



THE 2022 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.

1) Experimental Design: Differentiating Unlabelled Monoprotic Acids (Mandatory)

Given 200 mL quantities of each of three different 1.0 M monoprotic acidic solutions, design an experiment to determine which acid is which, knowing that one is a strong acid, one has a K_a of 1.8×10^{-5} and one has a K_a of 6.2×10^{-10} . You have access to solid sodium hydroxide, a burette, Erlenmeyer flasks, volumetric flasks, pipettes, pipette pumps, an electronic pH meter, universal indicator paper, a burette clamp, distilled water and retort stand as well as any other material and equipment you would commonly find in a high school lab. Clearly present your experimental steps and the reasoning behind them. In your experimental procedure, you should include the ways you might quickly differentiate the acids as well as how you would confirm your results and the acid dissociation constants for the weak acids. You must demonstrate a thorough understanding of the experiment you are performing, the data you need to collect, and the data analysis you must perform. Consider including diagrams to support your procedure and analysis as appropriate.

2) Finding Equilibrium (Choice)

What is chemical equilibrium and what is its importance in the study of chemistry? Using examples of equilibria with which you are familiar, explain the term “dynamic equilibrium” and explain how equilibrium involves opposing processes that occur at the same rate. Using chemical equilibrium systems, explain how buffers work and what the Common Ion Effect is. Explain how to use Le Chatelier’s Principle in a variety of ways to manipulate equilibria and how to precisely predict the equilibrium concentrations of reactants and products given the equilibrium constant for a reaction and initial concentration of reactants and products.

3) The Environmental Impact of Chemical Innovation (Choice)

To be good stewards of our planet, rethinking our daily practices is important. Chemistry research can help us understand the impact humans have on the environment and the changes that are effective in diminishing our environmental footprint. Changing behaviour can be challenging. People tend to hold on to previously held beliefs and practices. Changes also have to be considered thoughtfully as innovations which may seem positive at first glance, might have detrimental, unintended consequences. Over the last 20 years, research into thermodynamics, energy consumption, the design of clothes washing machines and the chemistry of surfactants demonstrate how understanding intermolecular forces, chemical processes and thermodynamics can help industry innovate and reduce human environmental impact. Washing clothes in cold water using a modern washing machine and cold-water surfactant cleans clothes just as effectively, is gentler on fabrics and saves up to 90% of the energy consumed compared with washing a load of laundry in hot water. Despite the research, most members of Canadian society continue to wash their clothes using hot water. Discuss the role of chemistry education, research and development in rethinking laundry and other daily practices. Be sure to demonstrate a thorough understanding of how the concepts you have learned during your study of chemistry are involved in the research, rethinking and education to change past practice and promote positive environmental stewardship.