



Chemical Institute of Canada | **For Our Future**
Institut de chimie du Canada | **Pour notre avenir**

THE 2015 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.

1) Experiment Design: Heating up your coffee, a question of calorimetry

There are many single serve coffee options on the market today. One new option is a thermos with a battery pack and a copper coil which heats 600 mL of water to two different temperatures. The consumer inserts a compostable single serve coffee sachet via a plastic tray directly into the thermos. A copper coil heats the water in the thermos and then the hot water drips through the coffee sachet to make the coffee inside the thermos. Pushing the “on” button once heats the water to 60.0 °C, pushing it twice heats the coffee to 68.3 °C. Propose a design for this thermos. Calculations and diagrams justifying and explaining your design are essential. Make reasonable assumptions in your design proposal. For both coffee temperature options indicate:

- The initial temperature of each component of the system
- The mass of copper needed in your design
- A written description explaining the assumptions you have made and why they are valid for this experimental design.

Include a paragraph outlining at least 2 sources of error and the degree to which these errors might affect your results. The mass of an empty insulated aluminum thermos and battery pack without a copper coil is 500 g. Some useful physical constants are:

specific heat of water	4.184 J g ⁻¹ K ⁻¹
specific heat of copper metal	0.386 J g ⁻¹ K ⁻¹
specific heat of aluminum	0.900 J g ⁻¹ K ⁻¹
density of water	1.000 g cm ⁻³ .

2) Chemistry is solutions

There are very practical reasons for preparing solutions in chemistry. Discuss various aspects of solutions, including what chemical solutions are, concentration and how to express it, how solutions form, why most chemical reactions occur in solution, different types of solutions, solubility, why some substances are more soluble than others, how to increase and decrease the solubility of substances, and the special properties of solutions. 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 solution chemistry and that you understand why solutions are important in chemistry and how solution chemistry applies to everyday-life.

3) Tackling Chemistry's Bad Rap

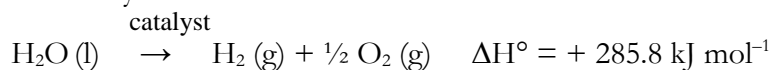
In 2013, a program on the BBC asked: “why do people hate chemicals?” Chemistry arguably has the worst public image among science streams studied in high school. Publishers, other than those of Chemistry textbooks, avoid the use of the word “chemistry” in book titles for fear of diminishing sales. Marketers use meaningless, unregulated slogans like “chemical-free” to boost the public image of their products. The International Union of Pure and Applied Chemistry (IUPAC) defines chemophobia as “the irrational fear of chemicals” (Djerassi, 2004). Today's biggest popular icon in Chemistry is Walter White. The entertainment value of the show “*Breaking Bad*” aside, Walter feeds into the preconceived notion that chemists are mad scientists and chemicals are bad for you.

Discuss between one and four applications of chemistry which positively influence society. Be sure to highlight why chemistry is necessary and what benefits society gains through these chemistry applications. You should conclude with suggestions to improve the public image of chemistry.

4) The potential of fuel cells

Two chemists at the University of Calgary, Curtis Berlinguette and Simon Trudel, have patented a production method for splitting water. They used less expensive catalysts than those previously found on the market to split the water molecule into hydrogen and oxygen gas. Fuel cell cars and fuel cells rely on the clean energy source produced as a result of splitting water into hydrogen and oxygen. The barrier to wide-scale production and use of fuel cells has been the cost of the catalysts required to produce the hydrogen fuel from the electrolysis of water.

The equation for the electrolysis of water is:



Prior to Berlinguette and Trudel's discovery, rare and toxic alloys of iridium or ruthenium were used. Berlinguette and Trudel made catalysts from abundant non-toxic metals such as iron, nickel and cobalt. “We're effectively just taking a nanoparticulate form of rust and binding it with other cheap metals,” Berlinguette said (Halverston, 2013). These cheaper catalysts, which perform as well as the more expensive options, work in what Berlinguette and Trudel call the “electrolyzer”. This groundbreaking development allows the storage of renewable energy (for example solar and wind power) in hydrogen fuel cells. Previously, if the wind was blowing at night and there was little demand for energy, the energy could not be stored for use at a time when there was high demand.

Discuss any or all of the following:

- 1) The entropy, enthalpy, spontaneity of the splitting of water through electrolysis and how renewable energy is used in this process
- 2) How catalysts work and why they are used in chemical reactions.
- 3) If these hydrogen fuel cells store hydrogen, provide a general description of how hydrogen can be used as a fuel to power other processes and why this process is a greener alternative to the burning of fossil fuels.
- 4) Why it is important to ensure that fuel cells are charged using green energy.

References

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- LaMonica, M. (2013, Mar 28). *A Cheaper Way to Make Hydrogen from Water*. Retrieved from Technology Review: <http://www.technologyreview.com/view/512996/a-cheaper-way-to-make-hydrogen-from-water/>