Chemical Institute of Canada | ***For Our Future***
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THE 2021 CANADIAN CHEMISTRY CONTEST
for High School and CEGEP Students

PART B – EXTENDED RESPONSE SECTION (90 minutes)

Students should answer **TWO** questions. All students **must** answer the experimental design question 1; students have the choice between answering **either** question 2 **or** question 3. For each question, students should write a scientific essay including appropriate equations, formulae and diagrams. Each essay is of equal value. Students should allocate equal time to each question. Scorers will consider the presentation, accuracy and quality of the information. A clear, concise, well-organized piece of written work will score higher than a long rambling one. Students may use a scientific calculator but they may not use phones or communication devices.

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1) Experimental Design: The Aluminum Advantage (Mandatory)

Aluminum beverage cans, which have been in use for over 60 years, are the most sustainable beverage packaging option. Aluminum can be recycled indefinitely without losing its integrity and 75% of the aluminum ever produced is still in use today.
Design an experiment, to verify the percent by mass aluminum content in an aluminum beverage can using stoichiometry, gas collection by water displacement, the Ideal Gas Law and Dalton's Law of Partial Pressure. Assume the experiment takes place at 23.0 °C, the partial pressure of water at 23°C is 21.1 mm Hg and atmospheric pressure is 96.3 kPa. Assume you have all of the laboratory equipment you would need to conduct this experiment, the aluminum can weighs between 13 g and 14 g and may be cut into smaller pieces using metal cutting scissors. Clearly present a step-by-step experimental plan and a thorough explanation of how to analyze the data for accurately determining the mass and percent of aluminum in the aluminum can. Drawings of the experimental setup to accompany the procedure would be ideal. Aluminum reacts with strong acids to produce the aluminum salt and hydrogen gas according to the reaction: $2\ Al\ (s) + 6\ H^+\ (aq) \rightarrow 2\ Al^{3+}\ (aq) + 3\ H_2\ (g)$

2) New Standards (Choice)

The Metre Convention, signed in Paris in 1875, is the international agreement on units of measurement in science. The International System of Units and Measures confirmed on May 20th, 2019 that the definition of 4 of the 7 base units: the mole, the kilogram, the kelvin and the ampere would be redefined by deriving them using physical constants including Planck's constant (h), the speed of light in a vaccuum (c), the hyperfine structure transition frequency of the caesium-133 atom, the elementary charge (e), the Boltzmann constant (k) and Avogadro's constant (N_A) rather than physical artifacts such as 0.012 kg of carbon-12 or the international metal prototype of the kilogram.

Incorporate your understanding of the importance of accuracy and precision in chemistry and discuss why this redefinition of SI units has been referred to as potentially the most significant revision to date. Discuss situations where emphasizing accuracy and precision has been important for chemistry. Use your knowledge of significant figures and error analysis to determine the degree to which the change in the definition of SI units will impact the study of chemistry.

3) Clean Energy? (Choice)

Canadians consume approximately 5 times more energy *per capita* than the global average. About 42% of Canada's industrial fuel use is from natural gas. The main component of natural gas is methane. Recently, researchers discovered how to convert methane into methanol at room temperature, avoiding the high temperatures and pressures previously needed for the process. Using your knowledge of the chemical compounds, your understanding of combustion and the data in the table below, discuss why methanol is characterized as a cleaner, more easily stored fuel than methane. Qualitatively compare energy generation from methanol with other sustainable energy generating chemical processes.

Compound	**$\Delta H°_f$ (kJ mol^{-1})**	**Compound**	**$\Delta H°_f$ (kJ mol^{-1})**
CH_4 (g)	-78.4	CO_2 (g)	-393.5
CH_3OH (l)	-238.6	H_2O (g)	-241.8