Chemistry 12

January 2001 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.	A	U	1	1	A2	25.	B	U	1	4	K8
2.	B	U	1	1	A6	26.	A	U	2	4	L11
3.	B	K	1	1	B3	27.	B	U	2	4	L12
4.	A	U	1	1	B1	28.	A	H	1	4	K6, L11
5.	A	U	2	1	B6, C4	29.	C	U	1	4	M4
6.	B	K	1	1	C3	30.	C	U	1	4	P6
7.	A	K	1	2	D4, F2	31.	D	K	1	4	N3
8.	D	K	1	2	D9	32.	C	U	2	4	O3
9.	C	U	1	2	E2	33.	D	U	2	4	P2
10.	C	H	2	2	E3	34.	D	U	1	4	O4, P1
11.	D	K	1	2	F3	35.	A	K	1	4	Q5
12.	C	U	2	2	F4	36.	A	K	1	4	Q3
13.	A	U	1	2	F8	37.	A	K	1	4	R1
14.	C	K	1	3	G2	38.	A	U	1	5	S1
15.	B	H	1	3	G6	39.	B	U	1	5	S2
16.	B	U	1	3	G6	40.	D	U	1	5	S5
17.	C	U	1	3	G8	41.	C	U	2	5	S5, U8
18.	B	H	1	3	H1	42.	C	U	1	5	S6
19.	D	U	2	3	H2	43.	D	U	2	5	T4
20.	C	H	2	3	I4	44.	B	H	1	5	U3, 5
21.	C	K	1	4	J1	45.	D	K	1	5	U9
22.	B	K	1	4	J4	46.	D	K	1	5	U10
23.	A	U	1	4	J7	47.	C	K	1	5	V3
24.	A	K	1	4	K4	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	5	1	C2, 5
2.	2	U	5	2	F7
3.	3	U	2	2	E2, F4
4.	4	U	2	3	H3
5.	5	U	5	3	I6
6.	6	U	2	4	J6, 11
7.	7	U	6	4	P3, 4
8.	8	U	4	4	L6, 10
9.	9	U	5	5	T2
10.	10	U	4	5	U1

Written Response = 40 marks

Multiple Choice	=	60 (48 questions)
Written Response	=	40 (10 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 calculation, full marks will NOT be given for providing only an answer.**

1. Consider the following reaction mechanism for the formation of NO_2.

Step 1	$2NO \rightarrow N_2O_2$
Step 2	________ $\rightarrow$ ________
Overall	$2NO + O_2 \rightarrow 2NO_2$

a) Complete Step 2. **(2 marks)**

Solution:

For Example:

$N_2O_2 + O_2 \rightarrow 2NO_2$ ← **2 marks**

b) Define the term *reaction intermediate*. **(2 marks)**

Solution:

For Example:

A species that is produced and then used up in a later step. ← **2 marks**

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

Solution:

N_2O_2 ← **1 mark**

2. Consider the following equilibrium system:

$$2COF_{2(g)} \rightleftarrows CO_{2(g)} + CF_{4(g)} \qquad K_{eq} = 2.00$$

A 2.00 L container is filled with 0.500 mol of COF_2.
Calculate the $[COF_2]$ at equilibrium. **(5 marks)**

Solution:

For Example:

	$2COF_{2(g)}$	$\rightleftarrows$	$CO_{2(g)}$	+	$CF_{4(g)}$
[I]	$\frac{0.500\ \text{mol}}{2.00\ \text{L}} = 0.250\ \text{mol/L}$		0		0
[C]	$-2x$		$+x$		$+x$
[E]	$0.250 - 2x$		x		x

← **2 marks**

$$K_{eq} = \frac{[CO_2][CF_4]}{[COF_2]^2}$$

$$2.00 = \frac{(x)(x)}{(0.250 - 2x)^2}$$

$$x = 0.0923\ \text{mol/L}$$

$$[COF_2] = 0.250 - 2x$$
$$= 0.250 - 2(0.0923)$$
$$= 0.065\ \text{mol/L}$$

← **3 marks**

3. Consider the following equilibrium system:

$$\underset{blue}{Cu^{2+}_{(aq)}} \quad + \quad \underset{colourless}{4Br^{-}_{(aq)}} \quad \rightleftarrows \quad \underset{green}{CuBr_{4\ (aq)}^{2-}}$$

