Chemistry 12

April 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.	D	K	1	1	A1	25.	B	U	1	4	K9
2.	A	U	1	1	A4	26.	C	U	2	4	K11
3.	C	K	1	1	B1	27.	B	U	1	4	L11
4.	B	U	1	1	B6	28.	D	U	2	4	L12
5.	C	U	1	1	B4	29.	C	U	1	4	M4
6.	D	H	1	1	C5	30.	B	U	1	4	N3
7.	C	U	1	2	D3	31.	C	U	1	4	N2
8.	A	K	2	2	D5	32.	D	H	1	4	O3; K6
9.	B	U	1	2	E2	33.	C	U	1	4	P2
10.	D	U	2	2	E2, 3	34.	B	K	1	4	P1, 5
11.	B	H	2	2	F4	35.	B	U	1	4	Q2
12.	A	K	1	2	F3	36.	D	K	1	4	R1
13.	D	U	1	2	F6	37.	A	K	1	4	R2
14.	D	K	1	3	G1	38.	C	U	1	5	S1
15.	D	K	1	3	G2	39.	B	U	2	5	S3
16.	A	U	1	3	G8	40.	D	U	1	5	S5
17.	C	U	1	3	H1	41.	C	H	1	5	S5
18.	A	H	2	3	H5	42.	D	U	1	5	S6
19.	B	U	2	3	H6	43.	B	U	1	5	T4
20.	A	K	1	3	I2	44.	A	H	1	5	U5
21.	C	K	2	4	J2	45.	D	K	1	5	U9
22.	C	U	1	4	J11	46.	A	K	2	5	U10
23.	A	H	2	4	K1, 6	47.	D	K	1	5	W2
24.	A	K	1	4	K6	48.	B	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	A3
2.	2	U	3	2	F7
3.	3	U	4	2	F8; D6
4.	4	U	3	3	I7
5.	5	U	4	3	G5; I3
6.	6	U	2	4	J7
7.	7	U	5	4	P1, 6
8.	8	U	5	4	M3
9.	9	U	5	5	T2
10.	10	U	4	5	W8

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**

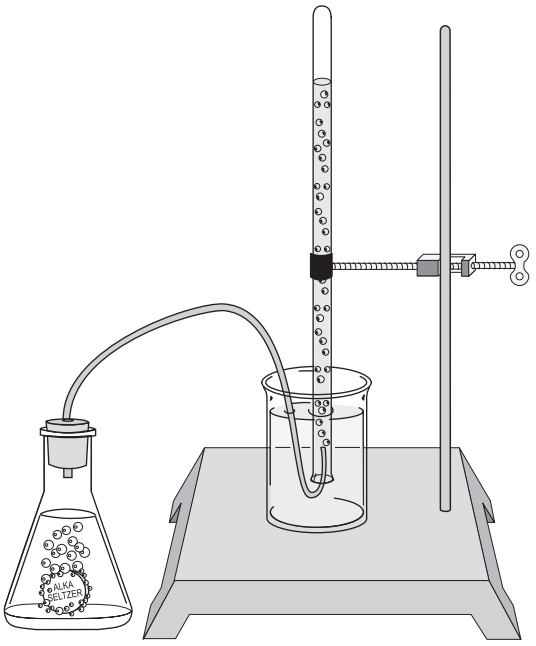
INSTRUCTIONS: You will be expected to communicate your knowledge and understanding of chemical principles in a clear and logical manner.

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. An Alka-Seltzer tablet is added to water to produce carbon dioxide gas. The gas was collected using water displacement.



The following data is recorded:

Time (s)	Volume of CO_2 (mL)
0.0	0
10.0	3.0
20.0	20.0
30.0	33.5
40.0	43.0
50.0	43.0
60.0	43.0

a) Calculate the average rate of reaction for the formation of CO_2 gas for the times:

i) $0 - 10\,s$ **(1 mark)**

Solution:

$$\text{rate} = \frac{\Delta \text{ vol}}{\Delta t} = \frac{3.0\,mL - 0.0\,mL}{10.0\,s}$$

$$= \frac{3.0\,mL}{10.0\,s} = 0.30\,mL/s \qquad \leftarrow \textbf{1 mark}$$

ii) $10 - 20\,s$ **(1 mark)**

Solution:

$$\text{rate} = \frac{\Delta \text{ vol}}{\Delta t} = \frac{20.0\,mL - 3.0\,mL}{20.0\,s - 10.0\,s}$$

$$= \frac{17.0\,mL}{10.0\,s}$$

$$= 1.70\,mL/s \qquad \leftarrow \textbf{1 mark}$$

b) Suggest a reason why the rate of reaction from 0 to 10.0 s is slower than the rate from 10.0 to 20.0 s ? **(1 mark)**

