Chemistry 12

April 1996 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.	K	1	D	1	I-C-1	25.	U	4	A	1	IV-E-3
2.	U	1	A	1	I-B-2	26.	U	4	C	1	IV-F-6
3.	H	1	A	1	I-D-5	27.	H	4	B	1	IV-F-9, 13
4.	U	1	B	1	I-D-8	28.	U	4	D	1	IV-G-3
5.	U	1	B	1	I-E-2	29.	U	4	B	1	IV-H-9
6.	U	2	C	1	II-A-3	30.	U	4	B	1	IV-J-1
7.	K	2	D	1	II-B-2	31.	H	4	C	1	IV-J-3
8.	U	2	B	1	II-D-1	32.	U	4	A	1	IV-J-4
9.	U	2	D	1	II-D-1	33.	U	4	A	1	IV-J-5
10.	U	2	C	1	II-E-3	34.	U	4	C	1	IV-K-1
11.	U	2	C	1	II-H-2	35.	U	4	D	1	IV-K-3
12.	H	2	B	1	II-J-3	36.	U	4	A	1	IV-L-3
13.	H	2	D	1	II-J-4	37.	K	5	D	1	V-A-2
14.	K	3	B	1	III-A-6	38.	K	5	B	1	V-A-6
15.	U	3	B	1	III-B-7	39.	U	5	B	1	V-B-3
16.	H	3	C	1	III-C-2	40.	U	5	D	1	V-C-1
17.	U	3	A	1	III-D-2	41.	U	5	B	1	V-C-1
18.	U	3	D	1	III-D-4	42.	U	5	D	1	V-D-2
19.	U	3	C	1	III-D-6	43.	U	5	C	1	V-E-2
20.	U	3	A	1	III-E-1	44.	K	5	C	1	V-G-5, A-6
21.	K	4	C	1	IV-A-4	45.	U	5	B	1	V-G-9
22.	U	4	A	1	IV-B-2	46.	U	5	A	1	V-H-3
23.	U	4	D	1	IV-C-2	47.	U	5	A	1	V-I-4
24.	U	4	B	1	IV-D-9	48.	K	5	B	1	V-J-2

Part B: Written Response

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

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

LEGEND:

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

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. a) Define the term *heterogeneous reaction.* **(1 mark)**

Response:

For example:

A reaction in which the reactants are in different phases.

b) Give one example of a heterogeneous reaction. **(1 mark)**

Response:

For example:

Solid Mg reacting with hydrochloric acid.

2. Consider the following reaction:

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

Explain why the mechanism for the above reaction involves more than one step. **(1 mark)**

Response:

This is a 5 particle collision and is unlikely to occur in one step.

3. Consider the following equilibrium:

$$2NO_{(g)} + O_{2(g)} \rightleftarrows 2NO_{2(g)} \qquad K_{eq} = 6.45 \times 10^5$$

a) Write the K_{eq} expression. **(1 mark)**

Response:

$$K_{eq} = \frac{[NO_2]^2}{[NO]^2[O_2]}$$

b) Explain why the $[NO_2]$ is greater than the $[NO]$ at equilibrium when the $[O_2]$ is 1.0 mol/L. **(1 mark)**

Response:

A large K_{eq} means $[\text{products}] > [\text{reactants}]$.

4. Consider the following equilibrium:

$$2HI_{(g)} \rightleftarrows H_{2(g)} + I_{2(g)} \qquad K_{eq} = 81.0$$

A 1.00 L container is initially filled with 4.00 mol HI. Calculate the [HI] at equilibrium. **(4 marks)**

Response:

	$2HI$	$\rightleftarrows$	H_2	+	I_2
$[\mathbf{I}]$	4.00		0		0
$[\mathbf{C}]$	$-2x$		$+x$		$+x$
$[\mathbf{E}]$	$4.00-2x$		x		x

← **1 ½ marks**

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

$$\frac{x^2}{(4.00-2x)^2} = 81.0$$

$$x = 1.8947 \text{ mol/L}$$

← **1 ½ marks**

$$[HI] = 4.00 - 3.79 = 0.21 \text{ mol/L}$$

← **1 mark**

5. Write a balanced chemical equation for the equilibrium in a saturated solution of an ionic compound with low solubility. **(2 marks)**

Response:

$$AgCl_{(s)} \rightleftarrows Ag^+_{(aq)} + Cl^-_{(aq)}$$

6. A saturated solution of $AgCH_3COO$ was evaporated to dryness. The 250.0 mL sample was found to contain 1.84 g $AgCH_3COO$. Calculate the solubility product constant for $AgCH_3COO$. **(4 marks)**

Response:

$$\text{Mol mass } AgCH_3COO = 107.9 + 2(12.0) + 3(1.0) + 2(16.0) = 166.9 \text{ g/mol}$$

$$\text{mol } AgCH_3COO = 1.84 \text{ g } AgCH_3COO\left(\frac{1 \text{ mol } AgCH_3COO}{166.9 \text{ g}}\right) = 0.0110 \text{ mol } AgCH_3COO$$

$$\left[AgCH_3COO\right] = \frac{0.0110 \text{ mol}}{0.250 \text{ L}} = 0.0441 \frac{\text{mol}}{\text{L}} AgCH_3COO$$

