product formed on the filter.
12. After complete drying, carefully **transfer** your product to the vial labelled "**A + Student Code**". For this you can use the yellow paper provided.

Q1.1 The lab assistant **will collect** your product at the end of the exam. Both you and the lab assistant should **sign** your answer sheet. 10 pt

The organisers will further dry your product in an oven before measuring the mass, however **it is important you have vacuum dried the product for 1 hour and broken up any aggregates** to remove the vast majority of the water before putting it in the vial.
(If the product is **not transferred** to the vial, it will **not be collected** and **ZERO points** will be awarded for the synthesis.)

Part B. Quantitative Analysis

You will use a complexometric titration to determine the concentration of M^{k+} in solution **R1-an**. The volumetric flask **R1-an** contains 10.0 mL of M^{k+} solution with the same concentration as in **R1-syn** in **Part A**.

1. **Dilute** the **R1-an** solution in the volumetric flask with H_2O up to the mark and **mix** thoroughly.
2. **Fill** the burette with 0.0770 M **EDTA**.
3. **Add** a 10.0 mL aliquot of the diluted solution **R1-an** using a graduated pipette, 5 mL of ammonia buffer solution (**NH_3 buffer**), and a tip of the plastic spatula of indicator (**Eriochrome**; the spatula is inside the sample container) to an Erlenmeyer flask. **Close** the bottle of **NH_3 buffer** after using it.
4. **Titrate** the mixture with 0.0770 M **EDTA** solution until the colour turns a stable blue.
5. **Repeat** steps 3-4 if necessary.

Q1.2 **Record** the observed volumes (V_0, mL – initial burette reading; V_f, mL– final burette reading; T, mL - titre). This table is for your convenience and will not be graded. 0 pt

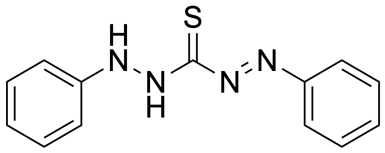
Q1.3 **Record** your accepted final titre of **EDTA** (V_{EDTA}, mL). 10 pt

Q1.4 **Calculate** the ratio of X^- and M^{k+} ($n_{X^-}/n_{M^{k+}}$) used in the synthesis according to your result. **Round** your answer to two decimal places. 1 pt

Part C. Qualitative Analysis

In this part, you need to perform different chemical tests to identify the components of complex **A**.

1. **Prepare** a 0.4 mL solution of complex **A** in the Eppendorf tube by adding the solvent with a Pasteur pipette from the Eppendorf tube labelled **Solvent** until the 0.4 mL mark. If the sample has not dissolved completely, shake the tube and use the supernatant for the tests below.
2. **Prepare** a 0.4 mL solution of the indicator Dithizone (**Dithiz.**) in the Eppendorf tube by adding the solvent with a Pasteur pipette from the Eppendorf tube labelled **Solvent** until the 0.4 mL mark. The structure of the indicator is given below.



3. **Take** four empty Eppendorf tubes and **transfer** 1 drop of the solution of **A** obtained to each.
4. **Perform** the individual tests **T1–T4** by **adding** the following reagents to each of the four Eppendorf tubes:

- **T1**: 2 drops of **Fe^{3+}**(acidified $Fe(NO_3)_3$)
- **T2**: 2 drops of the prepared **Dithizone** solution
- **T3**: 2 drops of **Cu^{2+}**($CuSO_4$)
- **T4**: 2 drops of **Cu^{2+}**($CuSO_4$) followed by 3 drops of **CH_2Cl_2** and **shake**

You may perform additional tests; for this you are provided with extra equipment and chemicals (e.g., solutions of Py and X^-). *Additional information:* $\rho(CH_2Cl_2) = 1.32$ g/cm^3

Q1.5 **Tick** the correct box(es) corresponding to your observation(s) in **T1 - T3**. 3 pt