Cooling the equilibrium changes the colour from green to blue. What effect will the decrease in temperature have on K_{eq} ? Explain, using Le Chatelier's Principle. **(2 marks)**

Solution:

For Example:

The value of K_{eq} decreased. ← **1 mark**

When the temperature stress is applied to the equilibrium system, the system shifts to the left to offset the stress and in the new equilibrium, the [products] has decreased. ← **1 mark**

4. Write the balanced complete ionic equation for the reaction that occurs when $0.20\,\mathrm{M}$ of $Ba(NO_3)_2$ is added to an equal volume of $0.20\,\mathrm{M}$ Na_2CO_3. **(2 marks)**

Solution:

$$\underbrace{Ba^{2+}_{(aq)} + 2NO_3^{-}{}_{(aq)}}_{\frac{1}{2}\ \mathbf{mark}} + \underbrace{2Na^{+}_{(aq)} + CO_3^{2-}{}_{(aq)}}_{\frac{1}{2}\ \mathbf{mark}} \rightarrow \underbrace{BaCO_{3(s)}}_{\frac{1}{2}\ \mathbf{mark}} + \underbrace{2Na^{+}_{(aq)} + 2NO_3^{-}{}_{(aq)}}_{\frac{1}{2}\ \mathbf{mark}}$$

5. Calculate the minimum number of moles of $Pb(NO_3)_2$ required to start precipitation in 50.0 mL of 0.15 M ZnI_2. **(5 marks)**

Solution:

For Example:

$$[ZnI_2] = 0.15\text{ M}$$
$$\therefore [I^-] = 2 \times 0.15\text{ M}$$
$$= 0.30\text{ M}$$

← **1 mark**

$$PbI_{2(s)} \rightleftarrows Pb^{2+} + 2I^-$$
$$K_{sp} = [Pb^{2+}][I^-]^2$$

← **1 mark**

$$8.5 \times 10^{-9} = (x)(0.30)^2$$ ← **1 mark**

$$x = 9.44 \times 10^{-8}\text{ mol/L}$$ ← **1 mark**

$$\text{moles} = 9.44 \times 10^{-8}\text{ mol/L} \times 0.0500\text{ L}$$
$$= 4.7 \times 10^{-9}\text{ mol}$$ ← **1 mark**

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

6. Consider the following Brønsted-Lowry equilibrium:

$$H_2SO_{3(aq)} + HPO_4{}^{2-}{}_{(aq)} \rightleftarrows H_2PO_4{}^{-}{}_{(aq)} + HSO_3{}^{-}{}_{(aq)}$$

a) Identify the two Brønsted-Lowry acids in the above equilibrium. **(1 mark)**

Solution:

For Example:

Species 1: H_2SO_3 ← **½ mark**

Species 2: $H_2PO_4{}^{-}$ ← **½ mark**

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

Solution:

For Example:

A conjugate acid is a species produced when a proton is accepted by a Brønsted-Lowry base. } ← **1 mark**

7. A 250.0 mL sample of HCl with a pH of 2.000 is completely neutralized with 0.200 M NaOH.

a) What volume of NaOH is required to reach the stoichiometric point? **(4 marks)**

Solution:

For Example:

$$
\left.
\begin{aligned}
[\text{HCl}] &= 1.00 \times 10^{-2}\ \text{M} \\
\text{mol HCl} &= (0.250\ \text{L})\left(1.00 \times 10^{-2}\ \text{mol/L}\right) \\
&= 2.50 \times 10^{-3}\ \text{mol} \\
\text{mol HCl} &= \text{mol NaOH} \\
\text{Volume of NaOH} &= \frac{2.50 \times 10^{-3}\ \text{mol}}{0.200\ \text{M}} = 1.25 \times 10^{-2}\ \text{L}
\end{aligned}
\right\} \leftarrow \textbf{4 marks}
$$

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

b) Write the net ionic equation for the neutralization reaction. **(1 mark)**

Solution:

For Example:

