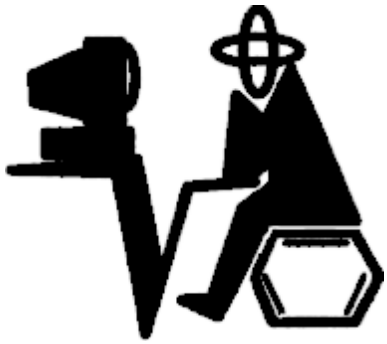
51st INTERNATIONAL MENDELEEV CHEMISTRY OLYMPIAD

April 24-29, 2017

Astana



PRACTICAL EXAM

ASTANA 2017

General directions

1. You will have 15 min to read the text and plan your work before the exam. You are not allowed writing anything or starting the experiment with in this time.

2. Wearing your lab coat and goggles (or you own correcting) is obligatory during the whole experimental exam.

3. Take care when handling the acid and alkali solutions!

4. Fill pipettes using pipette filler only. It is absolutely prohibited to suck solutions into the pipette.

5. The amount of the provided solutions is limited. A spilled or completely used up solution will be replaced with penalty.

6. You are provided with clean dry pipettes and a burette. **Do not spend the solutions for rinsing them**.

7. Pour used solutions into nearest sink (larger or smaller).

8. When working do not interfere with other Olympiad participants. Keep your working place in order.

9. If you have broken anything, ask your lab assistant. He/she will help you disposing the glassware and provide you with the substitute.

10. Use the back side of the booklet sheets for your draft work.

11. Total duration of the exam if 5 hours (including the time allocated for reading). After the STOP command you should immediately stop you work and hand over the Answer Sheets and the synthesis product to your lab assistant.

Chemicals and glassware

Name	Quantity	Lebeled
For each participant		
Potassium iodide, 120 g/L	22 mL	**KI** 12% (m/v)
Hydrochloric acid, 1M.	20 mL	**HCl 1M**
Ethanol 96%	40 mL	**C_2H_5OH**
Phthalic anhydride, solid	0.625 g	**Phthalic anhydride**
Phthalazole (a drug sample) in the 50 mL beaker	The weighed sample	-
Sodium hydrogen carbonate, solid, weighed sample of 2 g	4 pcs.	**$NaHCO_3$**
100 mL beaker (for TLC)	1 pc	**TLC camera**
Plastic watch glass	2 pcs	
25 mL volumetric flask with a stopper	1	
150 mL conical flask for titration with a weighed sample of sulfathiazole (1.25 g)	1 pc.	
250 mL beaker with the thiosulfate solution	50 мл	**$Na_2S_2O_3$ 0.1000 M**
250 mL conical flask (for filtrate)	1 pc.	**For filtrate**
Vial for the product dissolution (for TLC)	1 pc.	
10 mL measuring cylinder	1 pc.	
10 mL graduated pipette	1 pc.	
5 mL graduated pipette	1 pc.	
1 mL graduated pipette	1 pc.	
Burette	1 pc.	
Funnel for filtration	1 pc.	
Small funnel for the burette	1 pc.	
Glass rod	1 pc.	
Wash bottle with distilled water	1 pc.	
TLC plate with UV indicator	1 pc.	
TLC capillary	1 pc.	
Paper filter	1 pc.	
Pipette filler (bulb)	1 pc.	
Lab stand with a burette clamp and a ring	1 pc.	
Graphite pencil	1 pc.	
Tissue gloves (to handle hot glassware)	1 pair	
Rubber stopper	1 pc.	
Shared by two participants		
Heating plate	1 pc.	
Acetic acid, 1:1 v/v	22 mL	**CH_3COOH** 1:1 (v:v)
Sulfuric acid, 1:1 v/v	12 mL	**H_2SO_4** 1:1 (v:v)
Potassium bromide, 10 g/L	100 mL	**KBr 10 g/L**
Sodium nitrite, ca. 0.02 M.	155 mL	**$NaNO_2$**
Tropeolin 00 (indicator), 0.1% solution (in a dropper)	20 mL	**Tropeolin**
Starch, 1% solution (in a dropper)	20 mL	**Starch**
Ruler	1 pc.	

Shared by 10-12 students		
Sodium thiosulfate, 0.1000 M.	400 mL	**$Na_2S_2O_3$ 0.1000 M**
Eluent for TLC	1 pc.	**Eluent**
10 mL measuring cylinder (for the eluent)	1 pc.	
Tweezers	1 pc.	
Marker	1 pc.	
Paper tissues	1 roll	
Latex gloves (choose your size)	M, S, L	
UV lamp	1 pc.	
Common equipment (for a lab)		
Drying oven	1 pc.	

Operating heating plates

- **Grey-white (Fischer)**:

- a plate **with two regulators**: adjust the desired plate temperature with the left regulator

- a plate **with one regulator**: press **Power** button, then press **Heat** button and adjust the desired plate temperature with the round regulator.

