Chemistry 12

April 2003 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

Organizers	Sub-Organizers
1. Reaction Kinetics	A, B, C
2. Dynamic Equilibrium	D, E, F
3. Solubility Equilibria	G, H, I
4. Acids, Bases, and Salts	J, K, L, M, N, O, P, Q, R
5. Oxidation – Reduction	S, T, U, V, W

Part A: Multiple Choice

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	D	U	1	1	A4	25.	C	U	2	4	K1, 2, 3, 4
2.	C	K	1	1	A6	26.	C	K	1	4	K7
3.	C	U	1	1	B5	27.	D	K	1	4	L8
4.	A	K	1	1	B9	28.	C	U	1	4	L11
5.	A	U	2	1	C4	29.	A	U	1	4	M4
6.	C	U	1	1	C6	30.	D	U	1	4	N2
7.	C	K	1	2	D4	31.	C	U	2	4	N4
8.	B	K	2	2	D8	32.	B	K	1	4	O2
9.	D	H	2	2	E2	33.	A	U	2	4	O4
10.	C	K	1	2	E4	34.	D	U	2	4	P2
11.	B	U	1	2	F2	35.	A	U	1	4	P4
12.	A	U	1	2	D4, F3	36.	C	K	1	4	P6
13.	D	U	1	2	F3	37.	D	K	1	4	Q3
14.	D	U	1	2	F4	38.	A	H	1	5	S1
15.	C	K	1	3	G4	39.	C	U	1	5	S1
16.	D	H	1	3	G6	40.	C	U	1	5	S2
17.	D	U	1	3	G8	41.	A	U	1	5	S5, 6
18.	C	U	1	3	H2	42.	B	U	1	5	S2, 3
19.	B	U	2	3	H5	43.	B	U	2	5	U2
20.	B	U	1	3	I2	44.	A	H	2	5	U3, 5
21.	D	U	2	3	I3	45.	C	U	1	5	U9
22.	A	U	1	3	I6	46.	A	U	1	5	U7
23.	B	U	1	4	J7	47.	D	U	2	5	W4
24.	C	K	1	4	J11	48.	B	H	1	5	W4, 7

Multiple Choice = 60 marks (48 questions)

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	5	1	A3
2.	2	U	2	1	B1
3.	3	H	2	2	E5
4.	4	U	3	2	F6
5.	5	U	6	3	H3
6.	6	U	4	4	J3, 12, K8
7.	7	U	4	4	L6, 10
8.	8	U	4	4	M3
9.	9	U	3	5	S4
10.	10	U	3	5	T2
11.	11	H	4	5	W2, 4, 7

Written Response = 40 marks

Multiple Choice = 60 (48 questions)
Written Response = 40 (11 questions)
EXAMINATION TOTAL = 100 marks

LEGEND:
Q = Question Number **K** = Keyed Response **C** = Cognitive Level
B = Score Box Number **S** = Score **CO** = Curriculum Organizer
PLO = Prescribed Learning Outcome

PART B: WRITTEN RESPONSE

Value: 40 marks **Suggested Time: 50 minutes**

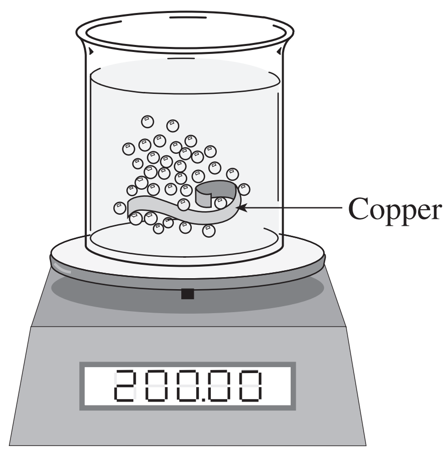
INSTRUCTIONS:	You will be expected to communicate your knowledge and understanding of chemical principles in a clear and logical manner. Your steps and assumptions leading to a solution must be written in the spaces below the questions. Answers must include units where appropriate and be given to the correct number of significant figures. **For questions involving calculations, full marks will NOT be given for providing only an answer.**

1. Consider the following reaction:

$$3Cu_{(s)} + 8HNO_{3(aq)} \rightarrow 3Cu(NO_3)_{2(aq)} + 2NO_{(g)} + 4H_2O_{(\ell)}$$

A piece of copper is added to a nitric acid solution in an open beaker, allowing the $NO_{(g)}$ to escape. The following data was obtained:

TIME (min)	MASS OF BEAKER AND CONTENTS (g)
0.0	200.00
1.0	197.50
2.0	195.45
3.0	193.55
4.0	191.70
5.0	189.90
6.0	188.15
7.0	186.45
8.0	184.80



a) Calculate the reaction rate for the time period 2.0 to 6.0 min. **(2 marks)**

Solution:

For Example:

$$\left.\begin{aligned} \text{rate} &= \frac{\text{mass change}}{\text{time change}} = \frac{195.45\ \text{g} - 188.15\ \text{g}}{(6.0 - 2.0)\ \text{min}} \\ &= \frac{7.30\ \text{g}}{4.0\ \text{min}} \\ &= 1.8\ \text{g/min NO produced} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

