2007 U. S. NATIONAL CHEMISTRY OLYMPIAD

NATIONAL EXAM—PART III

Prepared by the American Chemical Society Olympiad Laboratory Practical Task Force

OLYMPIAD LABORATORY PRACTICAL TASK FORCE

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DIRECTIONS TO THE EXAMINER–PART III

The laboratory practical part of the National Olympiad Examination is designed to test skills related to the laboratory. Because the format of this part of the test is quite different from the first two parts, there is a separate, detailed set of instructions for the examiner. This gives explicit directions for setting up and administering the laboratory practical.

There are two laboratory tasks to be completed during the 90 minutes allotted to this part of the test. Students do not need to stop between tasks, but are responsible for using the time in the best way possible. Each procedure must be approved for safety by the examiner before the student begins that procedure.

Part III **2 lab problems** **laboratory practical** **1 hour, 30 minutes**

Students should be permitted to use non-programmable calculators.

DIRECTIONS TO THE EXAMINEE–PART III

DO NOT TURN THE PAGE UNTIL DIRECTED TO DO SO. WHEN DIRECTED, TURN TO PAGE 2 AND READ THE INTRODUCTION AND SAFETY CONSIDERATIONS CAREFULLY BEFORE YOU PROCEED.

There are two laboratory-related tasks for you to complete during the next 90 minutes. There is no need to stop between tasks or to do them in the given order. Simply proceed at your own pace from one to the other, using your time productively. You are required to have a procedure for each problem approved for safety by an examiner before you carry out any experimentation on that problem. You are permitted to use a non-programmable calculator. At the end of the 90 minutes, all answer sheets should be turned in. Be sure that you have filled in all the required information at the top of each answer sheet. Carefully follow all directions from your examiner for safety procedures and the proper disposal of chemicals at your examining site.

2007 UNITED STATES NATIONAL CHEMISTRY OLYM
PART III — LABORATORY PRACTICAL

Student Instructions

Introduction

These problems test your ability to design and carry out laboratory experiments and to draw conclusions from your experimental work. You will be graded on your experimental design, on your skills in data collection, and on the accuracy and precision of your results. Clarity of thinking and communication are also components of successful solutions to these problems, so make your written responses as clear and concise as possible.

Safety Considerations

You are required to wear approved eye protection at all times during this laboratory practical. You also must follow all directions given by your examiner for dealing with spills and with disposal of wastes.

Lab Problem 1

You have been given two ionic solutions, 0.10 M unknown salt, $M\text{Cl}_x$ solution and 0.10 M sodium solution, $\text{Na}_z Y$. Devise and carry out an experiment to determine the identity of the unknown metal cation and the unknown anion in these solutions. The possible cations are potassium, zinc, aluminum, or silver. The possible anions are nitrate, carbonate, phosphate, or sulfide.
You should provide both *quantitative* and *qualitative* evidence to support your answers.

Lab Problem 2

LDPE (low density polyethylene, #4) is a petroleum-based polymer used to make flexible bottles, films, and plastic containers. Given water, ethanol (density = 0.789 $\text{g}\cdot\text{mL}^{-1}$), and the equipment provided, devise and carry out an experiment to precisely determine the thickness of the LDPE samples provided

Answer Sheet for Laboratory Practical **Problem 1**

Student's Name: _____

Student's School: _____ **Date:** _____

Proctor's Name: _____

ACS Section Name : _____ **Student's USNCO test #:** _____

1. Give a brief description of your experimental plan.

Before beginning your experiment, you must get approval (for safety reasons) from the examiner.	**Examiner's Initials:**

2. Record your data and other observations.

3. Calculations and Conclusions.

Answer Sheet for Laboratory Practical **Problem 2**

Student's Name: _____

Student's School:_____ **Date:** _____

Proctor's Name: _____

ACS Section Name :_____**Student's USNCO test #:** _____

1. Give a brief description of your experimental plan.

Before beginning your experiment, you must get approval (for safety reasons) from the examiner.	**Examiner's Initials:**

2. Record your data and other observations.

3. Calculations and Conclusions.

Your reported thickness of LDPE =

PERIODIC TABLE OF THE ELEMENTS

1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											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** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	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** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	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** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 181.0	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (269)	111 **Rg** (272)	112 **Uub** (277)		114 **Uuq** (???)		116 **Uuh** (???)		118 **Uuo** (???)

