Chemistry 12

January 2002 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	A1, A6	25.	B	K	1	4	K2
2.	D	K	1	1	A5, B9	26.	C	U	2	4	K8
3.	A	U	1	1	B5	27.	D	K	1	4	L1
4.	A	U	2	1	B6	28.	C	U	1	4	L11
5.	D	U	1	1	C5	29.	B	U	1	4	M4
6.	A	H	2	2	C4, D2	30.	C	U	1	4	N2
7.	D	U	1	2	D3	31.	C	U	2	4	N4
8.	D	U	2	2	D7	32.	B	K	1	4	O2
9.	B	U	1	2	E2	33.	A	U	2	4	O5
10.	C	H	1	2	E3	34.	A	H	2	4	P2
11.	D	U	1	2	F1	35.	D	K	1	4	R4
12.	A	K	1	2	F2	36.	C	K	1	4	P6
13.	D	U	1	2	F4	37.	B	K	1	4	Q3
14.	C	U	1	2	F5	38.	C	K	2	5	S1
15.	B	U	1	3	G6	39.	A	U	1	5	S2
16.	B	U	1	3	G3	40.	A	U	1	5	S2
17.	A	U	1	3	H2	41.	A	U	1	5	S2
18.	C	U	1	3	H4	42.	D	U	1	5	S6
19.	B	K	1	3	I2	43.	D	U	1	5	T1
20.	A	H	2	3	I3	44.	C	H	1	5	U9
21.	D	U	1	3	I4	45.	B	K	2	5	U3, U4
22.	C	U	2	3	I5	46.	B	U	2	5	U2
23.	B	K	1	4	J3	47.	C	U	1	5	V4
24.	B	U	1	4	J11	48.	D	U	1	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	K	2	1	B3
3.	3	U	2	2	E2, E3
4.	4	U	4	2	F6
5.	5	U	3	3	H3
6.	6	U	3	3	I6
7.	7	U	4	4	J10, J11
8.	8	U	5	4	L6, L10, O3
9.	9	U	4	4	J8, M5
10.	10	K	1	4	Q1
11.	11	U	4	5	T6
12.	12	H	5	5	W2, W4

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 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: **(3 marks)**

$$C_{12}H_{22}O_{11(s)} \rightarrow 11\ H_2O_{(g)} + 12C_{(s)}$$

The rate of decomposition of $C_{12}H_{22}O_{11}$ is $0.75\,\text{mol/min}$.
What mass of C is produced in $10.0\,\text{seconds}$?

Solution:

For Example:

$$\text{Rate of C production} = \frac{0.75\,\text{mol}\,C_{12}H_{22}O_{11}}{\text{min}} \times \frac{12\,\text{mol C}}{1\,\text{mol}\,C_{12}H_2O_{11}}$$

$$= \frac{9.0\,\text{mol}}{\text{min}}$$

$$\text{Mass of C in } 10\,\text{s} = \left(\frac{9.0\,\text{mol}}{\text{min}}\right) \times \left(\frac{12.0\,\text{g}}{\text{mol}}\right) \times (10.0\,\text{s}) \times \left(\frac{1\,\text{min}}{60\,\text{s}}\right)$$

$$= 18\,\text{g}$$

← **3 marks**

2. Define the term *activation energy*. **(2 marks)**

Solution:

For Example:

Activation energy is the minimum amount of energy required to form the activated complex from the reactants. ← **2 marks**

3. Consider the following equilibrium: **(2 marks)**

$$2NF_{2(g)} \rightleftarrows N_2F_{4(g)}$$

Equilibrium shifts to the right when volume is decreased. Describe the changes in reaction rates that cause this shift to the right.

Solution:

For Example:

Both forward and reverse rates increase as a result of increased concentration. ← **1 mark**

The forward rate increases more than the reverse rate, so the equilibrium shifts to the right. ← **1 mark**

4. Consider the following: **(4 marks)**

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$$

Initially, $0.200\,\text{mol}$ H_2 and $0.200\,\text{mol}$ I_2 are added to an empty $2.00\,\text{L}$ container. At equilibrium, the $[I_2] = 0.020\,\text{mol/L}$. What is the value of K_{eq} ?

