Chemistry 12

June 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.	C	U	1	1	A1	25.	A	U	1	4	K1
2.	D	K	1	1	A5	26.	B	U	2	4	K8
3.	C	K	1	1	B2	27.	B	K	1	4	L4
4.	C	U	1	1	B1	28.	A	K	1	4	L10
5.	B	U	1	1	B6	29.	A	K	1	4	M1
6.	B	U	1	1	C5	30.	B	U	1	4	N2
7.	B	K	1	2	D2	31.	D	U	2	4	N4
8.	A	U	1	2	D7	32.	D	K	1	4	O1, Q2
9.	A	U	1	2	E2	33.	C	U	2	4	O5
10.	A	H	2	2	E3	34.	C	K	1	4	P1
11.	C	K	1	2	F1	35.	B	H	2	4	P2
12.	A	K	1	2	F2	36.	D	U	2	4	Q5
13.	D	U	1	2	F4	37.	C	K	1	4	R4
14.	B	U	1	2	F5	38.	B	U	1	5	S1
15.	B	K	2	3	G8	39.	B	U	1	5	S2
16.	A	H	1	3	G6, H5	40.	C	U	1	5	S5
17.	D	U	1	3	H1	41.	D	U	1	5	T4
18.	C	U	2	3	H2	42.	D	U	2	5	T6
19.	D	U	1	3	H4	43.	C	U	1	5	U9, 11
20.	B	U	1	3	H5	44.	C	H	1	5	U2
21.	C	U	1	3	I4	45.	B	U	2	5	U9
22.	A	H	2	3	I4	46.	B	U	1	5	S1, U11
23.	B	K	1	4	J4	47.	D	H	1	5	V2
24.	B	K	1	4	J2	48.	D	U	2	5	W4

Multiple Choice = 60 marks (48 questions)

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	3	1	A3
2.	2	U	2	1	C5
3.	3	U	3	2	D9
4.	4	H	3	2	F8
5.	5	U	5	3	I3, 7
6.	6	U	5	4	J7, 11, K6, 8
7.	7	U	3	4	L1, 11
8.	8	U	5	4	M3, N2
9.	9	U	2	4	Q4
10.	10	U	4	5	T2
11.	11	U	2	5	S6
12.	12	H	3	5	V2

Written Response = 40 marks

Multiple Choice = 60 (48 questions)
Written Response = 40 (12 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 are 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 in an open flask: **(3 marks)**

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(\ell)} + CO_{2(g)}$$

A $155.0\,g$ sample of $CaCO_{3(s)}$ is placed in the flask and $HCl_{(aq)}$ is added.
The reaction consumes $HCl_{(aq)}$ at an average rate of $0.200\,mol/min$ for $10.0\,min$.
What mass of $CaCO_{3(s)}$ remains?

Solution:

For Example:

$\text{Amount of HCl reacting} = 0.200\,mol/min \times 10.0\,min = 2.00\,mol$ ← **½ mark**

$\text{Moles of } CaCO_3 \text{ reacting} = 2.00\,mol\ HCl \times \frac{1\,CaCO_3}{2HCl} = 1.00\,mol\ CaCO_3$ ← **½ mark**

$\text{Mass of } CaCO_3 \text{ reacting} = 1.00\,mol\ CaCO_3 \times \frac{100.1\,g}{1\,mol} = 1.00 \times 10^2\,g$ ← **1 mark**

$\text{Mass remaining} = 155.0\,g - 100.\,g = 55\,g$ ← **1 mark**

2. a) Write the equation for Step 3 in the following reaction mechanism. **(1 mark)**

Step 1	$2NO \rightarrow N_2O_2$
Step 2	$N_2O_2 + H_2 \rightarrow N_2O + H_2O$
Step 3	**?**
Overall Reaction	$2NO + 2H_2 \rightarrow N_2 + 2H_2O$

Solution:

Step 3: $N_2O + H_2 \rightarrow N_2 + H_2O$ ← **1 mark**

b) Identify a reaction intermediate in the above mechanism. **(1 mark)**

Solution:

Either N_2O_2 **OR** N_2O ← **1 mark**

3. Consider the following exothermic reaction:

$$C_3H_{8(g)} + 5O_{2(g)} \overset{?}{\rightarrow} 3CO_{2(g)} + 4H_2O_{(g)}$$

Explain, in terms of increasing or decreasing entropy and enthalpy, whether or not the reaction will reach equilibrium. **(3 marks)**

Solution:

For Example:

Entropy increases in the forward reaction. ← **1 mark**

Enthalpy decreases in the forward reaction. ← **1 mark**

Since both favour products, equilibrium will not be attained; or the reaction will go to completion. ← **1 mark**

4. Given the reacting system:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)} \qquad K_{eq} = 64$$

Equal moles of H_2, I_2 and HI are placed in a 1.0 L container. Use calculations to determine the direction the reaction will proceed in order to reach equilibrium. **(3 marks)**

Solution:

For Example:

	H_2	+	I_2	$\rightleftarrows$	2HI
[I]	x		x		x

$$\text{Trial } K_{eq} = \frac{[HI]^2}{[H_2][I_2]}$$

$$= \frac{(x)^2}{(x)(x)}$$

$$= 1$$ ← **2 marks**

Since Trial $K_{eq} < K_{eq}$, equilibrium is established by proceeding to the right. ← **1 mark**

5. After a $50.0\,\text{mL}$ sample of a saturated solution of Ag_2SO_4 was heated to dryness, $7.2 \times 10^{-4}\,\text{g}$ of solid Ag_2SO_4 remained. What is the value of K_{sp} for Ag_2SO_4 ? **(5 marks)**

Solution:

For Example:

$$Ag_2SO_{4(s)} \rightleftarrows 2Ag^+_{(aq)} + SO_4{}^{2-}_{(aq)}$$

$$\left[Ag_2SO_4\right] = \frac{7.2 \times 10^{-4}\,\text{g}}{0.0500\,\text{L}} \times \frac{1\,\text{mole}}{311.9\,\text{g}} = 4.62 \times 10^{-5}\,\text{M} \qquad \leftarrow \textbf{1 mark}$$

$$\left[Ag^+\right] = 2 \times 4.62 \times 10^{-5}\,\text{M} = 9.23 \times 10^{-5}\,\text{M} \qquad \leftarrow \textbf{1 mark}$$

$$\left[SO_4{}^{2-}\right] = 4.62 \times 10^{-5}\,\text{M} \qquad \leftarrow \textbf{1 mark}$$

$$K_{sp} = \left[Ag^+\right]^2\left[SO_4{}^{2-}\right]$$

$$= \left(9.23 \times 10^{-5}\right)^2\left(4.62 \times 10^{-5}\right) \qquad \leftarrow \textbf{1 mark}$$

$$= 3.9 \times 10^{-13} \qquad \leftarrow \textbf{1 mark}$$

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

6. a) Write an equation to represent the predominant reaction when $HC_2O_4^-$ is mixed with HSO_4^- . **(1 mark)**

Solution:

For Example:

$$HC_2O_4^- + HSO_4^- \rightleftarrows H_2C_2O_4 + SO_4^{2-} \quad \leftarrow \textbf{1 mark}$$

b) Justify your statement by comparing K_a values. **(1 mark)**

Solution:

For Example:

$$K_aHSO_4^- > K_aHC_2O_4^- \quad \leftarrow \textbf{1 mark}$$

c) Identify a conjugate acid-base pair. **(1 mark)**

Solution:

For Example:

HSO_4^- and SO_4^{2-}

OR $HC_2O_4^-$ and $H_2C_2O_4$ } ← **1 mark**

d) Predict whether the equilibrium will favour the formation of reactants or products. Explain. **(2 marks)**

Solution:

For Example:

Reactants are favoured since $K_aHSO_4^- < K_aH_2C_2O_4$ ← **2 marks**

7. Write an equation representing the ionization of water and state both ion concentrations that exist for pure water to have a $pH = 7.20$. **(3 marks)**

Solution:

For Example:

$$H_2O_{(\ell)} + H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$$ ← **1 mark**

Since $pH = 7.20$, $\left[H_3O^+\right] = 6.3 \times 10^{-8}\ M$ ← **1 mark**

$\left[H_3O^+\right] = \left[OH^-\right] = 6.3 \times 10^{-8}\ M$ ← **1 mark**

8. Calculate the pH of 0.25 M $NaHCO_3$, a basic salt. **(5 marks)**

Solution:

For Example:

	HCO_3^-	+	H_2O	$\rightleftarrows$	H_2CO_3	+	OH^-
[I]	0.25				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.25 - x$				x		x

} ← **1 mark**

(assume x is negligible)

$$K_b = \frac{1.0 \times 10^{-14}}{4.3 \times 10^{-7}} = \frac{[H_2CO_3][OH^-]}{[HCO_3^-]}$$ ← **1 mark**

$$2.33 \times 10^{-8} = \frac{x^2}{0.25}$$ ← **1 mark**

$$x = [OH^-] = 7.62 \times 10^{-5}\ M$$ ← **1 mark**

$$pOH = 4.12$$
$$pH = 9.88$$

} ← **1 mark**

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

9. Explain why the action of a buffer solution is limited. **(2 marks)**

Solution:

For Example:

Buffer action depends on the presence of

- sufficient amounts ← **1 mark**
- of weak acid and conjugate base ← **1 mark**

in the buffer solution.

10. Balance the following redox equation: **(4 marks)**

$$H_2S + CrO_4^{2-} \rightarrow S_8 + Cr^{3+} \qquad \text{(acidic)}$$

Solution:

For Example:

$$\left(8H_2S \rightarrow S_8 + 16H^+ + 16e^-\right) \times 3$$

$$\left(3e^- + 8H^+ + CrO_4^{2-} \rightarrow Cr^{3+} + 4H_2O\right) \times 16$$

$$24H_2S + \cancel{128H^+} + 16CrO_4^{2-} \rightarrow 3S_8 + \cancel{48H^+} + 16Cr^{3+} + 64\,H_2O$$

$$24H_2S + 80\,H^+ + 16CrO_4^{2-} \rightarrow 3S_8 + 16Cr^{3+} + 64H_2O$$

2 marks (1 mark for each half-reaction)

← **1 mark for the correct electron ratio**

1 mark for the final balanced equation

11. An excess of copper solid is dropped into a solution which contains $AgNO_3$, $Fe(NO_3)_3$ and $Zn(NO_3)_2$. Write the equations for any reduction half-reactions that occur over time under standard conditions. **(2 marks)**

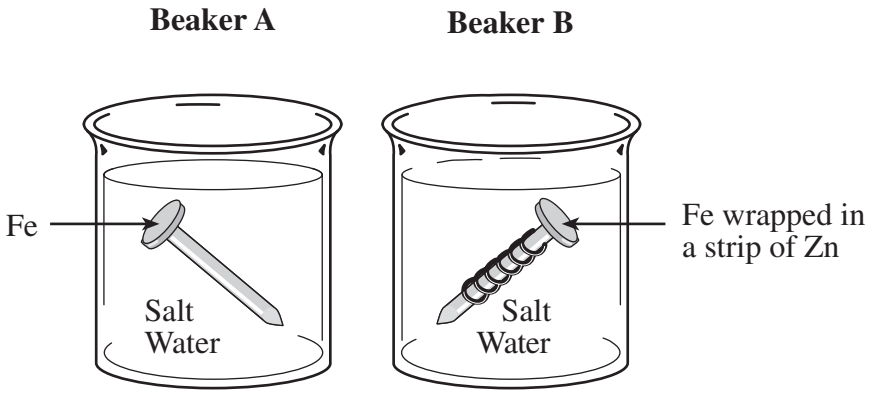
Solution:

For Example:

$Ag^+ + e^- \rightarrow Ag$ ← **1 mark**

$Fe^{3+} + e^- \rightarrow Fe^{2+}$ ← **1 mark**

12. Consider the following diagrams:



a) Predict what should happen to the Fe in Beaker A. **(1 mark)**

Solution:

For Example:

Prediction: The iron is oxidized. ← **1 mark**

b) Predict what should happen to the Fe in Beaker B. Explain. **(2 marks)**

Solution:

For Example:

Prediction: Nothing happens to the Fe. ← **1 mark**

Explanation: Zn is oxidized and protects the Fe.
OR
The Fe is cathodically protected by the Zn. } ← **1 mark**

END OF KEY