(a) No visible change
(b) Formation of precipitate
(c) Solution became colourless
(d) Solution became red or pink

Q1.6 **Tick** the correct box(es) corresponding to your observation(s) in **T4**. 1 pt

(a) The aqueous phase changed colour
(b) The aqueous phase did not change colour
(c) The CH_2Cl_2 phase changed colour
(d) The CH_2Cl_2 phase did not change colour

Q1.7 The above tests **T1–T4** are designed to identify the components of the complex **A**. **Tick** the box(es) that correctly describe(s) the result(s) of each test. 4 pt

(a) Identifies presence of metal M^{k+}
(b) Identifies presence of ligand X^-
(c) Identifies presence of ligand Py
(d) Identifies absence of ligand Py

Q1.8 **Identify** ligand X^- and metal M^{k+} with its charge in complex **A**. 2 pt

Q1.9 From the list below, **choose** the correct description of M^{k+}/X^{-} stoichiometry in the synthesis based on your reported results. Consider as little as an additional 1 mol% as an excess of the reagent. 1 pt

(a) M^{k+} and X^{-} were used in a stoichiometric amount
(b) M^{k+} was used in excess
(c) X^{-} was used in excess

Q1.10 **Write** the molecular formula of complex **A** assuming it follows the 18-electron rule. 1 pt

P2. Atlas of Enzymes

Equipment

Item	Quantity	Label
Eppendorf tubes rack	2	
Micropipette, 10-100 μL	1	
Micropipette tips	40	
Tips box	1	
96-well plate	2	

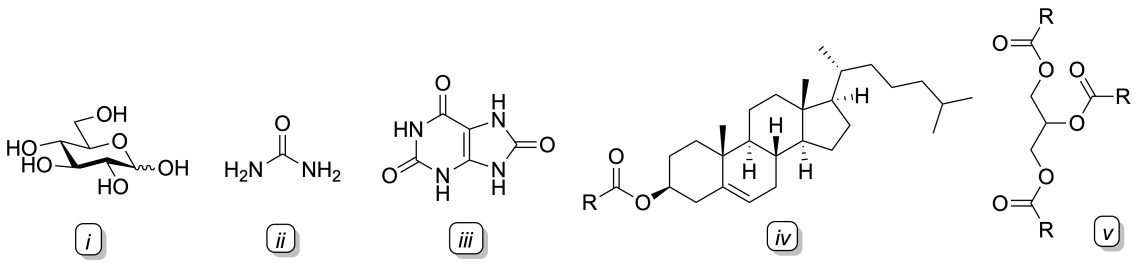
Chemicals

Name	State	Concentration	Quantity	Placed in	Label
Part A					
Mixture **E1**	aq	-	4 mL	Eppendorf tube, 5 mL	**E1**
Mixture **E2a**	aq	-	4 mL	Eppendorf tube, 5 mL	**E2a**
Mixture **E2b**	aq	-	4 mL	Eppendorf tube, 5 mL	**E2b**
Mixture **E3**	aq	-	4 mL	Eppendorf tube, 5 mL	**E3**
Mixture **E4**	aq	-	4 mL	Eppendorf tube, 5 mL	**E4**
Mixture **E5**	aq	-	4 mL	Eppendorf tube, 5 mL	**E5**
Substrates solutions **S1**–**S10**	aq	-	0.5 mL	Eppendorf tube, 0.5 mL	**S1**–**S10**
Part B					
Substrates solutions **M1**–**M3**	aq	-	0.5 mL	Eppendorf tube, 0.5 mL	**M1**–**M3**
Part C					
Substrates solutions **W1**–**W7**	aq	-	0.5 mL	Eppendorf tube, 0.5 mL	**W1**–**W7**

11 % of total									
Question	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	**Total**
Points	50	2	4	1	5	9	35	2	108

Atlas is a smooth single-faced fabric woven from natural silk. Atlas is not just a simple fabric—it is a woven chronicle of the unique Uzbek culture and identity.

