Chemistry 12

January 1999 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	CO	PLO	Q	K	C	CO	PLO
1.	C	U	1	A3	25.	A	K	4	L11
2.	B	K	1	B3	26.	D	K	4	L10
3.	D	K	1	B2	27.	A	U	4	L6
4.	C	H	1	B4	28.	A	U	4	L11
5.	A	U	1	B6	29.	A	H	4	K9, L11
6.	C	U	1	C5	30.	A	U	4	N3
7.	C	U	2	D4	31.	C	U	4	P1
8.	B	U	2	E2	32.	A	K	4	Q3
9.	C	U	2	E2, 5	33.	C	K	4	R1
10.	A	H	2	E3	34.	D	U	4	O5
11.	D	K	2	F3	35.	B	U	4	K11
12.	C	H	2	F4	36.	D	U	4	P5
13.	C	U	3	F7	37.	B	U	5	S1
14.	B	K	3	G4	38.	A	U	5	S2
15.	D	U	3	H2	39.	D	U	5	S5
16.	D	U	3	H3	40.	A	U	5	S6
17.	B	K	3	I2	41.	A	U	5	T3
18.	B	U	3	I3	42.	A	H	5	T4
19.	D	U	3	I5	43.	B	U	5	U3, U4
20.	C	U	3	H1, I4	44.	D	K	5	U8
21.	C	K	4	J7	45.	D	K	5	V2
22.	B	H	4	H5	46.	C	K	5	V3
23.	A	H	4	K1	47.	C	U	5	W4
24.	A	U	4	K6	48.	C	K	5	W5

Multiple Choice = 48 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	3	1	C2
2.	2	U	5	2	D4, F1, 5
3.	3	U	4	3	G5, I3
4.	4	U	4	4	M4, N1, 3
5.	5	U	4	4	M3
6.	6	U	4	4	P1, 4, 6
7.	7	U	3	5	T2
8.	8	U	3	5	T6
9.	9	U	2	5	W6

Written Response = 32 marks

Multiple Choice = 48 (48 questions)
Written Response = 32 (9 questions)
EXAMINATION TOTAL = 80 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: 32 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:

Step 1	?
Step 2	$H_2 + Cl \rightarrow HCl + H$
Step 3	$H + Cl_2 \rightarrow HCl + Cl$
Step 4	$Cl + Cl \rightarrow Cl_2$
Overall	$H_2 + Cl_2 \rightarrow 2HCl$

a) Write the equation for Step 1. **(2 marks)**

Solution:

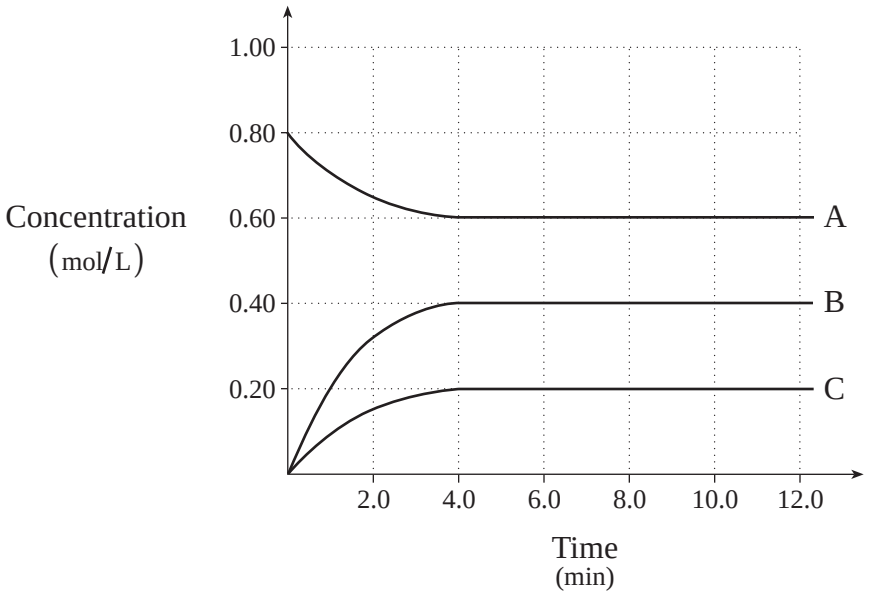
$Cl_2 \rightarrow Cl + Cl$

b) Identify the reaction intermediate(s). **(1 mark)**

Solution:

