CHEMISTRY 12

EXAMINATION SPECIFICATIONS

SEPTEMBER 2004

Assessment Department

The information in this booklet is intended to be helpful for both teachers and students.
Teachers are encouraged to make this information available to all students.

CHEMISTRY 12

The intent of the *Examination Specifications* is to convey to the classroom teacher and student how the Chemistry 12 curriculum will be tested on the provincial examinations. The Table of Specifications provides weightings for each of the curriculum organizers as well as the cognitive levels that are applied to questions. A detailed description of examinable material within each curriculum organizer will be found in the curriculum section of the *Chemistry 11 and 12 Integrated Resource Package* (IRP)*, 1995* and in Appendix A of that package.

Replaces All Previous Versions of Chemistry 12 Examination Specifications

1. The Chemistry 12 Provincial Examination is worth 90 marks.
2. The following tables will be provided for the provincial examinations in a separate data booklet:

   Periodic Table of the Elements
   Atomic Masses of the Elements
   Names, Formulae, and Charges of some Common Ions
   Solubility of Common Compounds in Water
   Solubility Product Constants at 25°C
   Relative Strengths of Brønsted-Lowry Acids and Bases
   Acid-Base Indicators
   Standard Reduction Potentials of Half-cells

3. Aside from an approved calculator, electronic devices including dictionaries and pagers are **not** permitted in the examination room.
4. This document provides examples of multiple-choice questions. Please refer to previous provincial examinations for sample written-response questions.

It is expected that there will be a difference between school marks and provincial examination marks for individual students. Some students perform better on classroom tests and others on provincial examinations. School assessment measures performance on all curricular outcomes, whereas provincial examinations may only evaluate performance on a sample of these outcomes.

The provincial examination represents 40% of the student's final letter grade and the classroom mark represents 60%.

Acknowledgement
The Assessment Department wishes to acknowledge the contribution of British Columbia teachers in the preparation and review of this document.

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DESCRIPTION OF THE PROVINCIAL EXAMINATION

The Table of Specifications (page 2) outlines the curriculum organizers, sub-organizers, and the cognitive level emphases covered on the provincial examination. A detailed description of examinable material within each curriculum organizer will be found in the *Chemistry 11 and 12 Integrated Resource Package, 1995.*

The provincial examination is divided into **two** parts:

PART A: **Multiple-choice** questions worth **60 marks**.

PART B: **Written-response** questions worth **30 marks**.

The **number** of written-response questions may vary from one examination to the next, depending on the value of each question; however, the total **marks** for the written-response questions will remain the same.

To obtain full marks in written-response questions students should note the following points:

1. Students are expected to communicate their knowledge and understanding of chemistry principles in a clear and logical manner. All steps leading to a solution must be clearly presented. Full marks will **not** be awarded for providing a final answer **only**.

2. Final answers must include appropriate **units** and be expressed to the number of **significant figures** justified by the data. The inappropriate use of units or significant figures will result in a maximum **one-mark** deduction in the entire examination.

A calculator is essential for the Chemistry 12 Provincial Examination. The calculator must be a hand-held device designed primarily for mathematical computations involving logarithmic and trigonometric functions and may be capable of performing graphing functions. Computers, calculators with a QWERTY keyboard or symbolic manipulation abilities, and electronic writing pads will not be allowed. Students must not bring any external devices (peripherals) to support calculators such as manuals, printed or electronic cards, printers, memory expansion chips or cards, CD-ROMs, libraries or external keyboards. Students may have more than one calculator available during the examination, of which one may be a scientific calculator. Calculators may not be shared and must not have the ability to either transmit or receive electronic signals. In addition to an approved calculator, students will be allowed to use rulers, compasses, and protractors during the examination.

Calculators must not have any information programmed into memory that would not be acceptable in paper form. Specifically, calculators must not have any built-in notes, definitions, or libraries. There is no requirement to clear memories at the beginning of the examination but the use of calculators with built-in notes is equivalent to the use of notes in paper form. Any student deemed to have cheated on a provincial examination will receive a "0" on that examination and will be permanently disqualified from the Provincial Examination Scholarship Program.

