Practical Final Exam 2026

CHEMISTRY.
OLYMPIAD.CH
CHEMIE-OLYMPIADE
OLYMPIADES DE CHIMIE
OLIMPIADI DELLA CHIMICA

G0-1

English (Official)

General Instructions

Instructions

- You have 3:00 hours to solve this practical exam. Before starting, you will have 15 min to look through the exam without starting to work.
- Wait for the **START** signal before you begin with the laboratory work.
- Finish your work immediately once the **STOP** signal has been given.
- Write your name on **every** page. If there is insufficient space to solve an exercise on the front page, use the back page and indicate that you did so.
- Only legible answers clearly assignable to problems can be considered. Only materials properly submitted can be considered.
- Write all necessary equations, calculations, observations and data points legibly.
- Do not communicate with other participants during the exam. You may quietly talk with the laboratory assistants after raising your hand.
- Stay at your designated workspace. Only leave the working area if you have been given permission to do so.
- You may ask the laboratory assistants for more deionised water, crushed ice, gloves and emptying of your waste beakers.
- You have one free request to replace a piece of glassware or a chemical. Any further replacements will lead to a deduction of points.
- Hazardous, reckless or unfair behaviour may lead to disqualification from this exam.
- This exam has **3** problems.

Good luck!

Viel Erfolg!

Bonne chance!

Buona fortuna!

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G0-2

English (Official)

Safety Instructions

Read carefully before starting the examination.

By continuing with this practical exam, you **confirm** that you understand and agree to follow all safety instructions.

GENERAL CONDUCT

- **Follow** all instructions given in the exam paper and by supervisors. **Do not perform** any unauthorised experiments.
- **Work** calmly and responsibly at all times. Running, horseplay, or distracting others is **not permitted**.
- **Keep** your workspace tidy. **Clean up** spills immediately and **dispose** of waste only as instructed.
- Eating, drinking, or chewing gum in the laboratory **is strictly prohibited**.

PERSONAL PROTECTIVE EQUIPMENT

- Safety goggles **must be worn** in the laboratory at all times. **Do not wear** contact lenses.
- **Wear** a laboratory coat and **ensure** long hair is tied back.
- Closed shoes are mandatory; loose clothing and jewelry **must be secured**.

CHEMICALS AND EQUIPMENT

- **Handle** all chemicals as if they are potentially hazardous.
- **Never taste** chemicals. **Do not smell** substances directly; waft vapours only if instructed.
- **Use only** the quantities specified in the exam instructions.
- **Do not return** unused chemicals to stock bottles.
- **Take particular care** when working with heat, glassware, or sharp objects.

ACCIDENTS AND EMERGENCIES

- **Report** any accident, injury, spill, or breakage to a supervisor immediately, no matter how minor.
- **Be aware** of the location of safety equipment such as eyewash stations, fire blankets, and fire extinguishers.
- **Follow** all instructions given by supervisors in the event of an emergency.

END OF EXAMINATION

- **Switch off** all equipment and **leave** your workspace clean and orderly.
- **Wash** your hands thoroughly before leaving the laboratory.

Failure to comply with these safety rules may result in disqualification from the examination.

Periodic Table of Elements

1 H 1.008																	2 He 4.003
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc [98]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57–71	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [212]
87 Fr [223]	88 Ra [226]	89–103	104 Rf [267]	105 Db [268]	106 Sg [269]	107 Bh [270]	108 Hs [270]	109 Mt [278]	110 Ds [281]	111 Rg [282]	112 Cn [285]	113 Nh [286]	114 Fl [289]	115 Mc [290]	116 Lv [293]	117 Ts [294]	118 Og [294]

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 140.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [266]

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Score Sheet

Problem	Title	Points	Percentage
Q1	Measuring Magnesium	40.0 pt	37%
Q2	Diels-Alder: The Lord of the (Fused) Rings	27.0 pt	34%
Q3	Incognito Ions	32.0 pts	29%
Total			**100%**

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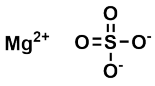
Q1-1

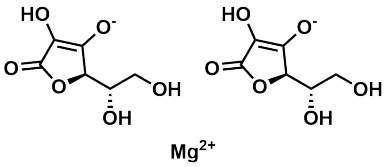
English (Official)

Measuring Magnesium 37%

In this problem, you will be determining the composition of a sample containing magnesium(II) sulfate $MgSO_4$ and magnesium(II) ascorbate, $Mg(asc)_2$, using different titration techniques.



