Provisional Curriculum
for the Canadian Chemistry Contest (CCC)
for High School and Cégep students.

This curriculum will be used for Parts A and B of the 2010 CCC contest examination[1]. It is based on the Grade 11-12 Chemistry section of the "*Common Framework of Science Learning Outcomes, K to 12"* (Pan-Canadian Protocol) published in 1997. The full version of the Pan-Canadian Protocol is currently available on the legacy website of the Council of Ministers of Education, Canada (CMEC) at http://204.225.6.243/science/framework/, but it should be noted that this website is slated to be discontinued in the coming months.

The CCC curriculum given here lists the required content knowledge only, however the CCC will also test the Science, Technology, Society, and the Environment (STSE) and Skills components associated with the specified curriculum content. Note that the chemistry content from the Pan-Canadian Protocol for Grades 8, 9 and 10 is included, and shown here in **green**. There are also some additions to the content given in the Pan-Canadian Protocol for Grades 11 - 12, which will be tested in the 2010 contest (shown in **red**). This content has been added because it is in most of the Canadian provincial Grade 11 – 12 Chemistry curricula.

Part C of the CCC is used as part of the selection process for the Canadian Chemistry Olympiad team, and requires knowledge of additional topics, see http://www.icho2009.co.uk/files/pdf/IChOsyllabus.pdf for further information.

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0. Safety

It is expected that students will be able to:

0.1 identify the Workplace Hazardous Materials Information System (WHMIS)[2] symbols for compressed gas, flammable and combustible material, oxidising material, poisonous and infectious material, corrosive material, and dangerously reactive materials

0.2 state examples of, and identify materials indicated by the WHMIS symbols listed above

0.3 identify the WHMIS symbols appropriate to different materials

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[1] Part A is the multiple choice section of the examination, which is taken by both by those contestants taking the Chemical Institute of Canada examination (Part B), and those taking the Canadian Chemistry Olympiad examination (Part C).

[2] **Further information about WHMIS can be found at** http://www.ccohs.ca/oshanswers/legisl/intro_whmis.html

0.4 recognize safe handing procedures for materials and apparatus generally found in high school chemistry laboratories

1. Organic Chemistry

It is expected that students will be able to:

1.1 illustrate, using chemical formulas, a wide variety of natural and synthetic compounds that contain carbon

1.2 explain the large number and diversity of organic compounds with reference to the unique nature of the carbon atom

1.3 write the formula and provide the IUPAC name for a variety of organic compounds

1.4 explain how carbon bonds to form alkanes

1.5 identify the following functional groups: alkene, alkyne, aryl, phenyl, alkyl halide (halogenoalkane), alcohol, ether, aldehyde, ketone, carboxylic acid, ester, acid halide, acid anhydride, amine, amide and nitrile

1.6 define isomers and illustrate the structural formulas for a variety of organic isomers: specifically (a) the different types of constitutional isomers (chain isomers, position isomers and functional group isomers); (b) optical isomers (chirality); and (c) geometric (*cis-trans*) isomers[3].

1.7 classify various organic compounds by determining to which families they belong, based on their names or structures

1.8 write and balance chemical equations to predict the reactions of selected organic compounds

1.9 identify the following types of organic reaction: reduction, oxidation, substitution, elimination and addition, and predict the products of these reactions

1.10 describe processes of polymerization **(addition and condensation)** and identify some important natural and synthetic polymers

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[3] Note that the terms "geometric" and "*cis/trans*" have been used here, because these are the terms generally used in high schools. Students should, however, be aware that, at university level, geometric isomers are simply treated as a type of stereoisomers, and that the terms *cis* and *trans* are replaced by *Z* (zusammen = together) and *E* (entgegen = opposite), which take into account the priority of the groups.

