Chemistry 12

August 1997 Provincial Examination

ANSWER KEY / SCORING GUIDE

Topics:
1. Kinetics
2. Equilibrium
3. Solubility
4. Acids, Bases, Salts
5. Oxidation – Reduction

Part A: Multiple Choice

Q	C	T	K	S	CGR	Q	C	T	K	S	CGR
1.	U	1	D	1	I-A-3	25.	U	4	C	1	IV-D-9
2.	K	1	D	1	I-C-1	26.	U	4	C	1	IV-F-6
3.	U	1	B	1	I-D-7, 6	27.	K	4	C	1	IV-F-7
4.	K	1	C	1	I-F-1, 2	28.	U	4	B	1	IV-H-9
5.	U	1	A	1	I-E-2	29.	U	4	A	1	IV-F-8, G-2
6.	U	2	D	1	II-A-3	30.	U	4	B	1	IV-G-3
7.	K	2	C	1	II-B-1, 2	31.	U	4	D	1	IV-F-14
8.	U	2	A	1	II-D-1	32.	U	4	B	1	IV-I-1, D-12
9.	U	2	A	1	II-E-2, 3	33.	K	4	C	1	IV-J-1
10.	U	2	D	1	II-G-1	34.	U	4	D	1	IV-J-3
11.	H	2	A	1	II-H-2	35.	H	4	C	1	IV-K-6
12.	U	2	C	1	II-J-1	36.	K	4	B	1	IV-L-3
13.	U	2	A	1	II-J-4	37.	U	5	A	1	V-A-3
14.	U	3	A	1	III-A-7	38.	K	5	C	1	V-A-2
15.	U	3	B	1	III-B-8	39.	U	5	C	1	V-A-7
16.	U	3	C	1	III-B-3	40.	U	5	C	1	V-C-1
17.	U	3	B	1	III-B-7	41.	H	5	B	1	V-B-1, 3
18.	U	3	A	1	III-D-3	42.	K	5	A	1	V-D-1
19.	U	3	D	1	III-D-4	43.	U	5	A	1	V-D-3
20.	H	3	A	1	III-B-7	44.	H	5	D	1	V-G-1, 2
21.	K	4	D	1	IV-A-2	45.	H	5	B	1	V-G-2
22.	U	4	B	1	IV-D-3, 7	46.	U	5	D	1	V-H-3
23.	K	4	A	1	IV-C-2	47.	U	5	C	1	V-I-4
24.	U	4	B	1	IV-E-2	48.	H	5	B	1	V-A-4, 5

Part B: Written Response

Q	B	C	T	S	CGR	Q	B	C	T	S	CGR
1.	1	K	1	2	I-D-2, 7	7.	7	U	4	2	IV-A-1
2.	2	U	1	2	I-E-1	8.	8	U	4	2	IV-G-1, F-11
3.	3	U	2	2	II-E-2	9.	9	U	4	3	IV-H-15
4.	4	U	2	3	II-J-3	10.	10	U	4	3	IV-J-5, H-3
5.	5	U	3	3	III-D-6	11.	11	U	5	4	V-E-2
6.	6	U	3	2	III-B-7	12.	12	U	5	4	V-G-1, 4, 5

Multiple Choice = 48 (48 questions)
Written Response = 32 (12 questions)
Total = 80 marks

LEGEND:

Q = Question Number
K = Keyed Response
B = Score Box Number
C = Cognitive Level
S = Score
T = Topic
CGR = Curriculum Guide Reference

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

Response:

For example:

Activation energy is the potential energy difference between the reactants and the activated complex. } ← **2 marks**

2. Consider the overall reaction:

$$4HBr_{(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)} + 2Br_{2(g)}$$

A proposed three-step reaction mechanism is:

Step 1: $HBr + O_2 \rightarrow HOOBr$

Step 2: ?