This examination is designed to be completed in **two hours**. *Students may, however, take up to 30 minutes of additional time to finish.*

CHEMISTRY 12

TABLE OF SPECIFICATIONS FOR THE PROVINCIAL EXAMINATION

CURRICULUM			COGNITIVE LEVEL MARKS			
ORGANIZERS	**SUB-ORGANIZERS**	**MARKS SUB-TOTAL**	Knowledge	Understanding and Application	Higher Mental Processes	**TOTAL MARKS**
Reaction Kinetics	A. Introduction B. Collision Theory C. Reaction Mechanisms and Catalysts	11	1	8	2	11
Dynamic Equilibrium	D. Introduction E. Le Châtelier's Principle	7	1	12	1	14
	F. The Equilibrium Constant	7				
Solubility Equilibria	G. Concept of Solubility H. Solubility and Precipitation	7	2	11	1	14
	I. Quantitative Aspects	7				
Acids, Bases and Salts	J. Properties and Definitions K. Strong and Weak Acids and Bases	8	3	24	3	30
	L. K_w , pH, pOH M. K_a and K_b Problem Solving N. Hydrolysis of Salts	11				
	O. Indicators P. Neutralizations of Acids and Bases Q. Buffer Solutions R. Acid Rain	11				
Oxidation-Reduction	S. Introduction T. Balancing Redox Equations	10	2	17	2	21
	U. Electrochemical Cells V. Corrosion W. Electrolytic Cells	11				
	TOTAL MARKS	90	9	72	9	90

The values in this table are approximate and may fluctuate.

Examination configuration: 60 marks in multiple-choice format
30 marks in written-response format

DESCRIPTION OF COGNITIVE LEVELS

*The following three cognitive levels are based on a modified version of Bloom's taxonomy (*Taxonomy of Educational Objectives*, Bloom* et al*., 1956). Bloom's taxonomy describes six cognitive domains: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. For ease of classification, the six cognitive domains have been collapsed into three.*

Knowledge

Knowledge is defined as including those behaviours and test situations that emphasize the remembering, either by recognition or recall, of ideas, material, or phenomena. Incorporated at this level is knowledge of terminology, specific facts (dates, events, persons, etc.), conventions, classifications and categories, criteria, methods of inquiry, principles and generalizations, theories and structures.

Understanding and Application

Understanding refers to responses that represent a comprehension of the literal message contained in a communication. This means that the student is able to translate, interpret or extrapolate. Interpretation involves the reordering of ideas (inferences, generalizations, or summaries). Extrapolation includes estimating or predicting based on an understanding of trends or tendencies.

Application requires the student to apply an appropriate abstraction (theory, principle, idea, method) to a new situation.

Questions at the *understanding and application* level subsume knowledge levels.

Higher Mental Processes

Included at this thought level are the processes of analysis, synthesis, and evaluation.

Analysis involves the ability to recognize unstated assumptions, to distinguish facts from hypotheses, to distinguish conclusions from statements that support them, to recognize which facts or assumptions are essential to a main thesis or to the argument in support of that thesis, and to distinguish cause-effect relationships from other sequential relationships.

Synthesis involves the production of a unique communication, the ability to propose ways of testing hypotheses, the ability to design an experiment, the ability to formulate and modify hypotheses, and the ability to make generalizations.

Evaluation is defined as the making of judgments about the value of ideas, solutions, and methods. It involves the use of criteria as well as standards for appraising the extent to which details are accurate, effective, economical, or satisfying. Evaluation involves the ability to apply given criteria to judgments of work done, to indicate logical fallacies in arguments, and to compare major theories and generalizations.

Questions at the *higher mental processes* level subsume both *knowledge* and *understanding and application* levels.

SAMPLE MULTIPLE-CHOICE QUESTIONS

The following are examples of the cognitive levels: K (*Knowledge*), U (*Understanding and Application*) and H (*Higher Mental Processes*). Refer to page 3 for a description of these terms.

It should be noted that cognitive level does not necessarily reflect "level of difficulty." For example, a certain K level question might be considered to be difficult by some and similarly an H level question may be considered to be easy.