Enzyme mixtures are used for qualitative and quantitative analysis of organic substances in biological fluids (plasma, urine, etc.). **E1**–**E5** can contain one or several enzymes. These also contain all the necessary reagents (buffer and other components). **E1**–**E5** are designed for the selective determination of *i) glucose*, *ii) urea*, *iii) uric acid*, *iv) cholesteryl ester,* and *v) triglyceride.*



i *ii* *iii* *iv* *v*

All reaction mixtures in this problem are prepared in a 96-well plate using a micropipette.

The instructions below apply when performing the reaction between any substrate solution with any enzyme mixture **E1**–**E5**:

1. For all reaction tests except those with **E2**, **add** 20 μL of the substrate solution to 100 μL of the enzyme solution and **incubate** for approximately 5 min at room temperature.
2. For mixture **E2** (composed of separate solutions **E2a** and **E2b**), **add** 20 μL of substrate solution to 100 μL of **E2a** solution. **Incubate** for approximately 5 min at room temperature. **Add** 100 μL of the **E2b** solution to this mixture and **continue** to incubate for approximately another 5 min at room temperature.
3. If the tested solution contains the specific substrate, the mixture shows a colour distinct from the other solutions without the specific substrate.

Part A

You are given the following substances in the 10 solutions **S1**–**S10**. Each solution **S1**–**S10** contains only two substances out of the five substances *i*–*v*. **S1**–**S10** contain different combinations of substances *i*–*v*. The composition of **S1**–**S5** is:

- **S1**: *i* + *ii*
- **S2**: *i* + *iv*
- **S3**: *ii* + *iii*
- **S4**: *iii* + *v*
- **S5**: *iv* + *v*

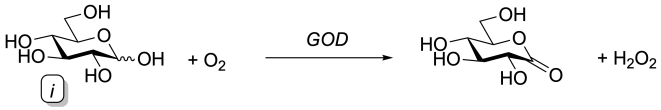
Perform the tests of each solution **S1**–**S10** with each enzyme mixture **E1**–**E5**. The tubes in your rack might not necessarily be arranged in numerical order. Some substrates could appear as cloudy solutions or suspensions.

Q2.1	**Tick** the box with the corresponding colour change for each of the enzyme mixtures **E1**–**E5** with substrates **S1**–**S10**, relative to the initial colour of **E1**, **E2a**, **E3**, **E4**, and **E5**. The colour codes are given below: **N** - no colour change **Y** - change to yellow **G** - change to green **B** - change to black **PR** - change to pink/red	50 pt

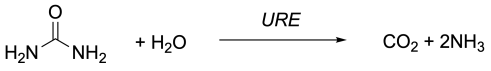
Q2.2	**Tick** the box for the enzyme–substrate pair(s) that gave a positive result.	2 pt

Q2.3	**Tick** the boxes for the correct substrates present in **S6**–**S10**.	4 pt

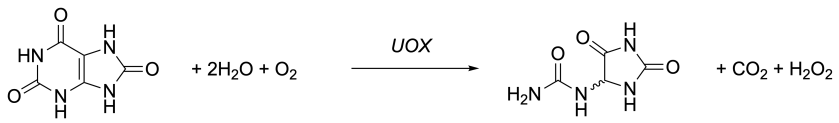
The reaction scheme of enzymes, substrates *i*–*v*, and additional components of mixtures **E1**–**E5** are given below:



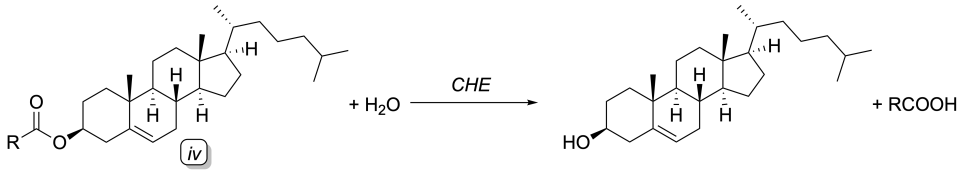
i

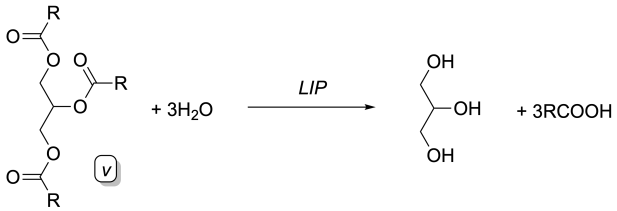


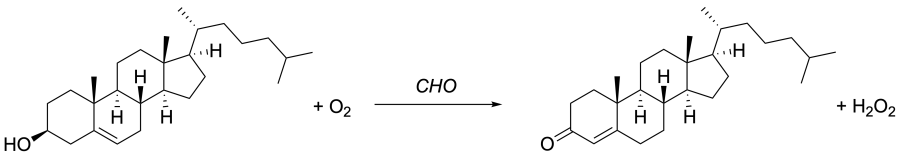
ii

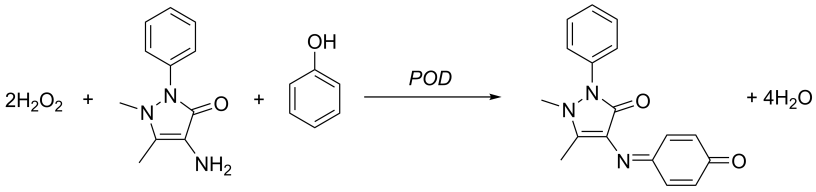


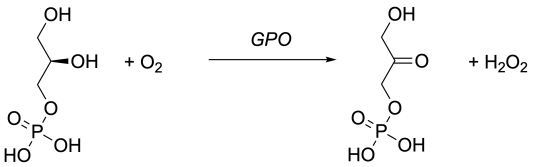
iii

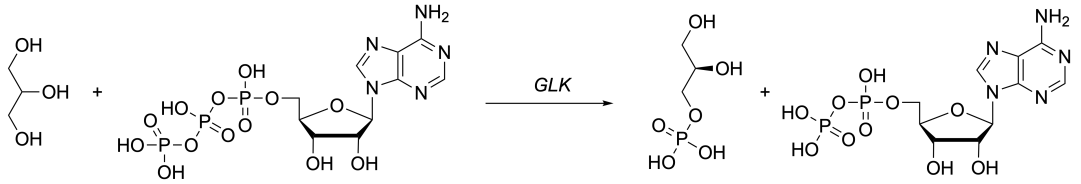

+ H_2O
CHE
+ RCOOH
iv

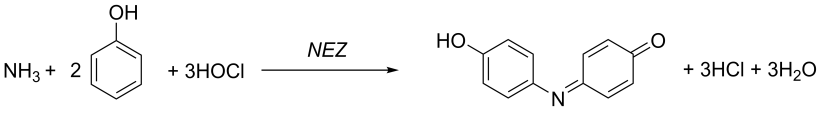

+ $3H_2O$
LIP
+ 3RCOOH
v


+ O_2
CHO
+ H_2O_2


$2H_2O_2$ +
+
POD
+ $4H_2O$


+ O_2
GPO
+ H_2O_2


+
GLK
+


NH_3 + 2
+ 3HOCl
NEZ
+ 3HCl + $3H_2O$

All of the reactions above are balanced. Abbreviations:

- Glucose oxidase – *GOD*
- Urease – *URE*
- Uricase – *UOX*
- Cholesterol esterase – *CHE*
- Lipases – *LIP*
- Cholesterol oxidase – *CHO*
- Peroxidase – *POD*
- Glycerol-3-phosphate oxidase – *GPO*
- Glycerol kinase – *GLK*
- Non-enzymatic reaction – *NEZ*