- **Blue (IKA)**:

- press the toggle switch (left), **press** the left regulator, adjust the desired plate temperature by rotating it.

The plate temperature should be selected by the trial so that the solution boils uniformly (for boiling ethanol, 140-150 deg should be set; for boiling the aqueous solution, 210-230 deg should be set; the proper values differ for different plates and depend on how many beakers are heated simultaneously).

Practical exam	Name	Place #

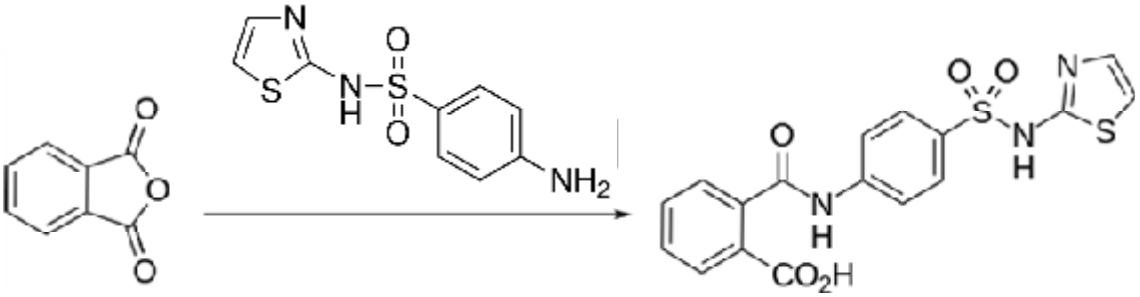
Preparation and titrimetric determination of Phthalazol

Sulfanilamides, derivatives of *p*-aminobenzene sulfonamide (amide of sulfanilic acid), have been used as anti-bacterial drugs since mid-20th Century. Prontosil was the first representative of this group of substances and the first synthetic anti-bacterial drug. Prontosil is not used nowadays, but a variety of its derivatives have been synthesized and put to practice. In particular, Phthalazol and Sulgin are applied to cure infectious deceases of gastrointestinal tract due to slow absorption and prolonged release in the intestine in therapeutic concentration.

In this task you will synthesize phthalazol and determine its quantity by titrimetry. You will also have to standardize the titrant (sodium nitrite).

Part I. Preparation and identification of phthalazol

Phthalazol (Phthalylsulfathiazole, $C_{17}H_{13}N_3O_5S_2$, M = 403 g/mol) is white or yellowish powder (melting point 264-277°C), insoluble in water, dilute acids, ether, and chloroform. It is readily dissolved in dimethylformamide and dilute solutions of alkali, carbonates, and hydrogen carbonates, and is poorly soluble in ethanol and acetone. Phthalazol is typically obtained via heating of 2-(*p*-aminobenzene-sulfonamid)thiazol (sulfathiazole, norsulfazole) with phthalic anhydride in an alcohol or by interfusing these substances:



I.1. Synthesis of phthalazol

Add the weighed sample of phthalic anhydride (0.625 g) and 12 mL of ethanol to the weighed sample of sulfathiazole (1.25 g, in the conical flask). Cover the mixture with the watch glass and gently boil for 5 min avoiding too intense boiling. You will first observe dissolution of all the substances, followed by the product precipitation. Cool down the flask under tap water and add 12 mL of distilled water. Label the filter paper (write your student's code with the graphite pencil). Filter off the precipitate using the paper filter. Transfer the precipitate leftover from the flask onto the filter using several 3-5 mL portions of ethanol.

Place a few corns of the product into the 20 mL vial for further TLC analysis. Fold the filter to avoid the product loss due to the fan in the oven. Place the folded filter onto a plastic watch glass. Ask your lab assistant to place the filter with the product into the drying oven. The product will be weighed by your lab assistant. Before handing your product to your lab assistant please make sure that your filter is labeled.

I.2. Identification of phthalazol by means of thin layer chromatography

First set the chromatography chamber. Using the cylinder, pour 2-3 mL of the eluent (ethanol – acetic acid, 9:1 v/v, placed on the table of common use) in the 100 mL beaker and cover it with the plastic watch glass to saturate the chamber with the solvent vapor. Add about 1 mL of ethanol to the 20 mL vial containing the product corns, and swirl the vial (the product is not completely dissolved due to the low solubility). Using the capillary apply about 1 μL (touch the plate 1-2 times) of the obtained solution onto one of the lines marked with the pencil (the start line). Any excess of the compound on the plate leads to the spot tailing. You are recommended to apply two different volumes of the solution at the start line at 0.5-0.8 cm distance between them. Dry the plate at air and put it into the chamber. (The start line should not be immersed in the eluent!) Let the front attain the second line, then remove it from the beaker (use the tweezers, at the table of common use) and let the eluent evaporate. Write down your student's code with the pencil at the spare part of the plate and observe the spot under the UV lamp (approach your lab assistant). Encircle the spot immediately with the pencil and measure the distance from the start line to the spot center. Write down the result and calculate R_f value:

Distance from the start line to the spot center *l*, cm	
$R_f = l / L$, where *L* is the front line distance	

Deliver the plate with the Answer Sheets. Make sure that there is your student's code at the plates.