2. Acids and Bases

It is expected that students will be able to:

2.1 classify substances as acids, bases, **amphoteric** or salts, based on their characteristics, name, and formula

2.2 describe how neutralization involves tempering the ~~effects~~ **chemical characteristics** of an acid with a base or vice versa

2.3 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials (e.g., use appropriate techniques for handling and disposing of acids and bases)[4]

2.4 describe various acid-base definitions ~~**up to** the Brønsted-Lowry definition~~ **including Arrhenius, Brønsted-Lowry and Lewis**[5]

2.5 predict products of acid-base reactions

2.6 compare strong and weak acids and bases using the concept of equilibrium[6]

2.7 calculate the pH of a **strong or weak** acid or base given its concentration, and vice versa

2.8 describe the interactions between H^+ ions and OH^- ions using Le Châtelier's principle

2.9 determine the concentration of an acid or base solution using stoichiometry

2.10 explain how acid-base indicators function

2.11 explain how buffers function

3. From Structure to Properties

It is expected that students will be able to:

3.1 investigate materials and describe them in terms of their physical properties

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[4] See also the new Section 0, Safety that has been added at the beginning of this curriculum

[5] The application of Lewis acid-base theory in an organic chemistry context (e.g. in substitution reactions) should be included

[6] See also Section 7, Equilibria

3.2 describe changes in the properties of materials that result from some common chemical reactions

3.3 use models in describing the structure and components of atoms and molecules

3.4 identify examples of common elements, and compare their characteristics and atomic structure

3.5 identify and write chemical symbols or molecular formulae of common elements or compounds

3.6 state the relative masses and charges of the three fundamental particles of the atom (proton, neutron and electron)

3.7 identify different isotopes of an element given the atomic number and the mass number

3.8 calculate relative atomic mass from the abundances of the isotopes of an element

3.9 differentiate between atomic number, mass number and relative atomic mass

3.10 illustrate and explain the electronic configurations of the elements using the Bohr model and the orbital and quantum mechanical models

3.11 illustrate and explain the formation of ionic, covalent, **polar covalent** and **metallic** bonds

3.12 predict the shape of polyatomic ions and molecules from their Lewis diagrams using the VSEPR theory

3.13 predict the polarity of molecules from their Lewis diagrams and VSEPR shapes

3.14 illustrate and explain hydrogen bonds and van der Waals' forces

3.15 write and name the formulas of ionic and molecular compounds, following simple IUPAC rules

3.16 identify and describe the properties of ionic and molecular compounds and metallic substances

3.17 describe how intermolecular forces account for the properties of ionic and molecular compounds and metallic substances

3.18 classify ionic, molecular, and metallic substances according to their properties

3.19 relate the properties of a substance to its structural model

3.20 explain the structural model of a substance in terms of the various bonds that define it[7]

4. Electrochemistry

It is expected that students will be able to:

4.1 describe the flow of charge in an electrical circuit

4.2 describe series and parallel circuits involving varying resistance, voltage, and current

4.3 define oxidation and reduction experimentally and theoretically

4.4 determine the oxidation states (numbers) of individual elements in a compound

4.5 write and balance half reactions and net reactions

4.6 compare oxidation-reduction reactions with other kinds of reactions

4.7 illustrate and label the parts of electrochemical and electrolytic cells and explain how they work

4.8 predict whether oxidation-reduction reactions are spontaneous based on their reduction potentials

4.9 **predict the voltage** of various electrochemical cells

4.10 compare electrochemical and electrolytic cells in terms of energy efficiency, electron flow/transfer, and chemical change

4.11 explain the processes of electrolysis and electroplating

4.12 explain how electrical energy is produced in a hydrogen fuel cell **and a variety of batteries**

[7] **Molecular orbital models are not required.**

5A Solutions and Stoichiometry [8]

It is expected that students will be able to:

5.1 identify and write chemical symbols or molecular formulae of common elements or compounds

5.2 represent chemical reactions and the conservation of mass using molecular models, and balanced symbolic equations

5.3 define molar mass and perform mole-mass inter-conversions for pure substances

5.4 describe the process of dissolving, using concepts of intramolecular and intermolecular forces

5.5 define the concept of equilibrium as it pertains to solutions

5.6 explain solubility, using the concept of equilibrium

5.7 explain how different factors affect solubility, using the concept of equilibrium