Step 3: $HBr + HOBr \rightarrow H_2O + Br_2$

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

Response:

For example:

$HBr + HOOBr \rightarrow 2HOBr$ ← **2 marks**

3. Consider the following equilibrium:

$$2NO_{(g)} + Cl_{2(g)} \rightleftarrows 2NOCl_{(g)} \qquad \Delta H = -77 \text{ kJ}$$

What happens to the amount of Cl_2 when the following changes are imposed? Explain, using Le Chatelier's principle.

a) Removing $NO_{(g)}$. **(1 mark)**

Response:

For example:

The amount of Cl_2 will increase because the equilibrium shifts left. ← **1 mark**

b) Decreasing the temperature. **(1 mark)**

Response:

For example:

The amount of Cl_2 will decrease because the equilibrium shifts right. ← **1 mark**

4. Consider the following equilibrium:

$$H_{2(g)} + S_{(s)} \rightleftarrows H_2S_{(g)} \qquad K_{eq} = 6.8 \times 10^{-2}$$

A 1.0 L container is initially filled with 0.050 mol H_2 and 0.050 mol S. The container is heated to $90°C$ and equilibrium is established. What is the equilibrium $[H_2S]$? **(3 marks)**

Response:

	$H_{2(g)}$	+ $S_{(s)}$	$\rightleftarrows$	$H_2S_{(g)}$
[**I**]	0.050			0
[**C**]	$-x$			$+x$
[**E**]	$0.050 - x$			x

← **1 $\frac{1}{2}$ marks**

$$K_{eq} = \frac{[H_2S]}{[H_2]}$$

$$6.8 \times 10^{-2} = \frac{(x)}{(0.050 - x)}$$

$$x = 0.0032$$

$$[H_2S] = 3.2 \times 10^{-3} \text{ mol/L}$$

← **1 $\frac{1}{2}$ marks**

5. A container is filled with 10.0 L of 0.050 M NaI. Calculate the maximum mass of solid $Pb(NO_3)_2$ that can be dissolved without forming a precipitate. **(3 marks)**

Response:

$$PbI_{2(s)} \rightleftarrows Pb^{2+}_{(aq)} + 2I^-_{(aq)}$$

$$[E] \qquad x \qquad 0.050$$

$$K_{sp} = [Pb^{2+}][I^-]^2 = 8.5\times10^{-9} \qquad \leftarrow \textbf{1 mark}$$

$$(x)(0.050)^2 = 8.5\times10^{-9}$$

$$x = [Pb^{2+}] = 3.4\times10^{-6}\ M \qquad \leftarrow \textbf{1 mark}$$

$$3.4\times10^{-6}\ M \times 331.2\ g/mol = 1.1\times10^{-3}\ g/L \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$1.1\times10^{-3}\ g/L \times 10.0\ L = 1.1\times10^{-2}\ g \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

6. Write net ionic equations for all precipitation reactions that occur when equal volumes of 0.20 M $Sr(OH)_2$ and 0.20 M $MgSO_4$ are mixed together. **(2 marks)**

Response:

$$Sr^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)} \rightarrow SrSO_{4(s)} \qquad \leftarrow \textbf{1 mark}$$

$$Mg^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Mg(OH)_{2(s)} \qquad \leftarrow \textbf{1 mark}$$

7. State two tests that could be safely performed to determine whether an unknown solution is acidic. Predict the results if the solution is acidic. **(2 marks)**

Response:

For example:

Test: Use an indicator such as litmus.
Result: Turns red.

Test: Add magnesium metal.
Result: H_2 gas is given off.

Test: pH meter.
Result: pH < 7

← **any test and result for 1 mark each**

8. An aqueous solution of Na_2CO_3 undergoes hydrolysis.

a) Write the equation for the hydrolysis. **(1 mark)**

Response:

$$CO_3^{2-}{}_{(aq)} + H_2O_{(\ell)} \rightleftarrows HCO_3^{-}{}_{(aq)} + OH^{-}{}_{(aq)}$$ ← **1 mark**

b) Calculate K_b for the hydrolysis in a). **(1 mark)**

Response:

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{5.6 \times 10^{-11}} = 1.8 \times 10^{-4}$$ ← **1 mark**

9. A solution of 0.0100 M lactic acid, $HC_3H_5O_3$, has a pH of 2.95.
Calculate the K_a value. **(3 marks)**

Response:

pH of 2.95, therefore $\left[H_3O^+\right] = 0.00112$ M

$$\left[C_3H_5O_3^-\right] = 0.00112 \text{ M}$$

$$HC_3H_5O_{3(aq)} + H_2O_{(aq)} \rightleftarrows H_3O^+_{(aq)} + C_3H_5O_3^-{}_{(aq)}$$