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	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** (260)

2007 U. S. NATIONAL CHEMISTRY OLYMPIAD

NATIONAL EXAM—PART III - ANSWERS

Prepared by the American Chemical Society Olympiad
Laboratory Practical Task Force

Lab Problem #1

This problem involves knowledge of solubility rules and precipitation reactions. In addition, the identification of the unknown cation and anion requires relating the volumes (drops) of the reacting solutions to the quantity of precipitate produced and hence, to the molar ratios of the reacting ions.

Plan

The plan should include both an intention to gather qualitative information about the individual solutions and the mixture and quantitative information related to the quantity of precipitate produced upon combining the two solutions.

Qualitative observations

Both solutions are clear and colorless.
There is no odor from the anion solution.
When mixed, a white precipitate is formed.
No bubbles/gas is produced.

Quantitative observations

When the two solutions are mixed in test tubes so that the ratio of the cation and anion are varied in a systematic manner the quantity of precipitate should be greatest in the tube with a 3:2 ratio of MCl_x:Na_zY.

Excellent Student Results

Student included a range of qualitative observations and reasoning based on them such as;

Clear MCl_x solution indicates the absence of Ag^+ since AgCl is insoluble.

Lack of odor in Na_zY solution indicates the absence of S^{2-}.

Appearance of precipitate indicates the absence of K^+ and NO_3^- ions since all their compounds are soluble.

Lack of bubbles in Na_zY solution and upon mixing indicates absence of CO_3^{2-}.

Possible cations are Zn^{2+} and Al^{3+} while the anion is most likely PO_4^{3-}.

Student provided a clear explanation of the variation of the number of drops to determine the stoichiometry ratio of MCl_x:Na_zY.

Student gave a clear data table with several trials to demonstrate the 3:2 ratio of MCl_x:Na_zY.

Student identified the cation as Zn^{2+} and the anion as PO_4^{3-}.

Average Student Results

Some qualitative information is given to demonstrate a knowledge of solubility and precipitation.
Student provided evidence of several combinations of the two solutions and may have inferred about the relationship between the solution ratio and identity of the salts.

Below Average Student Results

Little or no qualitative information was reported or used to make predictions about the identity of the unknown cation and anion.
Student either did not report any quantitative information or was unable to use the quantitative information acquired to infer any information about the reaction stoichiometry from it.

##########

Lab Problem #2

Excellent Students Results:

Student proposed a clear, detailed procedure for determining the thickness of the LDPE sheet, recognizing that measuring the volume of such a sheet directly would not be possible because of the small volume. Excellent procedures invariably involved measuring the density of the plastic; good methods included making a series of ethanol-water mixtures and interpolating the mixture of neutral buoyancy, or starting with one liquid and adding the other until neutral buoyancy was achieved. Density of the neutrally buoyant liquid was measured either by using the weighted average of ethanol or water, or by direct measurement of the mass of a known volume of the liquid.

Student performed several buoyancy trials, either using a variety of water-ethanol volume ratios in a series of standards, or by redetermining the point of neutral buoyancy. Results were clearly displayed in a data table. Area and mass of LDPE piece(s) were measured in duplicate.
Calculations are clearly shown using proper unit measurements and significant figures in final answers.
Student demonstrated knowledge of the assumptions used in calculation (for example, the assumption of additive volumes if density of the neutrally buoyant mixture was calculated rather than measured directly).
Final value for thickness was within 20% of the accepted value.

Average Student Results:

Measurement of density was proposed, but not clearly thought out; or, less precise procedures for determining volume directly (e.g., by displacement of liquid in the graduated cylinder) were proposed.
Student made only qualitative (floats in water, sinks in ethanol) or grossly erroneous measurements of density.
Only one trial was performed.
Final value for thickness was within 40% of the accepted value.

Below Average Student Results:

Procedure was vague or unintelligible.
Calculations were unclear or in error.
Final value for thickness was over 40% off from the accepted value.