Reaction Kinetics

Knowledge

1. The statement, *the minimum energy needed to achieve a successful collision,* defines

   A. entropy.
   * B. activation energy.
   C. the ΔH of reaction.
   D. the activated complex.

Understanding and Application

2. Consider the following reaction mechanism:

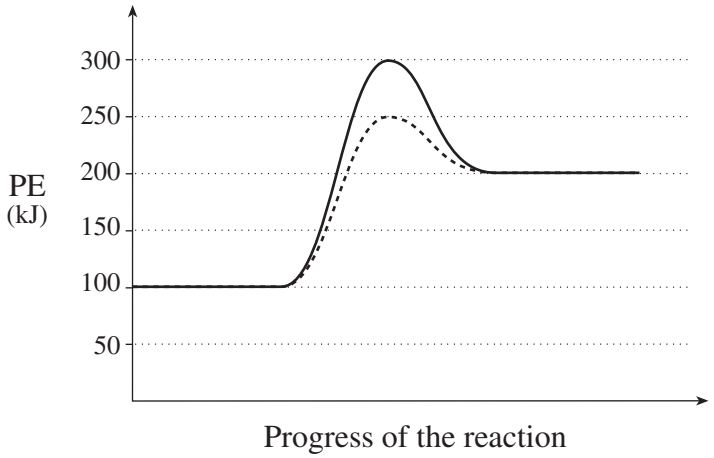
Step 1	$Cl_2 \rightarrow 2Cl$
Step 2	$CHCl_3 + Cl \rightarrow HCl + CCl_3$
Step 3	$CCl_3 + Cl \rightarrow CCl_4$

   Which of the following is a reactant in the overall reaction?

   A. Cl
   B. HCl
   C. CCl_3
   * D. $CHCl_3$

Higher Mental Processes

3. Consider the following PE diagram for a catalyzed and uncatalyzed reaction:



Which of the following describes the **reverse** reaction?

		Reverse Reaction	Activation Energy (kJ)	ΔH (kJ)
*	A.	catalyzed	50	−100
	B.	uncatalyzed	50	−100
	C.	catalyzed	50	+100
	D.	uncatalyzed	50	+100

Dynamic Equilibrium

Knowledge

4. Starting with equal moles of reactants, which of the following equilibrium systems most favours the reactants?

A. $SO_{2(g)} + NO_{2(g)} \rightleftarrows SO_{3(g)} + NO_{(g)}$ $K_{eq} = 3.4$

B. $CO_{(g)} + H_2O_{(g)} \rightleftarrows CO_{2(g)} + H_{2(g)}$ $K_{eq} = 31.4$

C. $H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$ $K_{eq} = 10$

* D. $N_{2(g)} + O_{2(g)} \rightleftarrows 2NO_{(g)}$ $K_{eq} = 1.0 \times 10^{-31}$

Understanding and Application

Use the following equilibrium equation to answer questions 5 and 6.

$$\mathbf{CO_{2(g)} + H_{2(g)} \rightleftarrows H_2O_{(g)} + CO_{(g)}}$$

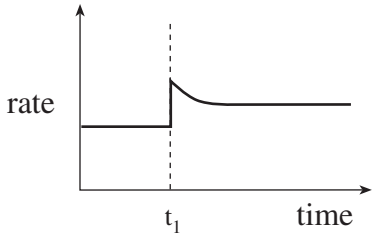
5. Which two stresses will each cause the equilibrium to shift to the left?

   A. increase $[H_2]$, increase $[CO]$
   * B. decrease $[H_2]$, increase $[H_2O]$
   C. increase $[CO_2]$, decrease $[CO]$
   D. decrease $[CO_2]$, decrease $[H_2O]$

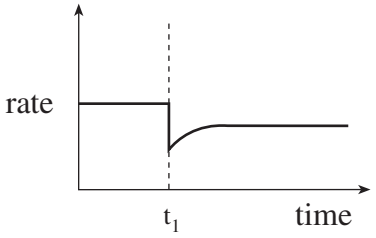
Higher Mental Processes

6. Which of the following graphs represents the rate of the forward reaction when $H_2O_{(g)}$ is added to the above equilibrium at time = t_1 ?