[**I**]	0.0100	0	0
[**C**]	−0.00112	+0.00112	+0.00112
[**E**]	0.0088	0.00112	0.00112

← **1 $\frac{1}{2}$ marks**

$$K_a = \frac{\left[H_3O^+\right]\left[C_3H_5O_3^-\right]}{\left[HC_3H_5O_3\right]}$$

$$= \frac{\left(1.12 \times 10^{-3}\right)^2}{0.0088}$$

$$= 1.4 \times 10^{-4}$$

← **1 $\frac{1}{2}$ marks**

10. Calculate the pH of a solution prepared by adding 40.0 mL of 0.440 M NaOH to 60.0 mL of 0.320 M HCl. **(3 marks)**

Response:

For example:

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(\ell)} + NaCl_{(aq)}$$

$$\begin{aligned} \text{mol } H_3O^+ &= 0.320 \text{ mol/L} \times 0.0600 \text{ L} \\ &= 0.0192 \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{mol } OH^- &= 0.440 \text{ mol/L} \times 0.0400 \text{ L} \\ &= 0.0176 \text{ mol} \end{aligned}$$

} ← **1 mark**

$$\begin{aligned} \text{excess mol } H_3O^+ &= 0.0192 - 0.0176 \\ &= 0.0016 \text{ mol} \end{aligned}$$

$$\begin{aligned} \left[H_3O^+\right] &= \frac{0.0016 \text{ mol}}{0.100 \text{ L}} \\ &= 0.016 \text{ M} \end{aligned}$$

$$\begin{aligned} \text{pH} &= -\log(0.016) \\ &= 1.80 \end{aligned}$$

} ← **2 marks**

11. Balance the following redox reaction: **(4 marks)**

$$Mn^{2+} + BiO_3^- \rightarrow MnO_4^- + Bi^{3+} \quad \text{(acidic)}$$

Response:

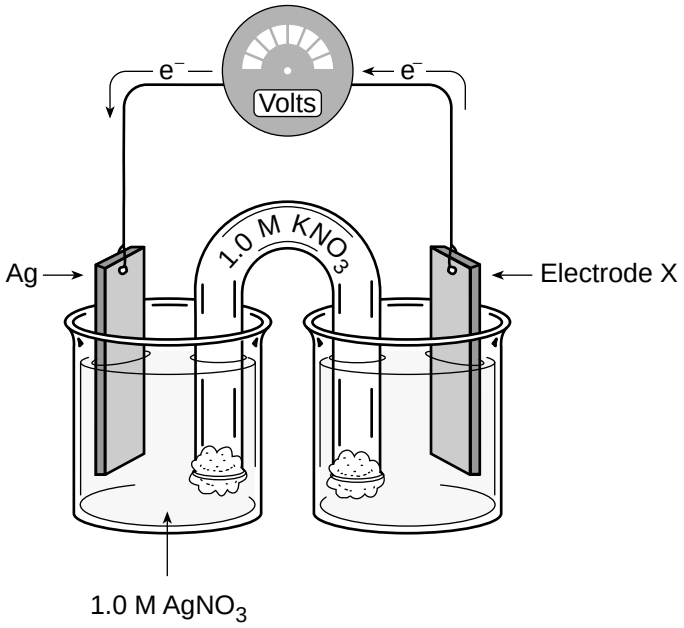
1 mark

$$5\left(BiO_3^- + 6H^+ + 2e^- \rightarrow Bi^{3+} + 3H_2O\right) \quad \leftarrow \textbf{1 mark}$$

$$2\left(Mn^{2+} + 4H_2O \rightarrow MnO_4^- + 8H^+ + 5e^-\right) \quad \leftarrow \textbf{1 mark}$$

$$5BiO_3^- + 2Mn^{2+} + 14H^+ \rightarrow 5Bi^{3+} + 2MnO_4^- + 7H_2O \quad \leftarrow \textbf{1 mark}$$

12. Consider the following electrochemical cell:



a) The initial cell voltage in the diagram above is 1.25 V. Identify electrode **X**. **(1 mark)**

Response:

Iron. ← **1 mark**

b) Towards which electrode will the K^+ ions migrate? **(1 mark)**

Response:

K^+ ions migrate toward the Ag electrode. ← **1 mark**

c) Write the equation for the reduction half-reaction that occurs. **(1 mark)**

Response:

$Ag^+_{(aq)} + e^- \rightleftarrows Ag_{(s)}$ ← **1 mark**

d) On the diagram, indicate the direction of electron flow. **(1 mark)**

Response:

Electrons flow from electrode X to the silver electrode. See diagram above. ← **1 mark**

END OF KEY