Magnesium sulfate



Magnesium ascorbate

Materials

- 1 × 10.00 mL volumetric pipette
- 1 × 50 mL graduated cylinder
- 1 × 50 mL burette
- 1 × small glass funnel
- 1 × squirt bottle containing deionised water
- 1 × universal pH indicator paper strips
- 5 × plastic pipette
- 1 × 10 mL graduated pipette
- 1 × 100 mL beaker
- 1 × Schott flask labelled "Waste Q1"
- 1 × small metal spatula
- 1 × stirring plate/hot plate
- 1 × 100 mL volumetric flask containing sample
- 3 × 200 mL Erlenmeyer flask

Chemicals

- 120 mL 0.010 mol L^{-1} EDTA solution
- 75 mL Schwarzenbach buffer, pH 10
- vial with a small amount of Eriochrome T dispersed in sodium chloride
- 120 mL 0.010 mol L^{-1} Iodine solution
- 10 mL 1% aqueous starch solution
- 1 × solution in 100 mL volumetric flask containing acidified $MgSO_4$, $Mg(asc)_2$

Safety

- $MgSO_4$ and $Mg(asc)_2$ are not classified as hazardous but **should be handled** with care. **Avoid** unnecessary exposure, inhalation of dust, and contact with eyes or bare skin, as mild irritation may occur.
- EDTA and Eriochrome T may be harmful if swallowed and may cause irritation to the skin and eyes. Dust may irritate the respiratory tract. **Avoid** inhalation and contact with skin and eyes.
- Dilute sulfuric acid and Schwarzenbach buffer (containing ammonia and ammonium salts) may cause irritation to the skin, eyes, and respiratory tract. **Avoid** contact with skin and eyes and avoid inhalation of vapours. Although dilute, exposure **should be kept** to a minimum.
- Iodine is an irritant and oxidising agent that is known for staining (skin). **Wear** goggles and gloves when handling it. **Clean up** small spills with a paper towel.

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Q1-3

English (Official)

Procedure

Complexometric Titration of Mg^{2+}

1. You have received a sample containing unknown amounts of $MgSO_4$ and $Mg(asc)_2$ in a 100.00 mL volumetric flask. **Fill** the volumetric flask with deionised water to the 100.00 mL mark and **mix** well. This solution will from now on be referred to as "the sample solution".
2. **Transfer** 10.00 mL of your sample solution into a clean 200 mL wide-necked Erlenmeyer flask using a volumetric pipette.
3. **Add** 15 mL of buffer solution.
4. **Dilute** the solution with deionised water until approximately 50 mL.
5. **Check** the pH of your solution using pH paper strips. It should be around pH = 10. If necessary, **adjust** the pH of your solution using the buffer solution until pH = 10.
6. While swirling the solution, **add** a small amount (tip of a spatula) of the indicator Eriochrome T. **Avoid** adding too much indicator to make the titration as accurate as possible. Your solution should have a light wine-red colour.
7. **Fill** your 50 mL burette with 0.010 mol L^{-1} EDTA solution.
8. **Titrate** the solution in your 200 mL Erlenmeyer flask slowly, until you achieve a persistent colour change from red to blue. As soon as you observe the colour change, **stop** the titration and **note** the volume of EDTA solution you used in the table below.
9. **Dispose** of any generated aqueous waste in the waste container labelled "Waste Q1".
10. **Repeat** steps 2 to 9 as many times as you deem necessary.

Titration Run	V_{EDTA} / mL
1	
2	
3	
4	
5	

Iodometric Titration

1. **Transfer** 10.00 mL of your sample solution into a 200 mL wide-necked Erlenmeyer flask using a volumetric pipette.
2. **Dilute** the solution with deionised water to approximately 50 mL.
3. **Add** ten drops of starch solution.
4. **Fill** your 50 mL burette with 0.010 mol L^{-1} iodine solution.
5. **Titrate** the solution in your 200 mL Erlenmeyer flask slowly, until the solution is no longer colourless. **Stop** the titration and **note down** the volume of iodine solution you used in the respective table below.
6. **Dispose** of any generated aqueous waste in the waste container labelled "Waste Q1".
7. **Repeat** steps 1 to 6 as many times as you deem necessary.

