Chemical Institute of Canada | ***For Our Future***
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THE 2016 CANADIAN CHEMISTRY CONTEST
for High School and CEGEP Students

PART B – EXTENDED RESPONSE SECTION (90 minutes)

In this section, respond to **TWO** questions. For each question, write a scientific essay including appropriate equations, formulae and diagrams. Each essay is of equal value. The quality of **both** responses is considered in the final competition. Allocate approximately equal time to each question. The judging is based on the accuracy of the information and presentation of the responses. A clear, concise, well-organized piece of written work will be rated more highly than a long rambling one. A scientific calculator is allowed. No phones or any communication devices are allowed.

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1) Experiment Design: Identifying an Unknown Solution

You must identify the contents of a 500 mL bottle of an unknown clear solution found in the acid/base chemical storage area in your high school. Universal indicator paper qualitatively indicates the solution has a pH of 3.

Write a procedure outlining how you would experimentally determine the **identity and concentration** of the unknown solution. You may use any equipment, reagents, and materials typically found in a high school chemistry classroom. Clearly present your experimental steps and the reasoning behind them. You must demonstrate a thorough understanding of the experiment you are performing, the data you need to collect, and the data analysis you must perform.

Apply all of the necessary precautions normally used while handling any acid or base. Your high school only has hydrochloric acid, acetic acid (CH_3COOH, $K_a = 1.8 \times 10^{-5}$), lactic acid ($HC_3H_5O_3$, $K_a = 1.38 \times 10^{-4}$), monochloroacetic acid ($HC_2H_2ClO_2$, $K_a = 1.35 \times 10^{-3}$), sodium hydroxide, and ammonia (NH_3, $K_b = 1.8 \times 10^{-5}$) in stock, and your unknown solution must be one of these.

2) Catalytic Chemistry

Catalysts are everywhere. In our bodies, enzymes catalyze all sorts of reactions. New photocatalytic processes split water into hydrogen and oxygen and many industrial processes depend on catalysts. Catalysis is essential not only in research but also for the global economy and for technological advancement. Many commercial chemical products require one or more catalytic steps in their syntheses and approximately one fifth of Nobel Prizes awarded in Chemistry have been for applications of catalysis.

Discuss the use of catalysis in at least two different fields, including but not limited to biochemistry, organic chemistry, inorganic chemistry, and materials chemistry. In your essay, be sure to explain how catalysts work and why they are useful, and provide specific examples to support your discussion.

3) The Future of the Periodic Table

On December 30th, 2015, IUPAC ratified the existence of four new elements, giving credit for element 113 to Japanese researchers at the RIKEN institute in Wako, Japan, and elements 115, 117 and 118 to the collaboration among the Joint Institute for Nuclear Research in Dubna, Russia, the Lawrence Livermore National Laboratory in California, USA and the Oak Ridge National Laboratory in Tennessee, USA (International Union of Pure and Applied Chemistry, 2016). These elements are still unnamed. According to the IUPAC rules for naming, names should relate to a mythological concept, a mineral, a place or country, a property, or a scientist. The names of all new elements must have the ending "-ium" for groups 1-16, "ine for elements of group 17 and "-on" for group 18 (International Union of Pure and Applied Chemistry, 2015). Discuss these new discoveries by addressing one or both of the following questions:

1) What names would you propose for the new elements? Provide a rational based on historical precedent or chemical importance for the names you propose.
2) Many newspaper headlines stated: "the Periodic Table is now complete". Does the discovery of these four new elements mark the end of the discovery of any further new elements? Provide a solid rationale for your answer.

4) New Safety Standards in Canada

On June 1st, 2015, Canada adopted WHMIS 2015 to align the former Workplace Hazardous Materials Information System with the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). The GHS calls for more clarity in the safe labelling of a wider variety of substances; for example, the GHS includes specific symbols for classifying substances that negatively impact the environment or human health.

Discuss chemical lab safety in your high school laboratory by addressing how educational environments and industry create a culture of safety by enforcing WHMIS 2015 and other safety precautions in the lab. Use specific situations to illustrate your points. You may also want to address cost implications, training implications, the potential for green chemistry, and the responsibility of students, teachers and schools/workplaces for ensuring safety in chemistry labs.