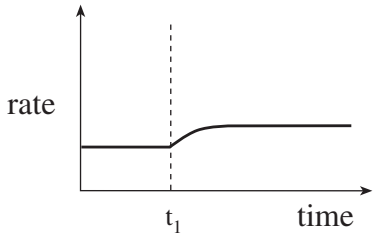
A.



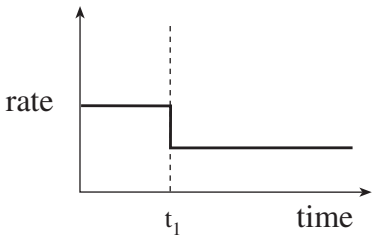
B.



* C.



D.



Solubility Equilibria

Knowledge

7. In every solubility equilibrium system, the rate of dissolving is

   A. equal to zero.
   * B. equal to the rate of crystallization.
   C. less than the rate of crystallization.
   D. greater than the rate of crystallization.

Understanding and Application

8. A 3.0 L solution of $BaCl_2$ has a chloride ion concentration of 0.20 M. The barium ion concentration in this solution is

   A. 0.067 M
   * B. 0.10 M
   C. 0.20 M
   D. 0.60 M

Higher Mental Processes

9. Consider the following solubility equilibrium:

$$AgCl_{(s)} \rightleftarrows Ag^+_{(aq)} + Cl^-_{(aq)}$$

   Some $NaCl_{(s)}$ is added to the equilibrium. When equilibrium is reestablished, how have the ion concentrations changed from the original equilibrium?

	$[Ag^+]$	$[Cl^-]$
* A.	decreased	increased
B.	decreased	decreased
C.	increased	decreased
D.	increased	increased

Acids, Bases and Salts

Knowledge

10. A basic solution can be defined as one in which

    A. $\left[H_3O^+\right]$ is not present

    B. $\left[H_3O^+\right]$ is equal to $\left[OH^-\right]$

    * C. $\left[H_3O^+\right]$ is less than $\left[OH^-\right]$

    D. $\left[H_3O^+\right]$ is greater than $\left[OH^-\right]$

Understanding and Application

11. Write the K_b expression for

$$NH_{3(aq)} + H_2O_{(\ell)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

    A. $K_b = \dfrac{\left[NH_3\right]}{\left[NH_4^+\right]\left[OH^-\right]}$

    * B. $K_b = \dfrac{\left[NH_4^+\right]\left[OH^-\right]}{\left[NH_3\right]}$

    C. $K_b = \dfrac{\left[NH_3\right]\left[H_2O\right]}{\left[NH_4^+\right]\left[OH^-\right]}$

    D. $K_b = \dfrac{\left[NH_4^+\right]\left[OH^-\right]}{\left[NH_3\right]\left[H_2O\right]}$

Higher Mental Processes

12. A chemical indicator has a transition point at a $pOH = 8.0$. Calculate its K_a value and identify the indicator.

    A. $K_a = 1 \times 10^{-8}$, phenol red

    B. $K_a = 1 \times 10^{-6}$, methyl red

    C. $K_a = 1 \times 10^{-8}$, thymol blue

    * D. $K_a = 1 \times 10^{-6}$, chlorophenol red

Oxidation-Reduction

Knowledge

13. A reducing agent

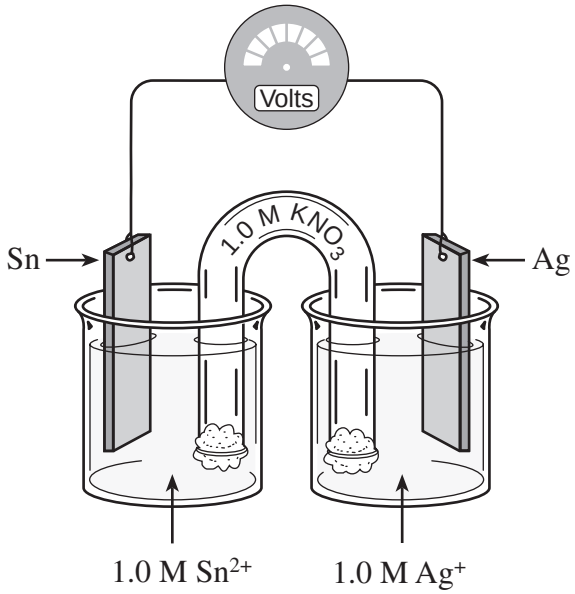
    A. loses electrons and is reduced.
    B. gains electrons and is reduced.
* C. loses electrons and is oxidized.
    D. gains electrons and is oxidized.