Titration Run	V_{I_2} / mL
1	
2	
3	
4	
5	

Theory Questions

1.1 **Give** your accepted values for the volumes of EDTA and I_2 necessary to reach the respective endpoints. 30.0 pt

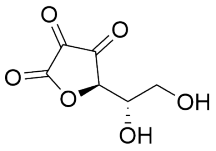
$V_{EDTA} =$ _____ mL $V_{I_2} =$ _____ mL

1.2 **Explain** which chemical species give rise to the red and blue colour respectively in the complexometric titration. 1.0 pt

1.3 **Calculate** the total mass of magnesium in grams in the sample you received for this task using your results. **Note:** If you do not have an accepted volume, you may use $V'_{EDTA} = 30.15\,mL$ instead. The molar mass of Mg^{2+} is $M_{Mg^{2+}} = 24.305\,g\,mol^{-1}$. 2.5 pt

$m_{Mg^{2+}} =$ _____ g

1.4 **Write down** the stoichiometric equation for the iodometric titration. **Use** the molecular formula for ascorbic acid and its oxidised product. **Hint**: The structure of the oxidation product of ascorbic acid is shown below: 2.0 pt



1.5 **Calculate** the total mass of ascorbate in grams in the sample you received for this task. **Note**: If you do not have an accepted volume, you may use $V'_{I_2} = 12.75\,\text{mL}$ instead. The molar mass of ascorbate is $M_{asc^-} = 175.124\,\text{g mol}^{-1}$. 2.5 pt

$m_{asc^-} =$ _____ g

1.6 **Write down** the formula for calculating the total mass of sulfate $m_{SO_4^{2-}}$ in the sample you received for this task, given the moles of magnesium $n_{Mg^{2+}}$ and ascorbate n_{asc^-}. 1.0 pt

1.7 **Explain** how you would directly determine the total amount of sulfate in the sample. 1.0 pt

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Q2-1

English (Official)

Diels-Alder: The Lord of the (Fused) Ring 34%

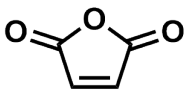
One of the earliest reports of the Diels-Alder reaction dates to January 1929, when the German chemists Otto Diels and Kurt Alder reported their publication titled: "Synthesen in der hydro-aromatischen Reihe, II. Mitteilung: Über Cantharidin". The authors were attempting the synthesis of various interesting natural products, including Cantharidin. They discovered that furan and cyclopentadiene react readily with maleic anhydride, producing bicyclic ring structures, which were further elaborated into derivatives of natural products, such as Cantharidin.

In a Diels-Alder reaction, an electron-rich diene reacts with an electron-poor dieneophile, producing a substituted cyclohexene. If cyclic dienes, for example, furan, are used, the products of the Diels-Alder reaction are bicyclic ring structures, which are hard to synthesise with other methods.

Although this reaction was reported almost a century ago, it is still subject to discussion, especially concerning the stereochemical course of the reaction.

Today, we are going to replicate the reaction between furan and maleic anhydride.

Furan



Maleic anhydride

Materials

- 1 × 10 mL graduated pipette
- 2 × 100 mL round-bottom flask
- 1 × ice bath
- 1 × stirring plate/hot plate
- 1 × weighed glass vial with your name
- 1 × stir bar
- 4 × plastic pipette
- 1 × Büchner filter
- 2 × filter paper fitting for Büchner funnel
- 1 × suction flask
- 1 × reflux condenser
- 1 × spatula

Chemicals

2.00 g maleic anhydride
30 mL diethyl ether
4.0 mL furan ($\rho_{\text{furan}} = 0.936\,\text{g}\,\text{cm}^{-3}$), in a 100 ml round-bottomed flask on your bench
deionised water
20 mL ethyl acetate
crushed ice

