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THE 2020 CANADIAN CHEMISTRY CONTEST
for High School and CEGEP Students

PART B – EXTENDED RESPONSE SECTION (90 minutes)

Students should answer **TWO** questions as follows: 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: Determine the Percent Oxalate in an Iron Oxalate Complex Salt (mandatory question)

Design an experiment to determine the percent oxalate ($C_2O_4^{2-}$) in an iron oxalate complex salt with the general formula $K_wFe_x(C_2O_4)_y \bullet zH_2O$. The potassium iron oxalate salt is a solid green crystalline structure. The balanced equation for the oxidation of the oxalate ion with permanganate is:

$$16\ H^+ + 5\ C_2O_4^{2-} + 2\ MnO_4^- \rightarrow 10\ CO_2 + 2\ Mn^{2+} + 3\ H_2O$$

You can determine the equivalence point the reaction by titrating dilute acidified aqueous solutions of the potassium iron oxalate salt with standardized 0.010 mol L^{-1} $KMnO_4$ until the solution achieves a light pink colour that persists for 30 s. The reaction of permanganate with oxalate is slow at room temperature and the ideal temperature for the reaction is 75°C.

You have 0.500 g of the potassium iron oxalate salt, 2 L of acidified distilled water for the dissolution of the green crystal, a 50 mL buret, several 250 mL Erlenmeyer flasks, a stirring rod, a 100 mL volumetric flask, an analytical balance which measures to the nearest 0.0005 g, weigh boats, a hot plate, a funnel, a spatula and a mortar and pestle. You also have any other equipment, reagents and materials typically found in a high school chemistry classroom. Clearly present a step-by-step experimental plan and thorough analysis of the data for determining the percent oxalate in the potassium iron oxalate salt. Assume all of the iron in the salt is Fe^{3+}. You must demonstrate a thorough understanding of the experiment you are proposing. Indicate the specific quantities of reagents and the safety precautions you would use, how you would prepare any solutions you require, how you would minimize waste and maximize precision and accuracy, what data you would to collect, and what data analysis you would perform.

2) Van der Waals Forces

The study of Van der Waals intermolecular interactions are part of the chemistry curriculum in every jurisdiction in Canada. Describe what Van der Waals forces are, and discuss their importance in the study of chemistry. How accurately do you think chemists can predict the strength of Van der Waals interactions? Explain your answer and explain why chemists might describe Van der Waals forces as quantum mechanical phenomena.

3) Chemistry's Role in Creating Solutions to Global Challenges.

We hear a lot about the need for solutions to global challenges as the population of the world grows and our equilibrium with the earth is changing. There is frequent public discussion about climate change, air pollution, food security, energy production, energy consumption, poverty, the spread of disease and improving the global standard of living. What do you think the roles of chemistry knowledge and research are in understanding global problems and finding solutions? Be as specific as possible about the chemical concepts you believe will be important in addressing global challenges. In your answer, demonstrate an in depth understanding of chemistry and its application in understanding and tackling global challenges.