



# THE CHEMICAL INSTITUTE OF CANADA L'INSTITUT DE CHIMIE DU CANADA

“Chemists, engineers and technologists working together.”

“Les chimistes, les ingénieurs et les technologistes travaillant ensemble.”

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## THE CANADIAN CHEMISTRY CONTEST 2007 for high school and CEGEP students (formerly the National High School Chemistry Examination)

### PART B – EXTENDED RESPONSE SECTION (90 minutes)

In this section you should respond to **TWO** topics only, writing in the form of scientific essays (or, for Question 4, 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/experiment 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.

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#### 1. Period 3

In this essay you should discuss the properties of the Period 3 elements (from sodium to argon) with particular reference to how these elements and their compounds illustrate trends in properties across the Periodic Table. Although it is appropriate to consider atomic scale properties such as atomic and ionic radii, ionization energies, electron affinities and electronegativity, your essay will be more interesting if it shows how these factors are related to macro-scale physical properties such as molar volume, melting points and boiling points, and also to chemical reactivity. With regard to compounds of the elements you might like to consider the periodicity of the formulae of oxides, chlorides and hydrides, together with their chemical properties. You might also wish to discuss the structure and bonding of the elements and their compounds.

#### 2. The Greenhouse Effect

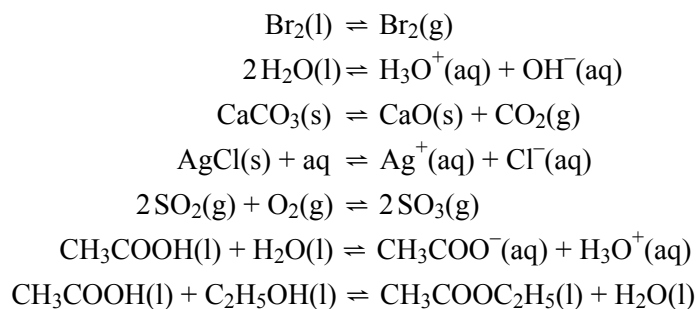
This essay should be written in the form of a magazine article. You should explain what is meant by the greenhouse effect, and how it is important in controlling the climate of the Earth. Some of the gases that you might like to consider are: water vapour, carbon dioxide, methane, ozone, chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and halons (bromine-containing halogenoalkanes). Using some or all of these examples, or other gases of your choice, you should explain the differences between natural greenhouse gases and those that are produced by human activity, and indicate the mechanisms by which the gases are produced by writing chemical equations. You could also discuss the problems that might arise if the concentration of greenhouse gases becomes significantly elevated, and how these difficulties might be averted by human intervention.

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### 3. Chemical Equilibrium

In answering this question you should explain what is meant by dynamic equilibrium systems and how these relate to reversible reactions: in doing this you need to specify the characteristics of dynamic equilibrium. You should also discuss the effect of changing conditions, such as concentration, pressure and temperature, on the position of equilibrium. You should consider Le Châtelier's principle, and how this relates to the equilibrium law expression (equilibrium constant). You might also like to compare equilibrium constants for homogeneous and heterogeneous processes, and to consider "special case" equilibrium constants, such as those governing acid dissociation ( $K_a$ ), solubility ( $K_{sp}$ ), and the ionisation of water ( $K_w$ ). You could also discuss how equilibrium considerations are used to optimise steady state conditions for industrial processes, with appropriate examples.

You may use some or all of the following equations as examples, and/or other reaction equations if you so wish.



### 4. Experimental Design

In this question you are required to design an experiment to determine the enthalpy change of solution (heat of solution) of anhydrous copper sulfate in water, which is a very exothermic reaction.

In your response you should state what you understand by enthalpy change of solution, and outline your experimental procedure, giving details of the apparatus and materials you would need for performing the experiment in a high school laboratory. It is important to specify any safety precautions that might be required. You should indicate what readings you would take and how you would use these readings to calculate a result. You should consider any problems that you might encounter when performing your experiment (including what might happen if the copper sulfate is partly hydrated), and how these factors might give rise to errors in the final value obtained. You might also like to discuss how your experiment could be improved in order to overcome these problems.