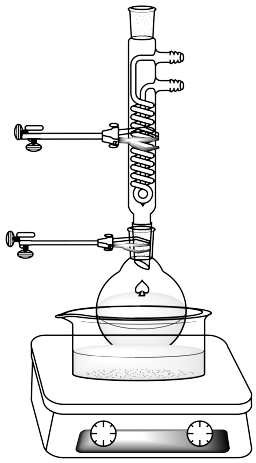
Safety

- Diethyl ether, ethyl acetate and furan are highly flammable liquids whose vapours may form explosive or flammable mixtures with air. **Keep** them away from heat, sparks, and open flames, and **use only** in well-ventilated areas. **Avoid** direct inhalation of vapours and unnecessary exposure, as vapours may cause dizziness or irritation and contact with skin or eyes may cause irritation. Exposure to furan **should be kept** to an absolute minimum, and prolonged exposure **should be avoided**.
- Maleic anhydride is a corrosive and sensitising substance that may cause severe irritation or burns to the skin and eyes and may irritate the respiratory tract. **Avoid** inhalation of dust or vapours and **prevent** contact with skin and eyes. Exposure **should be kept** to a minimum, and prolonged or repeated exposure **should be avoided**, as allergic reactions may occur after repeated contact.

Procedure

Synthesis

1. **Add** 12 mL of diethyl ether to the 100 mL round-bottom flask containing 4.0 mL of furan.
2. **Add** a stir bar.
3. **Stir** the mixture until a homogeneous solution is obtained.
4. **Add** 2.00 g (all of your) solid maleic anhydride, provided to you in a glass vial.
5. **Keep** the reaction mixture at room temperature until all the maleic anhydride has dissolved.
6. **Add** the reflux condenser to the flask and **raise** your hand, so an assistant can come to check your setup, shown in the figure below, and help you start the heating to 35 °C. **Monitor** the temperature continuously with a thermometer.
7. **Keep stirring** the reaction for at least 60 min.
8. **Let** the reaction cool down to room temperature.
9. **Filter** the precipitated product using a Büchner filter. **Keep** the filtrate in the flask until the end of the exam.
10. **Wash** your product with 3 mL ice-cold diethyl ether.



Set-up with the 100 mL round-bottomed flask and reflux condenser clamped over a water bath.

Purification by Recrystallisation

1. **Add** your solid product to a clean, 100 mL round-bottom flask equipped with a stir bar.
2. **Add** 1 mL of ethyl acetate.
3. **Raise** your hand, so an assistant can come to check your setup and help you start the heating of the water bath to 80 °C.
4. When the ethyl acetate starts boiling, **add** more ethyl acetate (only a small amount, a few drops at a time) and **stir** the solution until the solution is boiling again.
5. **Repeat** this process of adding small amounts of ethyl acetate at boiling temperature until all the

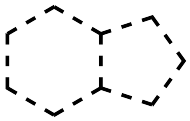
product has dissolved. **Make sure** to use as little solvent as possible.

6. **Stop** the heating and **let** the solution cool back down to room temperature.
7. **Cool** the solution further by placing it into an ice water bath for 15 min. **Request** an ice bath from your laboratory assistants.
8. **Filter** the precipitated product using a Büchner filter.
9. **Leave** the product to dry further for at least 15 min (vacuum off).

Theory Questions

2.1 **Transfer** the solid into the glass vial labelled with "Product" and **place it** on the first level of your workspace shelf. 20.0 pt

2.2 **Draw** the product of the reaction. You can use the provided molecular scaffold below. **Hint:** The sum formula of the product is $C_8H_6O_4$. 2.0 pt



2.3 **Write down** the formula for calculating the yield of your reaction, given the quantities added to the reaction ($m_{\text{maleic anhydride}}$, V_{furan}, m_{product}, M). Otto, a student at the Swiss Chemistry Olympiad, obtained 3.00 g of product via the same synthesis you just performed. **Calculate** the yield of his synthesis. 3.0 pt

Otto's yield: _____%

2.4 **Explain** the problem with adding too much ethyl acetate during the recrystallisation of the product. 2.0 pt

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Incognito Ions

29%

In this task, you will be performing qualitative inorganic analysis to determine the nature of three solutions, each containing one unknown inorganic salt.

Materials

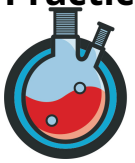
- 1 × test tube rack
- 8 × plastic pipette
- 18 × test tube

Chemicals

- 15 mL 1 mol L^{-1} HCl
- 15 mL 1 mol L^{-1} H_2SO_4
- 15 mL 2 mol L^{-1} NH_3
- 15 mL 1 mol L^{-1} NaOH
- 15 mL unknown sample **A**
- 15 mL unknown sample **B**
- 15 mL unknown sample **C**
- deionised water