} ← **2 marks**

$$AgCH_3COO_{(s)} \rightleftarrows Ag^+_{(aq)} + CH_3COO^-_{(aq)}$$

$$0.0441 \qquad 0.0441$$

$$K_{sp} = \left[Ag^+\right]\left[CH_3COO^-\right]$$

$$= (0.0441)(0.0441)$$

$$= 1.94 \times 10^{-3}$$

} ← **2 marks**

(subtract $\frac{1}{2}$ **mark** for incorrect sig. fig)

7. Sodium phosphate, Na_3PO_4, is commonly used as a cleaning agent. Write the net ionic equation for the hydrolysis reaction between Na_3PO_4 and water. **(2 marks)**

Response:

$$PO_4^{3-}{}_{(aq)} + H_2O_{(\ell)} \rightleftarrows HPO_4^{2-}{}_{(aq)} + OH^-_{(aq)}$$

8. Calculate the pH of 0.30 M CH_3COOH. **(3 marks)**

Response:

$$CH_3COOH + H_2O \rightleftarrows H_3O^+ + CH_3COO^-$$

[**I**]	0.30	0	0
[**C**]	$-x$	$+x$	$+x$
[**E**]	$0.30 - x$	x	x
	≈ 0.30		

← **1 ½ marks**

$$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]} = 1.8 \times 10^{-5}$$

$$\frac{(x)(x)}{0.30} = 1.8 \times 10^{-5}$$

$$x^2 = 5.4 \times 10^{-6}$$

$$x = 2.32 \times 10^{-3}$$

$$[H_3O^+] = 2.32 \times 10^{-3}$$

$$pH = 2.63$$

← **1 ½ marks**

9. A new indicator "B.C. red" is red when $\left[H_3O^+\right] > 6.3\times10^{-3}$ and blue when $\left[H_3O^+\right] < 2.5\times10^{-4}$. Calculate the pH value at the transition point for this indicator. **(2 marks)**

Response:

For example:

$$\text{pH at } 6.3\times10^{-3} = 2.20 \qquad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$\text{pH at } 2.5\times10^{-4} = 3.60 \qquad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$\text{Transition point pH} = \frac{2.20+3.60}{2} \qquad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$= 2.90 \qquad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

10. Calculate the mass of NaOH which is required to neutralize 25.00 mL of 0.500 M H_2SO_4. **(3 marks)**

Response:

For example:

$$\text{mol } H_2SO_4 = 0.02500 \text{ L} \times 0.500 \text{ M} = 1.25\times10^{-2} \text{ mol } H_2SO_4 \qquad \leftarrow \textbf{1 mark}$$

$$\text{mol NaOH} = \frac{2}{1}\left(1.25\times10^{-2}\right) = 2.50\times10^{-2} \text{ mol NaOH} \qquad \leftarrow \textbf{1 mark}$$

$$\text{mass of NaOH} = \frac{40.0 \text{ g}}{\text{mol}}\left(2.50\times10^{-2}\right)\text{mol} = 1.00 \text{ g} \qquad \leftarrow \textbf{1 mark}$$

(subtract $\tfrac{1}{2}$ **mark** for incorrect sig. fig)

11. Balance the following half-reaction: **(3 marks)**

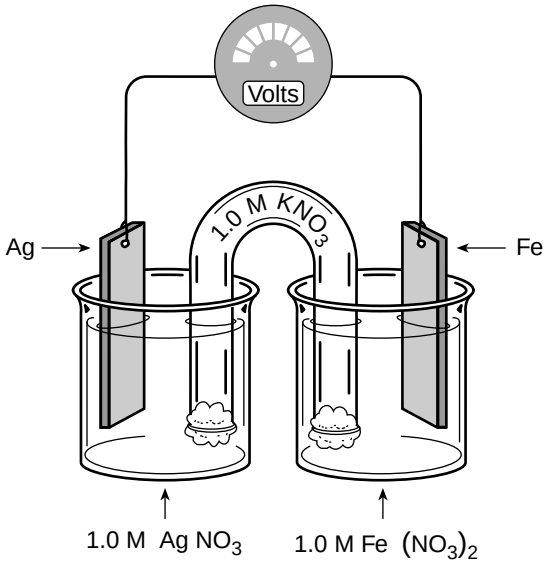
$$Sb_2O_5 \rightleftarrows Sb_2O_3 \qquad \text{(basic)}$$

Response:

$$Sb_2O_5 + 4H^+ + 4e^- \rightleftarrows Sb_2O_3 + 2H_2O \qquad \leftarrow \textbf{2 marks}$$

$$Sb_2O_5 + 2H_2O + 4e^- \rightleftarrows Sb_2O_3 + 4OH^- \qquad \leftarrow \textbf{1 mark}$$

12. Consider the electrochemical cell:



a) Towards which half-cell do the $NO_3^-{}_{(aq)}$ in the salt bridge initially move? **(1 mark)**

Response: For example:

Towards Fe cell **or** Towards right

b) Write the equation for the half-reaction occurring at the silver electrode. **(1 mark)**

Response:

$Ag^+ + e^- \rightarrow Ag$

c) Identify the anode. **(1 mark)**

Response:

$Fe_{(s)}$

d) What is the initial cell voltage? **(1 mark)**

Response:

1.25 V

END OF KEY