(Deduct $\frac{1}{2}$ **mark** for incorrect significant figures.)

b) Calculate the mass of copper consumed in the first 5 minutes. **(3 marks)**

Solution:

For Example:

$$\text{moles NO produced} = \frac{200.00\ \text{g} - 189.90\ \text{g}}{30.0\ \text{g/mol}} = 0.3367\ \text{mol NO} \quad \} \leftarrow \textbf{1 mark}$$

$$\text{moles Cu consumed} = 0.3367\ \text{mol NO} \times \frac{3\ \text{mol Cu}}{2\ \text{mol NO}} = 0.5050\ \text{mol Cu} \quad \} \leftarrow \textbf{1 mark}$$

$$\text{mass Cu consumed} = 0.5050\ \text{mol Cu} \times \frac{63.5\ \text{g Cu}}{1\ \text{mol Cu}} = 32.1\ \text{g Cu} \quad \} \leftarrow \textbf{1 mark}$$

2. Using collision theory, explain why reactions between two solutions occur more rapidly than reactions between two solids. **(2 marks)**

Solution:

For Example:

- Particles must be able to collide to react.
- Only the particles on the surface of a solid are available for reaction. In a solution, all particles are available.

} ← **2 marks**

3. Consider the following reaction for the Haber Process for ammonia production:

$$N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)} \qquad \Delta H = -92\,\text{kJ}$$

The system is normally maintained at a temperature of approximately 500°C.

a) Explain why 1000°C is not used. **(1 mark)**

Solution:

For Example:

Equilibrium will be shifted to the left, reducing the yield of NH_3. ← **1 mark**

b) Explain why 100°C is not used. **(1 mark)**

Solution:

For Example:

The rate of the reaction would be too low. ← **1 mark**

4. Consider the following equilibrium:

$$SO_{3(g)} + NO_{(g)} \rightleftarrows NO_{2(g)} + SO_{2(g)}$$

In an experiment, 0.100 moles of SO_3 and 0.100 moles of NO are placed in a 1.00 L container. When equilibrium is achieved, $[NO_2] = 0.0414$ mol/L. Calculate the K_{eq} value. **(3 marks)**

Solution:

For Example:

	SO_3	+	NO	$\rightleftarrows$	NO_2	+	SO_2
[I]	0.100		0.100		0		0
[C]	−0.0414		−0.0414		+0.0414		+0.0414
[E]	0.059		0.059		0.0414		0.0414

← 1½ marks

$$K_{eq} = \frac{[NO_2][SO_2]}{[SO_3][NO]}$$ **← ½ mark**

$$= \frac{(0.0414)(0.0414)}{(0.059)(0.059)}$$

$$= 0.50$$ **← 1 mark**

5. a) Write the net ionic equation for the reaction between $Pb(NO_3)_{2(aq)}$ and $NaCl_{(aq)}$.

(2 marks)

Solution:

For Example:

$$Pb^{2+}_{(aq)} + 2Cl^{-}_{(aq)} \rightarrow PbCl_{2(s)}$$ **← 2 marks**

b) Determine, with calculations, whether a precipitate will form when 15.0 mL of 0.050 M $Pb(NO_3)_2$ is added to 35.0 mL of 0.085 M NaCl. **(4 marks)**

Solution:

For Example:

$$[Pb^{2+}] = 0.050\text{ M} \times \frac{15.0\text{ mL}}{50.0\text{ mL}} = 0.015\text{ M}$$ **← 1 mark**

$$[Cl^{-}] = 0.085\text{ M} \times \frac{35.0\text{ mL}}{50.0\text{ mL}} = 0.0595\text{ M}$$ **← 1 mark**

$$\text{Trial } K_{sp} = [Pb^{2+}][Cl^{-}]^2 = (0.015)(0.0595)^2 = 5.3 \times 10^{-5}$$ **← 1 mark**

K_{sp} for $PbCl_2 = 1.2 \times 10^{-5}$

Since Trial $K_{sp} > K_{sp}$, a precipitate does form. **← 1 mark**

6. An acid-base reaction occurs between HSO_3^- and IO_3^- .

a) Write the equation for the equilibrium that results. **(1 mark)**

Solution:

For Example:

$HSO_3^- + IO_3^- \rightleftarrows SO_3^{2-} + HIO_3$ ← **1 mark (equilibrium arrow required)**

b) Identify one conjugate acid-base pair in the reaction. **(1 mark)**

Solution:

For Example:

HSO_3^- and SO_3^{2-} **OR** IO_3^- and HIO_3 ← **1 mark**

c) State whether reactants or products are favoured, and explain how you arrived at your answer. **(2 marks)**

Solution:

For Example:

Reactants are favoured. ← **1 mark**

HSO_3^- is a weaker acid than HIO_3 **OR**

IO_3^- is a weaker base than SO_3^{2-} } ← **1 mark**

7. At 10°C, $K_w = 2.95 \times 10^{-15}$.

a) Determine the pH of water at 10°C. **(3 marks)**

Solution:

For Example:

$$K_w = 2.95 \times 10^{-15} = \left[H_3O^+\right]\left[OH^-\right]$$ ← **1 mark**

Since $\left[H_3O^+\right] = \left[OH^-\right]$,

$$\left[H_3O^+\right]^2 = 2.95 \times 10^{-15}$$

$$\left[H_3O^+\right] = 5.43 \times 10^{-8}$$ ← **1 mark**

$$pH = 7.265$$ ← **1 mark**

(Deduct $\frac{1}{2}$ **mark** for incorrect significant figures.)

b) State whether water at this temperature is acidic, basic or neutral, and explain. **(1 mark)**

Solution:

For Example:

Since $\left[H_3O^+\right] = \left[OH^-\right]$, the water is neutral. ← **1 mark**

8. Calculate the pH of $0.50\,M\ H_2S$. **(4 marks)**

Solution:

For Example:

	H_2S	+	H_2O	$\rightleftarrows$	H_3O^+	+	HS^-
[I]	0.50				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.50 - x$				x		x

(assume x is negligible)

← $1\frac{1}{2}$ mark

$$K_a = 9.1 \times 10^{-8} = \frac{[H_3O^+][HS^-]}{[H_2S]} = \frac{(x)(x)}{(0.50)}$$ **← 1 mark**

$x = [H_3O^+] = 2.13 \times 10^{-4}$ **← 1 mark**

pH = 3.67 **← $\frac{1}{2}$ mark**

9. Consider the following experimental results:

$$Ce^{4+} + Pd \rightarrow Pd^{2+} + Ce^{3+}$$

$$In^{3+} + Cd \rightarrow \text{no reaction}$$

$$Pd^{2+} + In^{2+} \rightarrow In^{3+} + Pd$$

$$Cd^{2+} + Pd \rightarrow \text{no reaction}$$

Use these results to complete the table of reduction half-reactions below. **(3 marks)**

Solution:

For Example:

Oxidizing Agents (WEAKEST ↑ STRONGEST)		Reducing Agents (WEAKEST ↓ STRONGEST)
$Ce^{4+} + e^-$	$\rightleftarrows$	Ce^{3+}
$Pd^{2+} + 2e^-$	$\rightleftarrows$	Pd
$Cd^{2+} + 2e^-$	$\rightleftarrows$	Cd
$In^{3+} + e^-$	$\rightleftarrows$	In^{2+}

← **3 marks**

10. Balance the following equation. **(3 marks)**

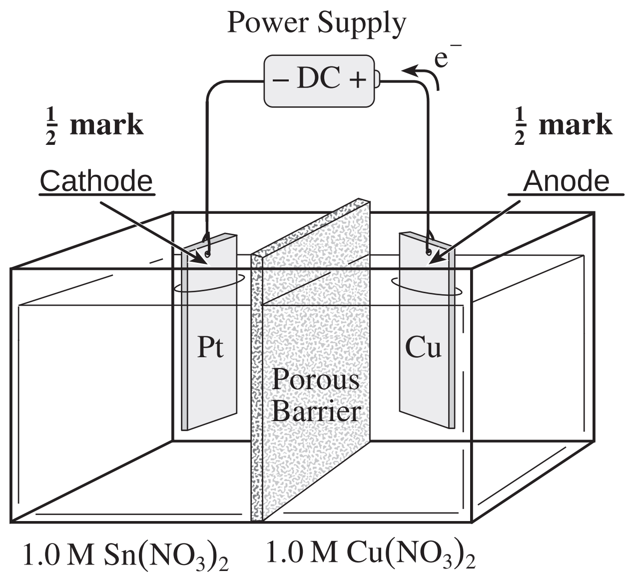
$$Cr_2O_7^{2-} + C_2O_4^{2-} \rightarrow Cr^{3+} + CO_2 \qquad \text{(acidic)}$$

Solution:

For Example:

$$\left.\begin{array}{r} \left(6e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O\right) \times 1 \\ \left(C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-\right) \times 3 \\ \hline 14H^+ + Cr_2O_7^{2-} + 3C_2O_4^{2-} \rightarrow 2Cr^{3+} + 7H_2O + 6CO_2 \end{array}\right\} \leftarrow \textbf{3 marks}$$

11. Consider the following **electrolytic cell** which contains a porous barrier to prevent general mixing of solutions.



a) Label the anode and cathode in the space provided on the diagram above. **(1 mark)**

Solution:

For Example:

See diagram above.

b) Write an equation for the overall cell reaction. **(2 marks)**

Solution:

For Example:

$Sn^{2+} + Cu_{(s)} \rightarrow Cu^{2+} + Sn_{(s)}$ ← **2 marks**

c) Calculate the minimum theoretical voltage required for this reaction under standard conditions. **(1 mark)**

Solution:

For Example:

0.48 V ← **1 mark**

END OF KEY