Cl and H

2. Consider the following diagram for a chemical system containing three substances represented by A, B and C:



a) What feature of the graph indicates that the system reaches equilibrium? **(1 mark)**

Solution:

For Example:

The concentrations become constant.

b) Write a balanced equation for the equilibrium reaction. **(2 marks)**

Solution:

$$A \rightleftarrows 2B + C$$

c) Calculate K_{eq} at equilibrium. **(2 marks)**

Solution:

$$K_{eq} = \frac{[B]^2[C]}{[A]} = \frac{(0.40)^2(0.20)}{0.60} = 0.053$$

3. In an experiment to determine the solubility of barium fluoride, $500.0\,\text{mL}$ of the saturated solution was heated in an evaporating dish to remove the water. The evaporating dish and residue were heated two more times, to ensure all the water had been driven off.

I.	Volume of saturated solution of BaF_2	$500.0\,\text{mL}$
II.	Mass of evaporating dish	$72.540\,\text{g}$
III.	Mass of evaporating dish and BaF_2 after first heating	$73.500\,\text{g}$
IV.	Mass of evaporating dish and BaF_2 after second heating	$72.855\,\text{g}$
V.	Mass of evaporating dish and BaF_2 after third heating	$72.855\,\text{g}$

Using the data above, calculate the K_{sp} for BaF_2. **(4 marks)**

Solution:

Use the final unchanged mass $(\text{dish} + BaF_2)$:

$\therefore \text{Mass of } BaF_2 = 72.855\,\text{g} - 72.540\,\text{g} = 0.315\,\text{g}$ ← **1 mark**

Solubility is

$$\frac{0.315\,\text{g} \times \frac{1\ \text{mol}}{175.3\,\text{g}}}{0.5000\ \text{L}} = 0.00359\ \text{mol/L}$$

← **1 $\frac{1}{2}$ marks**

$$K_{sp} = \left[Ba^{2+}\right]\left[F^-\right]^2$$
$$= (0.00359)(0.00718)^2$$
$$= 1.86 \times 10^{-7}$$

← **1 $\frac{1}{2}$ marks**

4. Consider the salt sodium oxalate, $Na_2C_2O_4$.

a) Write the dissociation equation for sodium oxalate. **(1 mark)**

Solution:

$$Na_2C_2O_4 \rightarrow 2Na^+ + C_2O_4{}^{2-} \quad \leftarrow \textbf{1 mark}$$

b) A $1.0\,M$ solution of sodium oxalate turns pink when a few drops of the indicator phenolphthalein are added. Write a hydrolysis equation and explain why this salt causes the indicator to change colour. **(2 marks)**

Solution:

For Example:

$$C_2O_4{}^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftarrows HC_2O_4{}^{-}{}_{(aq)} + OH^-{}_{(aq)} \quad \leftarrow \textbf{1 mark}$$

The formation of the OH^- caused the indicator to change colour. $\leftarrow$ **1 mark**

c) Calculate the equilibrium constant for the hydrolysis in b). **(1 mark)**

Solution:

$$\left.\begin{aligned} K_b &= \frac{K_w}{K_a} \\ &= \frac{1.0\times10^{-14}}{6.4\times10^{-5}} \\ &= 1.6\times10^{-10} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

5. Calculate the pH of $0.50\,\text{M}\ H_3BO_3$. **(4 marks)**

Solution:

	H_3BO_3	+	H_2O	$\rightleftarrows$	H_3O^+	+	$H_2BO_3^-$
[I]	0.50				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.50 - \cancel{x}$				x		x

} ← **1 ½ marks**

neglect since $0.50\,\text{M} >> x$

$$K_a = \frac{\left[H_3O^+\right]\left[H_2BO_3^-\right]}{\left[H_3BO_3\right]}$$

$$7.3\times10^{-10} = \frac{(x)(x)}{0.50 - \cancel{x}}$$

$$= \frac{(x)(x)}{0.50}$$

$$x = \left[H_3O^+\right] = 1.91\times10^{-5}\,\text{M}$$

} ← **1 ½ marks**

$$\text{pH} = -\log 1.91\times10^{-5} = 4.72$$

} ← **1 mark**

NOTE: $\left(\frac{1}{2}\right.$ mark$\left.\right)$ is deducted for incorrect significant figures.

