Chemical Institute of Canada | ***For Our Future***
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THE 2014 CANADIAN CHEMISTRY CONTEST

for High School and CEGEP Students

PART B – EXTENDED RESPONSE SECTION (90 minutes)

In this section you should respond to **TWO** questions only, writing in the form of scientific essays (for number 1, an experimental description) including any appropriate equations, formulae and diagrams. Some suggestions are made about the direction(s) you could take, but these are not exclusive. Each essay is of equal value, and the quality of **both** responses will be considered in the final competition: you should therefore allocate approximately equal time to each of the subjects you choose. The judging of the responses will be based on both factual accuracy and presentation. A clear, concise and well-organized piece of written work will be rated more highly than a long rambling one that contains the same information. A scientific calculator is allowed. No phones or any devices that can be used for communication are allowed.

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1) Experiment Design: Producing 25.0 mL of Hydrogen Gas

Given 1.00 L of 6.0 mol L^{-1} HCl and 25.00 g of magnesium ribbon, distilled water and all of the apparatus commonly found in a high school chemical laboratory including, but not limited to, gas measuring apparatus (e.g. eudiometer, gas collection jar), thermometer and barometer, write a clear procedure for how you would accurately produce a 25.0 mL volume of hydrogen gas at Standard Temperature and Pressure (0°C and 100 kPa). You should provide any relevant chemical equations, clearly outlined calculations and a clearly outlined equipment set-up (you may want to include a diagram for clarity). In your procedure, you must indicate the specific equipment used and the precise amounts of reagents used in each step. A numbered step procedure is preferable to a procedure written in a paragraph. Showing an understanding of what it means to equalize the pressure of a gas and how that can be achieved in a laboratory is important.

After providing your procedure you should include a paragraph outlining at least two sources of error that could occur and the degree to which these errors might affect your results.

2) Chemistry is pHun.

Acid-base chemistry includes topics such as pH, pOH, equilibrium constants (K_a, K_b), pK_a, pK_b, titrations, salts, equivalence points, half-equivalence points, indicators and buffers, and equipment such as pH meters, burets and pipets. Discuss the importance of acid-base chemistry to everyday life and how a thorough understanding of acids and bases can help students understand everyday occurrences, consumer products, and medical conditions. In your discussion, try to address one or two practical applications in depth rather than several superficially. Your discussion should demonstrate that you have in-depth understanding of acid-base chemistry and that you understand how acid-base chemistry applies to everyday-life.

3) What is the Atom?

Atomic theory is arguably the most fundamental concept in chemistry. Discuss the progress of atomic theory from the initial conceptualization of a smallest, indivisible particle of matter to our present understanding of atomic structure. You need to demonstrate an understanding of the development of atomic theory and an understanding of quantum mechanics in your discussion. You may want to use some of the quotes below to help enrich your discussion:

> "[T]he atoms or elementary particles themselves are not real; they form a world of potentialities or possibilities rather than one of things or facts." — Werner Heisenberg

> "In the world of the very small, where particle and wave aspects of reality are equally significant, things do not behave in any way that we can understand from our experience of the everyday world...all pictures are false, and there is no physical analogy we can make to understand what goes on inside atoms. Atoms behave like atoms, nothing else." — John Gribbin author of: *In Search of Schrödinger's Cat: Quantum Physics and Reality*

4) The Origins of Oxygen and Implications for Earth's Energy Reserves

Oxygen was not originally present in significant quantities in the earth's atmosphere. Approximately 3 billion years ago, oxygen started accumulating in the atmosphere through photosynthesis:

$$\text{energy} + 6\ CO_2\ (g) + 6\ H_2O\ (l) \rightarrow 6\ O_2\ (g) + C_6H_{12}O_6\ (aq)$$

Today, oxygen makes up about 21% of the atmosphere and has contributed significantly to the development of multicellular life by allowing aerobic organisms to evolve and generate chemical energy through respiration:

$$6\ O_2\ (g) + C_6H_{12}O_6\ (aq) \rightarrow \text{energy} + 6\ CO_2\ (g) + 6\ H_2O\ (l)$$

The estimated total mass of the atmosphere is 5.15×10^{18} kg. Proven oil reserves are at an estimated 1526 billion barrels (the estimated mass of a barrel of oil is 140 kg). With 11% of the world's proven oil reserves, Canada is the 3rd largest oil producer in the world. Most of these reserves are in the Alberta oil sands and are part of the world's unconventional oil reserves that until fairly recently were considered too difficult and costly to extract. Conventional oil reserves include natural gas and crude oil that can be extracted from conventional oil wells. Using the concepts of conservation of mass, photosynthesis, and respiration, discuss any or all of the following. Make any reasonable estimates

1) The likelihood of unproven fossil fuel reserves being discovered if every mole of atmospheric oxygen represents a mole of organically-fixed carbon.
2) The environmental effects of the reaction products from burning all organically fixed carbon
3) The environmental effects of using up the reactants from burning all organically fixed carbon.