Part II. Diazometric determination of phthalazol

Phthalazol determination includes its hydrolysis affording sulfathiazole with subsequent diazotation of the latter. First, you will need to standardize the titrant (sodium nitrite).

II.1.Standardization of sodium nitrite solution

Fill the burette with the standard 0.1000 M sodium thiosulfate solution (your individual portion of the solution is placed in the 250 mL beaker; extra amount of the solution can be found on the table of common use). Place 2 g of sodium hydrogen carbonate (ready-to-use samples are in the 4 mL plastic containers) into the 125 mL conical flask and add 5 mL of the potassium iodide solution (120 g/L). Using the pipette, add 10.0 mL of the sodium nitrite solution to be standardized (approximately 0.02 M) and mix the contents well. When the major part of the sodium hydrogen carbonate sediments, add 1.6mL of acetic acid (1:1) with the pipette, let the acid distribute evenly throughout the solution (*avoid shaking*), and *apply the stopper not tightly*. When the gas evolution is nearly finished, carefully swirl the flask to mix its contents. Once the sodium hydrogen carbonate sediments again, add with pipette 1.2 mL of the sulfuric acid solution (1:1) and *apply the stopper not tightly*. When the carbon dioxide evolution is nearly over (up to 3-4 min), carefully mix the contents by gently swirling the flask. Then rinse the stopper over the flask and the flask walls with 25 mL of distilled water and titrate the sample with the thiosulfate solution till pale yellow coloration. Then add few drops of starch solution and continue titrating the blue solution with vigorous swirling till discoloration.

Practical exam	Name	Place #

Record the data in the table.

Titration number	The initial burette reading, mL	The final burette reading, mL	The volume consumed, mL

Your accepted volume of the thiosulfate solution_____ mL

Questions, section 1 (can be completed later)

1-1. Write down ionic equations of the reactions occurring when potassium iodide is added to sodium nitrite and upon the above titration with thiosulfate:

1-2. Why sodium hydrogen carbonate and acetic acid are added prior to the titration? Write down equation of the side reaction, which would have garbled the titration result in the absence of hydrogen carbonate:

1-3. Why sulfuric acid is added? Write down ionic equations of the reactions occurring in the system after addition of sulfuric acid (recall the system appearance; the previously given reactions can be written once again):

1-4. Calculate the sodium nitrite concentration based on the titration results:

Concentration of the standard sodium nitrite solution: _____ M

II.2. Phthalazol hydrolysis

Add with cylinder 10 mL of 1 M hydrochloric acid to phthalazol weighed sample placed in the 50 mL beaker. Cover the beaker with the small watch glass and heat it up to boiling on the heater regularly mixing the contents with the glass rod. Maintain intense boiling to avoid precipitate disposal at the beaker bottom (the precipitate disposal at the bottom leads to uncontrolled mixture splashing).

Adjust the heater so that the boiling is even (typically when the regulator is at 210–230 ^{o}C, still can be different from heater to heater!). Boil the mixture for 30 min. You can add hydrochloric acid in case of evaporation (note you will need the acid for diazotation, see Section II.3). Cool down the mixture containg the precipitate, transfer it quantitatively into the 25 mL volumetric flask and bring up to the mark with distilled water.

II.3. Sulfathiazole determination by diazometry

The method is applied for determination of primary amines bearing sulfanilamide moiety, including amines appearing as a result of phthalazol or acetyl sulphonyl guanidine hydrolysis. You will hydrolyze the given phthalazol sample and titrate the obtained sulfathiazole by using diazotation with sodium nitrite in acidic medium. The titration end point is determined following the change of the tropeolin 00 indicator color due to its oxidation by nitrous acid.

Add 1 mL of 1 M hydrochloric acid with pipette and 5 mL of KBr solution (10 mg/mL) with cylinder to the 2.0 mL aliquot of the analyzed solution in the conical flask for titration. Titrate the mixtures with the previously standardized sodium nitrite solution in the presence of tropeolin 00 indicator (ca. 2 drops of the 0.1 % solution). Do not harry while titrating (consume ca. 3 mL of the titrant per min). In the course of titration, the crimson-red mixture turns yellow-orange, which is followed by the abrupt transfer into yellow color at the titration end point. *Note*. Keep the overtitrated solution in a beaker or large conical flask to use it as the reference providing for more precise recording of the titration end point.

Practical exam	Name	Place #

Record the data in the table.

Titration number	The initial burette reading, mL	The final burette reading, mL	The volume consumed, mL

Your accepted volume of the nitrite solution_____ mL

Questions, section 2

2-1. Write down ionic equation of the sulfathiazole diazotation. Denote sulfathiazole as $R–NH_2$:

2-2. Calculate the sulfathiazole concentration (M) in the volumetric flask:

Sulfathiazole concentration: M