Solution:

For Example:

	H_2	+	I_2	$\rightleftarrows$	$2HI$
[I]	$0.100\,\text{mol/L}$		0.100		0
[C]	−0.080		−0.080		+0.160
[E]	0.020		0.020		0.160

$$K_{eq} = \frac{[HI]^2}{[H_2][I_2]} = \frac{(0.160)^2}{(0.020)(0.020)} = 64$$

← **4 marks**

5. When equal volumes of 0.20 M $Pb(NO_3)_2$ and 0.20 M KCl are mixed, a precipitate of $PbCl_2$ forms.

a) Write the formula equation for the above reaction. **(1 mark)**

Solution:

$$Pb(NO_3)_{2(aq)} + 2KCl_{(aq)} \rightarrow PbCl_{2(s)} + 2KNO_{3(aq)}$$ ← **1 mark**

b) Write the complete ionic equation for the above reaction. **(1 mark)**

Solution:

$$Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2K^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2(s)} + 2K^+_{(aq)} + 2NO_3^-{}_{(aq)}$$ ← **1 mark**

c) Write the net ionic equation for the above reaction. **(1 mark)**

Solution:

$$Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2(s)}$$ ← **1 mark**

6. Calculate the maximum $\left[CO_3^{2-}\right]$ that can exist in $0.0010\,M\ Mg(NO_3)_2$. **(3 marks)**

Solution:

For Example:

$$K_{sp}\ \ MgCO_3 = 6.8 \times 10^{-6}$$

$$MgCO_{3(s)} \rightleftarrows Mg^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)}$$

$$1.0 \times 10^{-3}\,M \qquad x$$

← **1 mark**

$$\left[CO_3^{2-}\right] = \frac{K_{sp}}{\left[Mg^{2+}\right]}$$

$$= \frac{6.8 \times 10^{-6}}{1.0 \times 10^{-3}}$$

$$= 6.8 \times 10^{-3}\,M$$

← **2 marks**

7. The two reactants in an acid-base reaction are $HNO_{2(aq)}$ and $HCO_3^-{}_{(aq)}$.

a) Write the equation for the above reaction. **(2 marks)**

Solution:

$$HNO_{2(aq)} + HCO_3^-{}_{(aq)} \rightleftarrows H_2CO_{3(aq)} + NO_2^-{}_{(aq)}$$ ← **2 marks**

b) Define the term *conjugate acid-base pair.* **(1 mark)**

Solution:

For Example:

A conjugate acid-base pair are two species whose formulas differ by a proton. ← **1 mark**

c) Write the formulas for a conjugate acid-base pair for the above reaction. **(1 mark)**

Solution:

HNO_2 and NO_2^- **OR** H_2CO_3 and HCO_3^- ← **1 mark**

8. At 10.0°C, $K_w = 2.95 \times 10^{-15}$ for pure water.

a) Calculate the pH of water at 10.0°C. **(3 marks)**

Solution:

For Example:

$$K_w = 2.95 \times 10^{-15} = [H_3O^+][OH^-] \quad \leftarrow \textbf{1 mark}$$

Since $[H_3O^+] = [OH^-]$

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

$$[H_3O^+] = 5.43 \times 10^{-8}\ M \quad \leftarrow \textbf{1 mark}$$

$$pH = 7.265 \quad \leftarrow \textbf{1 mark}$$

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

b) A mixture of the indicators phenolphthalein and bromcresol green is added to the water. What is the resulting colour of the mixture? Explain. **(2 marks)**

Solution:

For Example:

Resulting colour:

Blue at pH = 7.265. ← **1 mark**

Explanation:

Bromcresol green is blue at pH 7.265; phenolphthalein is colourless. ← **1 mark**

9. At a particular temperature a $1.0\,\text{M}$ H_2S solution has a $\text{pH} = 3.75$. Calculate the value of K_a at this temperature. **(4 marks)**

Solution:

For Example:

	H_2S	+ H_2O $\rightleftarrows$	H_3O^+	+	HS^-
[I]	1.0		0		0
[C]	-1.78×10^{-4}		$+1.78 \times 10^{-4}$		$+1.78 \times 10^{-4}$
[E]	$1.0 - 1.78 \times 10^{-4}$		1.78×10^{-4}		1.78×10^{-4}

← **2 marks**

$$\text{pH} = 3.75$$

$$\left[H_3O^+\right] = 1.78 \times 10^{-4}\,\text{M}$$

$$K_a = \frac{\left[H_3O^+\right]\left[HS^-\right]}{\left[H_2S\right]} = \frac{\left(1.78 \times 10^{-4}\right)^2}{1.0 - 1.78 \times 10^{-4}} = 3.2 \times 10^{-8}$$

← **2 marks**

10. What is the main function of a buffer solution? **(1 mark)**

Solution:

For Example:

The main function of a buffer solution is to resist changes in pH. ← **1 mark**

11. A titration is performed to determine the concentration of Fe^{2+} in 25.00 mL of an $FeSO_4$ solution. It requires 22.52 mL of 0.015 M $KMnO_4$ to reach the equivalence point according to the following equation:

$$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

Calculate the $\left[Fe^{2+}\right]$. **(4 marks)**

Solution:

For Example:

$$\text{mol } MnO_4^- = 0.02252\,\text{L} \times 0.015\,\text{M} = 3.38 \times 10^{-4}\,\text{mol} \qquad \leftarrow \textbf{1 mark}$$

$$\text{mol } Fe^{2+} = 3.38 \times 10^{-4}\,\text{mol } MnO_4^- \times \frac{5\,\text{mol } Fe^{2+}}{1\,\text{mol } MnO_4^-} \qquad \left.\right\} \leftarrow \textbf{1}\tfrac{\textbf{1}}{\textbf{2}}\ \textbf{mark}$$

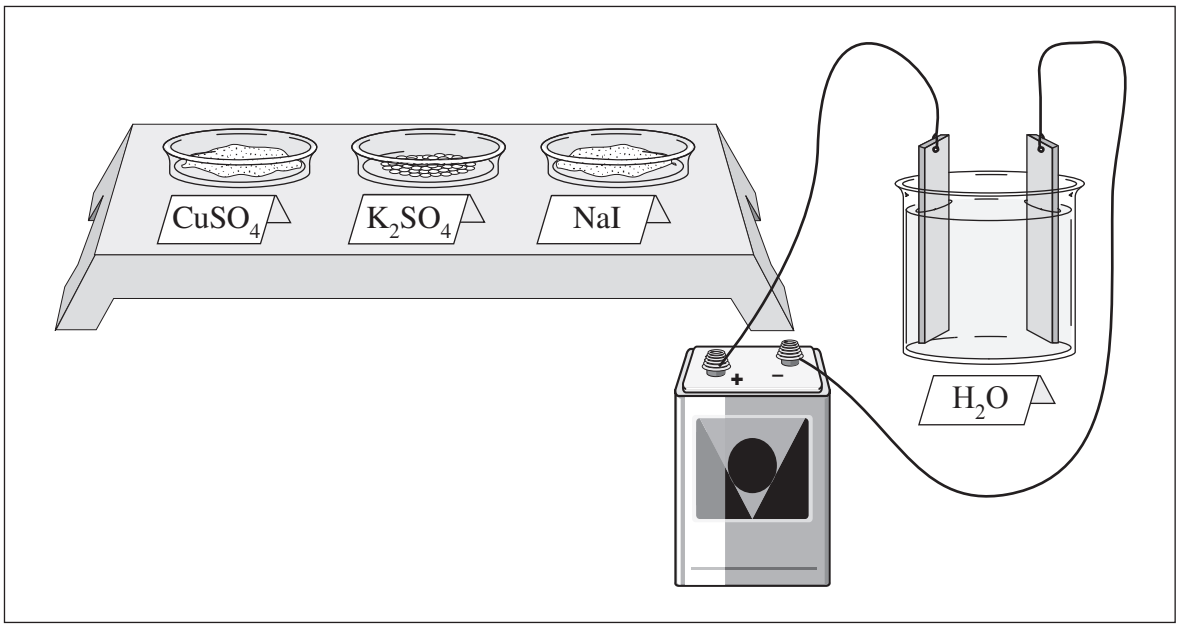
$$= 1.69 \times 10^{-3}\,\text{mol}$$

$$\left[Fe^{2+}\right] = \frac{1.69 \times 10^{-3}\,\text{mol}}{0.0250\,\text{L}} \qquad \left.\right\} \leftarrow \textbf{1}\tfrac{\textbf{1}}{\textbf{2}}\ \textbf{mark}$$

$$= 0.068\,\text{M}$$

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

12. Consider the following diagram:



Students are asked to produce hydrogen and oxygen gas by the electrolysis of water. They are given three substances $(CuSO_4$, K_2SO_4 and NaI$)$ to choose from to prepare an electrolytic solution that will only produce hydrogen and oxygen.

a) Which substance should be selected? Explain why. **(3 marks)**

Solution:

For Example:

Substance: K_2SO_4 **(1 mark)**

Explanation: It is the only one of the three substances that will neither oxidize **(1 mark)** nor reduce **(1 mark)** before water does.

b) Write the equation for the half-reaction that occurs at the anode in the electrolytic cell. **(1 mark)**

Solution:

For Example:

$H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$ ← **1 mark**

c) Explain why it would **not** be acceptable to use a copper anode in this cell. **(1 mark)**

Solution:

For Example:

A copper anode would oxidize. ← **1 mark**

END OF KEY