6. A $25.0\,\text{mL}$ sample of $Sr(OH)_2$ is titrated with a standardized solution of HCl to the equivalence point.

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

Solution:

$Sr(OH)_2 + 2HCl \rightarrow SrCl_2 + 2H_2O$ ← **1 mark**

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

Solution:

For example:

$H^+ + OH^- \rightarrow H_2O$ ← **1 mark**

c) What is meant by the term "standardized" solution? **(1 mark)**

Solution:

For example:

A solution of known concentration.
OR
A solution that has had its concentration determined by carrying out a titration against another solution of known concentration.
← **1 mark**

d) Define *equivalence point.* **(1 mark)**

Solution:

For example:

The equivalence point in a titration is the point at which the moles of the reactants are in the ratio given by the balanced equation. ← **1 mark**

7. Balance the following redox reaction in acidic solution:

$$RuO_4 + P \rightarrow Ru(OH)_2^{2+} + H_3PO_3 \qquad (acid)$$ **(3 marks)**

Solution:

$$3\times\left(RuO_4 + 6H^+ + 4e^- \rightarrow Ru(OH)_2^{2+} + 2H_2O\right)$$
$$4\times\left(P + 3H_2O \rightarrow H_3PO_3 + 3H^+ + 3e^-\right)$$

1 mark for reactions
1 mark for balancing electrons

$$3RuO_4 + 6H^+ + 6H_2O + 4P \rightarrow 3Ru(OH)_2^{2+} + 4H_3PO_3$$

1 mark for addition and simplification

8. A technician tests the concentration of methanol, CH_3OH, in diluted windshield washer fluid using a redox titration. A $25.00\,mL$ sample is titrated with $14.50\,mL$ of $0.0200\,M$ $KMnO_4$. Determine the concentration of methanol in the sample given the following redox reaction:

$$6H^+ + 2MnO_4^- + 5CH_3OH \rightarrow 5CH_2O + 2Mn^{2+} + 8H_2O \qquad \textbf{(3 marks)}$$

Solution:

$$\text{Moles of } KMnO_4 = 0.01450\,L \times 0.0200\,mol/L = 2.90 \times 10^{-4}\,mol \qquad \leftarrow \textbf{1 mark}$$

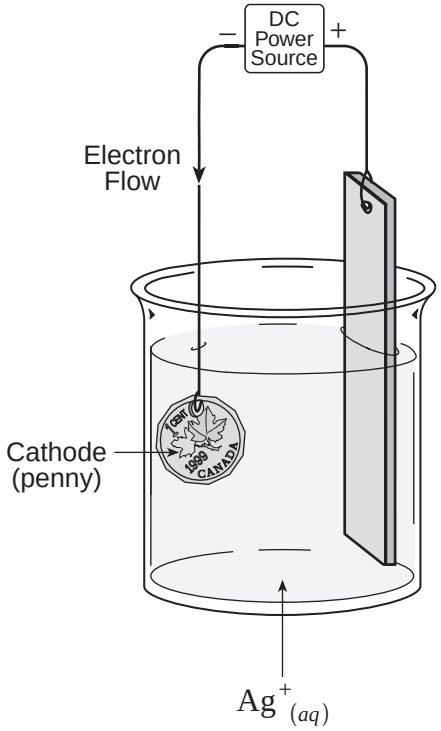
$$\text{Moles of } CH_3OH = \frac{5\left(2.90 \times 10^{-4}\,mol\right)}{2} = 7.25 \times 10^{-4}\,mol \qquad \leftarrow \textbf{1 mark}$$

$$\left[CH_3OH\right] = 7.25 \times 10^{-4}\,mol/0.0250\,L = 0.0290\,M \qquad \leftarrow \textbf{1 mark}$$

NOTE: $\left(\frac{1}{2}$ mark$\right)$ is deducted for incorrect significant figures.

9. An electrolytic cell can be used to plate a copper penny with a silver coating. Sketch a diagram of the electrolytic cell. Label the cathode and show the direction of electron flow. **(2 marks)**

Solution:



1 mark for diagram

$\frac{1}{2}$ mark for cathode

$\frac{1}{2}$ mark for electron flow

END OF KEY