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"Chemists, engineers and technologists working together."
"Les chimistes, les ingénieurs et les technologistes travaillant ensemble."

THE 2013 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.

1) Experiment Design: Determine the Enthalpy of Fusion of Ice

When a solid is heated, the particles in the solid structure eventually gain enough kinetic energy to overcome the intermolecular forces that hold them together in the solid form. This process is called melting. The temperature, measured at a standard pressure of 100 kPa*, at which the solid phase changes to the liquid phase is called the melting point of the substance. The reverse process releases as much heat as is required for melting, and is called freezing. A container with the solid that is melting will remain at the same temperature until all of the solid phase has turned into a liquid. Design an experiment to determine the enthalpy of fusion of ice in kJ mol $^{-1}$. You have access to the following materials: ice, water, an electronic balance, a Styrofoam calorimeter, a thermometer, beakers, and a stirring rod. Design the observation table you would use to record your data and outline the calculations you would use and the experimental errors that would have to be considered in this experiment. If the accepted value of heat of fusion of ice is 334 kJ kg $^{-1}$ and you obtained a value of 5.65 kJ mol $^{-1}$, what is your percent error in this experiment? Suggest what factors in the design of the experiment might have contributed to this error. You may want to discuss the following terms and their relationship to this experiment: heating curve, specific heat capacity, heat, temperature.

2) Why Bother Continuing to Complete Mendeleev's Periodic Table?

In May 2012, IUPAC officially approved the name flerovium (Fl) for the newly discovered element with the atomic number 114 and livermorium (Lv) for the element with the atomic number 116. The credit for the discovery of these elements is attributed to the collaboration between the Flerov Laboratory of Nuclear Reactions in Dubna, Russia and the Lawrence Livermore National Laboratory in California, USA. Neither of these elements have any known use. Scientists continue to devote a great deal of funds and research to discovering new elements (notably, the discovery of elements 113, 115, 117 and 118 are still to be confirmed). Discuss the value of investing in this type of research and the technology that has been developed to enable the discovery of new elements.

Standard Pressure is 100 000 Pa as recommended by IUPAC since 1982
IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997).

3) Green Chemistry: What Is It and Why Practice It?

Many of the chemical processes that are used to make products we use daily (e.g. medicines, plastics, gasoline, fertilizers, pesticides, synthetic fabrics and solvents) can result in harm to the environment and human health. Green Chemistry provides a framework for designing or improving the environmental profile of products, processes and systems. The twelve principles of Green Chemistry* include:

1) Prevention
2) Atom Economy
3) Less Hazardous Chemical Synthesis
4) Designing Safer Chemicals
5) Safer Solvents and Auxiliaries
6) Design for Energy Efficiency
7) Use of Renewable Feedstocks
8) Reduce Derivatives
9) Catalysis
10) Design for Degradation
11) Real-Time analysis of Pollution Prevention
12) Inherently Safer Chemistry for Accident Prevention

Discuss the application of at least two of these principles in an industrial process you know about or in the high school chemistry context. In your answer, you should demonstrate a good understanding of what green chemistry is, how the principle you chose is applied, and why green chemistry practices are desirable.

4) The Battery: the Potential of Electrochemistry

At the core of all electronic gadgets is the battery. It is arguably the greatest determining factor in the size, weight, and output capacity of every new device. The potential of the battery is explained by electrochemistry. Scientists are exploring the promise of lithium-ion-conducting solid electrolytes which may allow higher energy output and safer use than the lithium-ion batteries presently on the market.

The first exploration of electrochemistry involved Luigi Galvani and Alessandro Volta. Galvani was an Italian physician, physicist and philosopher who first observed what he called “animal electricity” when probing a dissected frog with metal instruments. He observed that the frog’s muscle twitched when two different metals were in contact with fluids inside the frog. Galvani argued that the twitch he observed was because of life force within the muscles of the frog.

Alessandro Volta is said to have disagreed with Galvani’s conclusions and he designed a new experiment based on Galvani’s observations. The result was a series of zinc and copper discs in an electrolyte solution of sodium chloride which became known as the voltaic cell, a prototype for the first battery.

Discuss your understanding of electrochemistry and its application to batteries and electrolysis. You should use diagrams, if appropriate, and you should discuss the following concepts and processes: potential difference, current, galvanic cell, electrolytic cell, standard reduction potential, cell potential, electrolyte, electrode, and salt bridge. Use real-world examples to support your explanations.

* Anastas, P. T. and Warner, J. C. Green Chemistry: Theory and Practice. Oxford University Press: New York, 1998, p. 30