Safety

- Dilute solutions of salts **A**, **B** and **C** may be harmful if swallowed and may cause irritation to the skin and eyes. They may additionally stain skin and clothing.
- 1 mol L^{-1} hydrochloric acid and 1 mol L^{-1} sulfuric acid are strongly acidic solutions that may cause irritation or burns to the skin and serious irritation or damage to the eyes. **Avoid** contact with skin and eyes, and **avoid** inhalation of vapours.
- 2 mol L^{-1} ammonia solution and 1 mol L^{-1} sodium hydroxide are strongly alkaline solutions that may cause irritation to the skin and serious irritation or damage to the eyes. Ammonia may also release vapours that irritate the respiratory tract. **Avoid** contact with skin and eyes, and **avoid** inhalation of vapours.



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Q3-2

English (Official)

Identification of Cations

1. **Transfer** a bit (≈ 1 mL) of **A** into one of the test tubes.
2. **Dilute** the aliquot with ≈ 10 mL of water.
3. Carefully **add** some of the 1 mol L^{-1} HCl, drop by drop.
4. **Swirl** the test tube gently.
5. **Add** more of the 1 mol L^{-1} HCl until you have added around 2 mL.
6. **Note** your observations below.
7. **Repeat** steps 1 through 6 with the 1 mol L^{-1} H_2SO_4 first, and then with the 2 mol L^{-1} NH_3 and the 1 mol L^{-1} NaOH.
8. **Repeat** steps 1 through 7 with **B** and then **C** instead of **A**.

	A	**B**	**C**
HCl			
H_2SO_4			
NH_3			
NaOH			

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Identification of Anions

1. **Perform** other tests with the **chemicals listed for this task**.
2. **Note** the observations clearly in the box below.

Ion Reactions

Ion	HCl	H_2SO_4	NH_3	NaOH	additional info.
Ag^+	↓	maybe clouding	maybe brown ↓ excess: sol.	brown ↓	AgCl (colourless) sol. in aq. NH_3 AgBr (pale yellow) sol. in aq. NH_3 AgI (yellow) not sol. in aq. NH_3 AgSCN (colourless) compl. insol. Ag_3PO_4: yellow ↓
Al^{3+}				↓ excess: sol.	
Ba^{2+}		↓ compl. insol.	maybe clouding	maybe clouding	$BaSO_4$ insol. even with excess HCl
Co^{2+}			orange		
Cu^{2+}	in conc. HCl: slight green		turquoise ↓ excess: dark blue sol.	blue ↓	I^-: brown sol.+ white ↓
Cu^+				red ↓	CuSCN ↓
Fe^{2+}			green ↓	green ↓	FeS: insol. black ↓
Fe^{3+}			orange-brown ↓	orange-brown ↓	Fe_2S_3: insol. black ↓ SCN^-: deep red I^-: light brown
Mn^{2+}				black ↓	Mn^{2+} is a very faint pink MnS ↓
Na^+					
NH_4^+				smell	
Ni^{2+}			green ↓ excess: blue sol.	green ↓	
Zn^{2+}			↓ excess: sol.	↓ excess: sol.	ZnS ↓

Theory Questions

It is now your job to determine the composition of **A** (a nitrate salt), **B** and **C**. **Note**: The unknown ions are only from the ones that appear in the table.

3.1 **Fill in** the table with the test reactions. **Note** any further observations and experiments in the appropriate box. 14.0 pt

3.2 **Identify** the cation in **A**. **Justify** your choice with at least two observations. 2.0 pt

Cation: _____

Justification:

3.3 **Identify** the cation in **B**. **Justify** your choice with at least two observations. 2.0 pt

Cation: _____

Justification:

3.4 **Identify** the cation in **C**. **Justify** your choice with at least two observations. 2.0 pt

Cation: _____

Justification:

3.5 **Identify** the anion in **B**. **Justify** your choice with at least two observations. 3.0 pt

Anion: _____

Justification:

3.6 **Identify** the anion in **C**. **Justify** your choice with at least two observations. 3.0 pt

Anion: _____

Justification:

3.7 **Write** balanced chemical equations for the precipitation (and redissolution) of Al^{3+} and (excess) NaOH. 2.0 pt

Precipitation:

Redissolution:

3.8 **Write** a balanced chemical equation for the mixing of Cu^{2+} and I^-. 2.0 pt

3.9 **Write** a balanced chemical equation for the addition of NH_3 to Co^{2+}. 2.0 pt