5.8 determine the molar solubility of a pure substance in water

5.9 explain the variations in the solubility of various pure substances, given the same solvent

5.10 use the solubility generalizations to predict the formation of precipitates

5.11 explain the effect of solutes on the melting point of solid water, using intermolecular forces

5.12 identify mole ratios of reactants and products from balanced chemical equations

5.13 perform stoichiometric calculations related to chemical equations, **including limiting reagent and yield calculations**

5.14 identify various stoichiometric applications

5.15 predict how the yield of a particular chemical process can be maximized

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[8] **See also Section 7, Equilibria**

5B The Gas Laws and Prerequisite Concepts

It is expected that students will be able to:

5.16 describe the relationship between the mass, volume, and density of solids, liquids, and gases using the particle model of matter

5.17 explain the effects of changes in temperature on the density of solids, liquids, and gases and relate the results to the particle model of matter

5.18 analyse quantitatively the density of various substances

5.19 describe qualitatively the relationship between mass and weight

5.20 describe quantitatively the relationship between force, area, and pressure

5.21 explain qualitatively the relationship between pressure, volume, and temperature when liquid and gaseous fluids are compressed or heated

5.22 Perform calculations using the ideal gas equations: $PV = nRT$, $P_1V_1/T_1 = P_2V_2/T_2$, and Dalton's law of partial pressures.

6A Thermochemistry

It is expected that students will be able to:

6.1 write and balance chemical equations for combustion reactions of alkanes

6.2 define endothermic reaction, exothermic reaction, specific heat, enthalpy, bond energy, heat of reaction, and molar enthalpy

6.3 calculate and compare the energy involved in changes of state that occur in chemical reactions

6.4 calculate the changes in energy of various chemical reactions using bond energy, heats of formation, and Hess's law

6.5 illustrate changes in energy of various chemical reactions, using potential energy diagrams

6.6 determine experimentally the changes in energy of various chemical reactions

6.7 compare the molar enthalpies of several combustion reactions involving organic compounds

6B Reaction Kinetics

It is expected that students will be able to:

6.8 illustrate how factors such as heat, concentration, light, and surface area can affect chemical reactions

6.9 state that rate is a change in some quantity over time

6.10 identify ways in which the rate of a particular chemical reaction can be measured, e.g by reference to changes in mass, volume, concentration or pH of a solution

6.11 find the rate of a reaction using the slope of a measured variable (mass, volume, concentration or pH of a solution) against time

6.12 identify the order of reaction with respect to a named reagent given the rate equation (rate expression)[9]

6.13 determine the overall order of reaction given the rate equation (rate expression)

6.14 determine the order of reaction with respect to individual reactants from initial rate data

6.15 define the term *half-life*

6.16 identify a reaction with a constant half-life as being overall first order

7. Equilibria[10]

It is expected that students will be able to:

7.1 State some examples of reversible reactions, which are an essential feature of equilibrium systems

7.2 Recognise different types of equilibria (both physical and chemical)

7.3 Distinguish between homogeneous and heterogeneous equilibria

7.4 List the characteristics of the equilibrium state

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[9] Note that mechanisms and integrated rate equations are NOT REQUIRED.

[10] See also Section 2, Acids and Bases and Section 5A Solutions and Stoichiometry.

7.5 State Le Châtelier's principle and apply it to the effect on equilibrium systems of (a) changing concentration, (b) changing temperature, (c) changing pressure and (d) using catalysts.

7.6 Use equilibrium principles to predict the conditions necessary for optimizing yields in continuous industrial processes run under steady state conditions.

7.7 Write the equilibrium law expression[11] (either *Kc* or *Kp* as appropriate) for a reversible reaction

7.8 Write the standard equilibrium law expressions used for K_{SP} , *Ka*, *Kb* and *Kw*, and the modified equilibrium law expressions used for heterogeneous reactions in general

7.9 Perform calculations using equilibrium law expressions

7.10 State what is meant by the common ion effect, and demonstrate its use in solubility calculations and in buffer solutions.

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[11] Also called the equilibrium constant expression, ECE, in some textbooks