Understanding and Application

14. Which of the following will react spontaneously with Br_2 but not with I_2 ?

    A. F^-
    B. Cr^{2+}
* C. Fe^{2+}
    D. Mn^{2+}

Use the following diagram to answer question 15.



15. In the above electrochemical cell, how do the mass of the anode and the $\left[Ag^{+}\right]$ change as the cell operates?

		Mass of the Anode	$\left[Ag^{+}\right]$
	A.	decreases	increases
	B.	increases	increases
*	C.	decreases	decreases
	D.	no change	decreases

CHEMISTRY 12 PROVINCIAL EXAMINATION TERMINOLOGY

This list is provided to clarify some chemistry-related terms commonly used on Chemistry 12 Provincial Examinations.

Arrows $\xrightarrow{?}$ or $\overset{?}{\rightleftarrows}$	Used to state that the predominant direction of the reaction is to be determined (e.g. forward, reverse, or reversible).
Chemical equations	A chemical equation should contain relevant information that would include balancing of atoms and charges, phase designations (s, ℓ, g, aq) and appropriate arrows (such as equilibrium arrows). A *skeletal equation*, commonly used in the redox section, refers to one that is incomplete with regards to balancing and/or chemical species.
Chemical species	A term used to describe any chemical entity such as NaCl, Ba^{2+}, etc.
Conditions	It is assumed that all reactions occur at standard conditions (unless otherwise stated).
E_a	Symbol for *activation energy.*
Favoured	In a chemical equilibrium it might be stated that products are *favoured*. This means that for that particular equilibrium there are proportionately more products than reactants.
Predominant reaction	The reaction that has the greatest overall effect on the system. *For example:* The predominant reaction in 1.0 M $NaHCO_{3(aq)}$ is the basic hydrolysis of HCO_3^- : $HCO_{3\,(aq)}^- + H_2O_{(\ell)} \rightleftarrows H_2CO_{3(aq)} + OH^-_{(aq)}$ even though other reactions such as $HCO_{3\,(aq)}^- + H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + CO_{3\,(aq)}^{2-}$ and $H_2O_{(\ell)} + H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$ are also occurring, but to a lesser degree.

Reactants and products	In equilibrium equations, the chemicals written on the left side are conventionally referred to as reactants and those on the right as products.
Standard Cu – Zn electrochemical cell	An electrochemical cell with $Cu(s)$, $Cu^{2+}(aq)$, $Zn(s)$, $Zn^{2+}(aq)$ as the relevant chemical species (at standard conditions).
Stress	A term used to describe a relevant change to one or more of the chemical species or conditions of an equilibrium system. *For example:* $HCO_{3\,(aq)}^{-} + H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + CO_{3\,(aq)}^{2-}$ if $HCl_{(aq)}$ is added, the stress is an **increase** in $\left[H_3O^+\right]$ in the original equilibrium, whereas, if $NaOH_{(aq)}$ is added, the stress is a **decrease** in $\left[H_3O^+\right]$ in the original equilibrium since the added OH^- predominantly reacts with the original H_3O^+ (the stronger acid).
Shift	A *shift left* in a chemical equilibrium means that more reactants are formed and fewer products result when compared to the original equilibrium.
Titrate	To react to the equivalence point (stoichiometric point).
Trial K_{eq}	A trial calculation used in certain equilibrium problems.
Trial K_{sp}	A trial calculation, the same as trial ion product (TIP), used in certain solubility problems.