Q2.4 Intensely coloured products are formed only in two reactions from the list above. **Tick** the boxes for the reactions that give coloured products. 1 pt

Q2.5 **Tick** the components that are present in reaction mixtures **E1**–**E5**. 5 pt

Part B

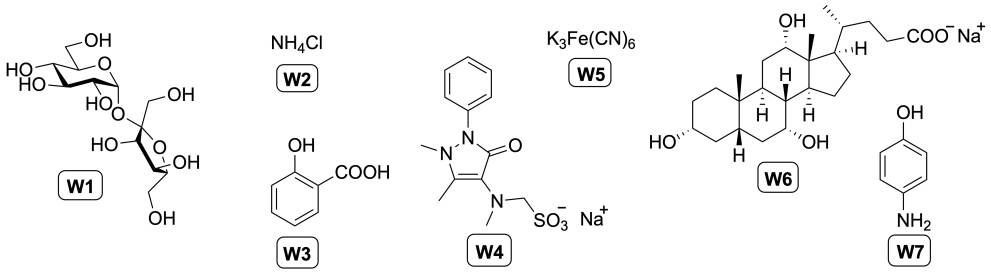
Enzymes **E2**, **E4**, and **E5** give positive tests with substrates **F**, **G**, and **H**, respectively. Solutions **M1**, **M2**, and **M3** contain all of the substrates **F**, **G**, and **H** in different concentrations. For solutions **M1**–**M3**, after approximately 5 min of enzymatic reaction, the colour intensity of the reaction mixture is linearly dependent on the initial concentration of the substrate. Assume that approximately 5 min is enough to achieve complete substrate conversion.

Perform the tests of each solution **M1**–**M3** with each enzyme mixture **E2**, **E4**, and **E5**. Some substrates could appear as cloudy solutions or suspensions.

Q2.6 **Arrange** **M1**–**M3** in increasing order of concentrations for each of **F**, **G**, and **H** substrates based on the performed reactions. 9 pt

Part C

Some or all of the substances **W1**–**W7** can react with components of mixtures **E1**–**E5** and interfere with the accurate determination of their native substrates. Substances **W1**–**W7** are given below:



Perform the tests of each substance **W1**–**W7** with each enzyme mixture **E1**–**E5**. Some substrates could appear as cloudy solutions or suspensions.

Q2.7 **Tick** the box with the corresponding colour change for each of the enzyme mixtures **E1**–**E5** with substances **W1**–**W7**. Use the same colour codes as in **Q2.1**. Compare the colour of the reaction mixtures to the initial colour of **E1**, **E2a**, **E3**, **E4**, and **E5**. 35 pt

Q2.8 **Write down** the balanced reaction equation(s) that describe(s) the positive test(s) in **Q2.7**. 2 pt

P3. The Adventures of Hodja Nasreddin

Equipment

Item	Quantity	Label
Part A		
pH meter with stand and probe stored in 3 M KCl	1	
Volumetric pipette, 50 mL	1	
Glass rod	1	
Part B		
Thermometer	1	
Funnel for filtration	1	
Cotton wool	1	
Glass beaker, 200 mL	2	
Measuring cylinder, 50 mL	1	
Plastic Pasteur pipette, 3 mL	2	
Plastic cup, 250 mL	20	

Chemicals

Name	State	Concentration	Quantity	Placed in	Label
Part A					
Solution **X3**	aq	To be determined	200 mL	Plastic bottle, 250 mL	**X3**
Solution **X4**	aq	To be determined	200 mL	Plastic bottle, 250 mL	**X4**
Solution **X5**	aq	To be determined	200 mL	Plastic bottle, 250 mL	**X5**
Solution **X6**	aq	To be determined	200 mL	Plastic bottle, 250 mL	**X6**
Part B					
Solution **Y1**	aq	-	3 mL	Eppendorf tube, 4 mL	**Y1**
Sliced red cabbage	s	-	15 g	Glass bottle, 100 mL	**RC**
Hydrochloric acid	aq	0.0100 M	100 mL	Plastic bottle, 250 mL	**HCl 0.01 M**

15 % of total										
Question	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	**Total**
Points	2	0	50	12	1	9	2	10	1	**87**

Part A

The chemist Nasreddin prepared solutions of **different acids** with the same pH value. To do this, he took:

- a strong monoprotic acid HA,

- a weak monoprotic acid HB,

- a diprotic acid H_2C.