$H_3O^+ + OH^- \rightleftarrows 2H_2O$ ← **1 mark**

c) If the HCl were titrated with a 0.200 M $NH_{3(aq)}$ instead of 0.200 M NaOH, how would the volume of base required to reach the equivalence point compare with the volume calculated in part a)? Explain your answer. **(1 mark)**

Solution:

For Example:

The volume of base required would not change, ← $\frac{1}{2}$ **mark**

because the strong acid results in the reaction going to completion in a 1:1 ratio. ← $\frac{1}{2}$ **mark**

8. Consider the following equilibrium:

$$\text{energy} + 2H_2O \rightleftarrows H_3O^+ + OH^-$$

a) Explain how pure water can have a $pH = 7.30$. **(2 marks)**

Solution:

For Example:

A lower temperature causes a shift to the left.
The $\left[H_3O^+\right]$ drops as a result, and the pH increases. } ← **2 marks**

b) Calculate the value of K_w for the sample of water with a $pH = 7.30$. **(2 marks)**

Solution:

For Example:

$$\left[H_3O^+\right] = \left[OH^-\right] = 1 \times 10^{-7.30} = 5.0 \times 10^{-8}\ M$$ ← **1 mark**

$$K_w = \left[H_3O^+\right] \times \left[OH^-\right] = \left(5.0 \times 10^{-8}\right)\left(5.0 \times 10^{-8}\right) = 2.5 \times 10^{-15}$$ ← **1 mark**

9. Balance the following redox reaction in basic solution. **(5 marks)**

$$SO_3^{2-} + MnO_4^- \rightarrow SO_4^{2-} + MnO_2 \qquad \text{(basic)}$$

Solution:

For Example:

$$\left.\begin{array}{r} 2 \times \left(2H_2O + 3e^- + MnO_4^- \rightarrow MnO_2 + 4OH^-\right) \\ 3 \times \left(2OH^- + SO_3^{2-} \rightarrow SO_4^{2-} + 2e^- + H_2O\right) \\ \hline H_2O + 2MnO_4^- + 3SO_3^{2-} \rightarrow 3SO_4^{2-} + 2MnO_2 + 2OH^- \end{array}\right\} \leftarrow \textbf{5 marks}$$

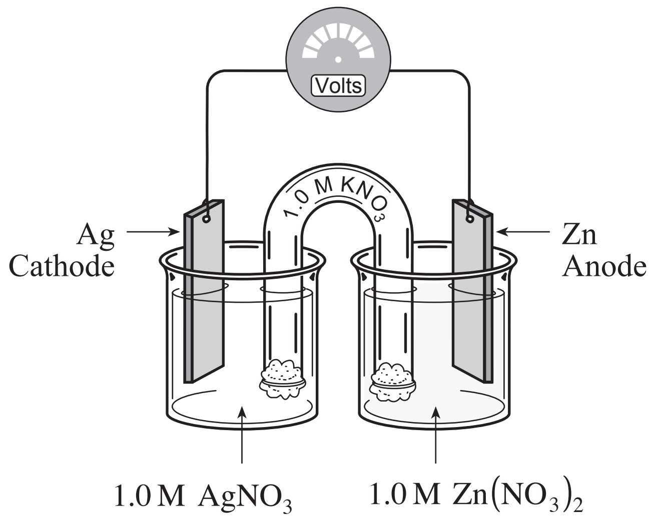
OR

$$\left.\begin{array}{r} 3 \times \left(H_2O + SO_3^{2-} \rightarrow SO_4^{2-} + 2H^+ + 2e^-\right) \\ 2 \times \left(3e^- + 4H^+ + MnO_4^- \rightarrow MnO_2 + 2H_2O\right) \\ \hline 2H^+ + 3SO_3^{2-} + 2MnO_4^- \rightarrow 3SO_4^{2-} + 2MnO_2 + H_2O \\ \\ H_2O + 3SO_3^{2-} + 2MnO_4^- \rightarrow 3SO_4^{2-} + 2MnO_2 + 2OH^- \end{array}\right\} \leftarrow \textbf{5 marks}$$

10. Draw and label the parts of an operating electrochemical cell using a zinc anode that will produce an electric current having a voltage of 1.56 V at standard conditions. **(4 marks)**

Solution:

For Example:



2 marks for set up.
1 mark for suitable cathode.
1 mark for suitable electrolytes.

END OF KEY