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THE 2017 CANADIAN CHEMISTRY CONTEST
for High School and CEGEP Students

PART B – EXTENDED RESPONSE SECTION (90 minutes)

Student will 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. Allocate approximately equal time to each question. Scorers consider the accuracy and quality 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 communication devices are allowed.

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1) Experimental Design: Gravimetric Analysis (mandatory question)

Through gravimetric analysis, researchers can determine the amount of one or more components present in a sample. In this question, you will propose a procedure for determining the percent phosphorus in a sample of commercial fertilizer. The main phosphorus containing component in the fertilizer sample is HPO_4^{2-}. You can precipitate the phosphorus spontaneously, without the addition of heat, according to the following equation:

$$5\ H_2O\ (l) + HPO_4^{2-}\ (aq) + NH_4^{+}\ (aq) + Mg^{2+}\ (aq) + OH^{-}\ (aq) \rightarrow MgNH_4PO_4 \bullet 6H_2O\ (s)$$

You have enough materials for one trial of your experiment. Write clear, step-by-step, detailed and easily -followed procedure to determine the mass of phosphorus in your sample of fertilizer. You have 4.00 g of fertilizer, 0.025 moles of 0.50 mol L^{-1} magnesium sulfate heptahydrate ($MgSO_4 \bullet 7H_2O$) as your source of magnesium ions and 0.30 mol of 2.0 mol L^{-1} ammonium solution, 250 mL beakers, a stirring rod, an electronic balance, funnels, filter paper, a retort stand, clamps, a wash bottle, distilled water, graduated cylinders, pipettes, burettes and safety goggles. Include diagrams of equipment set up and the formulas you would use for calculations you propose. After providing your procedure, outline at least two sources of error and how these errors might affect your results.

2) Thermodynamics

"…the deep impression that classical thermodynamics made upon me. It is the only physical theory of universal content concerning which I am convinced that, within the framework of applicability of its basic concepts, it will never be overthrown." – Einstein (Klein, M., 1967)

What is the study of thermodynamics? What are the laws that govern thermodynamics? Do you think the study of thermodynamics is important in high school chemistry? Why or why not? In your answer, be sure to clearly explain the fundamental terms and concepts involved in thermodynamics and thermochemistry. Where possible use examples to illustrate your ideas.

3) Chemistry and Innovation

New products hit the market everyday. Discuss an innovation based on chemistry that has garnered a lot of attention in the past 15 years. Focus on explaining the chemistry involved in the innovation and discuss two or more of the following: the innovation's benefit to society, environmental impact, sustainability, longevity, effect on the market economy and potential for further development.

References

Klein, M. J. (1967). Thermodynamics in Einstein's Thought. *Science*, 509-516. Retrieved from http://www.rpgroup.caltech.edu/courses/aph105c/2006/articles/Klein_Einstein.pdf