He obtained six solutions (**X1**–**X6**), all with **the same pH value** when rounded to the nearest integer. These six solutions included three solutions of individual acids and three pairwise mixtures, which contained individual acids in a 1 : 1 molar ratio (not necessarily in order given below).

HA	HB	H_2C	HA + HB (1 : 1)	HA + H_2C (1 : 1)	HB + H_2C (1 : 1)

In this part, you need to **perform titrations** of solutions **X3**–**X6** with a pH meter. Unfortunately, on the way to IChO 2026, Nasreddin lost solutions **X1** and **X2**, but he promises to help in determining their composition.

1. Using a volumetric pipette, **transfer** 50.0 mL of **X3** into a **plastic cup**.
2. **Measure** the pH of **X3** using the pH meter.

Q3.1 **Tick** the pH value of **X3** to the nearest integer. 2 pt

3. Using the pH meter, **titrate** 50.0 mL of **X3** with 0.0100 M NaOH solution by adding **0.5 mL portions** of NaOH solution and measuring the pH of the resulting solution until it reaches ~10. **Do not use** the stirring plate in this experiment.
4. **Record** the pH values. When a more accurate measurement is required, **wait** until the displayed pH value is stable for at least 5 seconds.
5. **Repeat** steps 1, 3 and 4 for **X4**–**X6**.

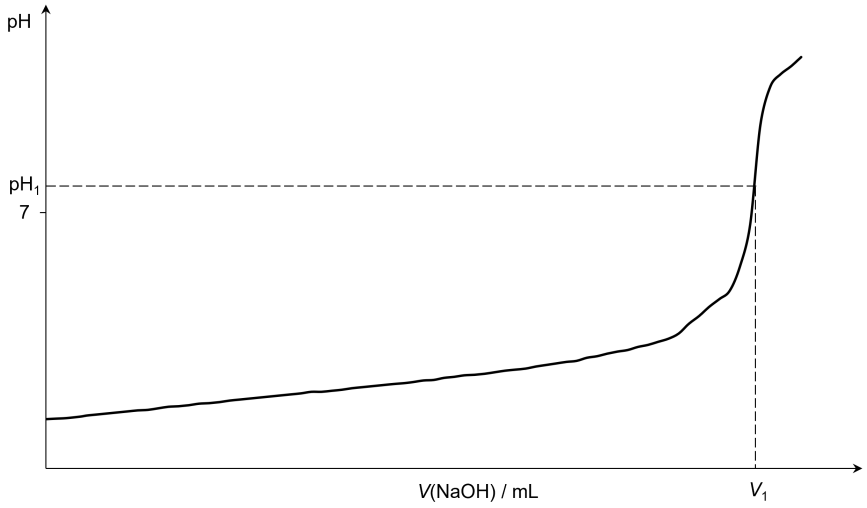
Q3.2 **Record** your results for the titration of solutions **X3**–**X6**. You **may sketch** the titration curves on the provided grids, but they will not be graded. 0 pt

Q3.3 **Determine** the ranges of NaOH volume (in mL) that correspond to the equivalence points during the titrations of **X3**–**X6**. **Tick** the appropriate boxes based on your results from **Q3.2**. 50 pt

For example, if the equivalence point lies in the range $4.0 < V \leq 4.5$, you **must tick** the box as shown below:

V_{NaOH}	3.5	☐	4.0	☑	4.5	☐	5.0

Nasreddin provides the following titration curve of 50.0 mL **X1** with 0.0100 M NaOH solution, where $V_1 = 34.75$ mL:



He also notes that for solution **X2**, the ratio between the total $V(\mathrm{NaOH})$ to reach the second equivalence point relative to $V(\mathrm{NaOH})$ to reach the first equivalence point is approximately 3 : 2.

Q3.4 **Determine** the composition of **X1**–**X6**. **Tick** the appropriate boxes. 12 pt

Q3.5 **Give** the pH of the resulting solution after mixing equal volumes of **X1**–**X6**. 1 pt

Part B

Nasreddin also prepared universal indicators **Y1** and **Y2** for acid–base titration. To prepare **Y2**, he made an extract from red cabbage.

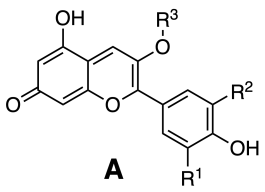
Prepare a fresh solution of **Y2** from red cabbage as follows:

1. **Transfer** all the sliced red cabbage into the 200 mL glass beaker with 60 mL of water.
2. **Place** the beaker on the hotplate and **heat** it at 70–95°C for 20 min.
3. **Filter** the extract through the funnel with cotton wool and **collect** the **Y2** solution in the clean 200 mL glass beaker.
4. **Determine** the order of colour transitions of **Y2** as pH changes using the available solutions and equipment. Using 100 μL of **Y2** per 1 mL of analyte provides the most reliable results.

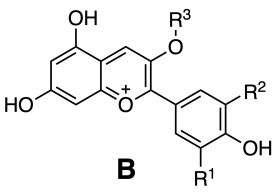
Q3.6 **Arrange** the colours of **Y2** in order of increasing pH using the colour abbreviations listed below. 9 pt

Red/pink	Yellow	Green	Blue	Violet
R	Y	G	B	V

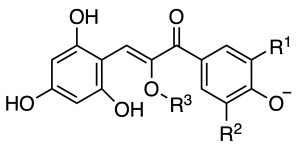
The extract of red cabbage contains anthocyanins responsible for such a wide range of colours. Below are the structures of anthocyanins at different pH:



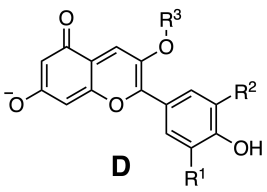
A



B



C



D

Q3.7 **Arrange** **A**–**D** according to which structures are most dominant as the pH is changed from low to high. 2 pt

To prepare **Y1**, Nasreddin mixed two individual indicators from the table:

#	**Indicator**	**pH range of colour changes**
1	Bromophenol blue (**BPB**)	yellow < 3.0 – 4.6 < blue
2	Congo red (**CR**)	blue < 3.0 – 5.2 < red
3	Bromocresol green (**BG**)	yellow < 3.8 – 5.4 < blue
4	Methyl red (**MR**)	red < 4.4 – 6.2 < yellow
5	Chlorophenol red (**CPR**)	yellow < 5.2 – 6.8 < purple
6	Bromothymol blue (**BTB**)	yellow < 6.0 – 7.6 < blue
7	Phenol red (**PR**)	yellow < 6.8 – 8.2 < pink
8	Thymol blue (**TB**)	yellow < 8.0 – 9.6 < blue
9	Phenolphthalein (**PP**)	colourless < 8.2 – 10.0 < pink
10	Alizarin yellow R (**AYR**)	yellow < 10.1 – 12.0 < red

Determine the pH ranges of the colour changes of **Y1** using the pH meter and available solutions. Using 5 μL of **Y1** per 1 mL of analyte provides the most reliable results.

Q3.8 **Tick** the appropriate boxes for the pH ranges of the colour changes of **Y1**. 10 pt

Q3.9 **Determine** the composition of **Y1**. **Tick** the appropriate boxes. 1 pt