Solution:

For Example:

The surface area of the tablet increases as the tablet crumbles. $\leftarrow$ **1 mark**

c) The rate of reaction is not constant during the entire interval from 10.0 to 40.0 s. Describe the change in rate and explain a reason for the change. **(2 marks)**

Solution:

For Example:

The rate decreases during the interval because the surface area decreases. } $\leftarrow$ **2 marks**

2. A flask is initially filled with some HI. At equilibrium, the $[HI] = 0.80\ \text{mol/L}$. What is the $[H_2]$ at equilibrium? **(3 marks)**

$$2HI_{(g)} \rightleftarrows H_{2(g)} + I_{2(g)} \qquad K_{eq} = 0.25$$

Solution:

For Example:

$$K_{eq} = \frac{[H_2][I_2]}{[HI]^2} \quad \leftarrow \textbf{1 mark}$$

$$0.25 = \frac{(x)(x)}{(0.80)^2} \quad \leftarrow \textbf{1 mark}$$

$$x = 0.40 \quad \leftarrow \textbf{1 mark}$$

$$[H_2] = 0.40\ \text{M}$$

3. Consider the following equilibrium system:

$$2NOCl_{(g)} \rightleftarrows 2NO_{(g)} + Cl_{2(g)} \qquad K_{eq} = 1.6 \times 10^{-5}$$

A 1.00 L flask is filled with 0.20 mol NOCl, 0.10 mol NO and 0.10 mol Cl_2. State and show by calculation the direction in which the reaction proceeds to reach equilibrium. **(4 marks)**

Solution:

For Example:

Direction: Reaction proceeds to the left. ← **1 mark**

Calculations:

$$2NOCl_{(g)} \rightleftarrows 2NO_{(g)} + Cl_{2(g)}$$

$$K_{Trial} = \frac{[NO]^2[Cl_2]}{[NOCl]^2} \quad \leftarrow \textbf{1 mark}$$

$$= \frac{(0.10)^2(0.10)}{(0.20)^2}$$

$$= 0.025 \quad \leftarrow \textbf{1 mark}$$

$$K_{Trial} > K_{eq} \quad \leftarrow \textbf{1 mark}$$

4. In a titration, 25.00 mL of $NaCl_{(aq)}$ reacts completely with 42.20 mL of 0.100 M $AgNO_3$. What is the $\left[Cl^-\right]$ in the original solution? **(3 marks)**

Solution:

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

$$\text{mol } Ag^+ = (0.100 \text{ mol/L})(0.04220 \text{ L})$$

$$= 0.00422 \text{ mol}$$

← **1 mark**

$$\text{mol } Cl^- = \text{mol } Ag^+$$

← **1 mark**

$$\left[Cl^-\right] = \frac{0.00422 \text{ mol}}{0.02500 \text{ L}}$$

$$= 0.169 \text{ M}$$

← **1 mark**

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

5. The following data was obtained when $20.0\,\text{mL}$ of a saturated solution of PbI_2 was evaporated to dryness.

Mass of evaporating dish	$30.250\,\text{g}$
Mass of evaporating dish and residue	$30.262\,\text{g}$

Use this information to determine the K_{sp} of PbI_2. **(4 marks)**

Solution:

For Example:

$$\text{Mass of } PbI_2 = 30.262\,\text{g} - 30.250\,\text{g} = 0.012\,\text{g} \qquad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$\text{Moles } PbI_2 = 0.012\,\text{g} \times \frac{1\,\text{mol}}{461.0\,\text{g}} = 2.60 \times 10^{-5}\,\text{mol} \qquad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$\left[Pb^{2+}\right] = \frac{2.60 \times 10^{-5}\,\text{mol}}{0.0200\,\text{L}} = 1.3 \times 10^{-3}\,\text{M} \qquad \leftarrow \textbf{1 mark}$$

$$\left[I^{-}\right] = \frac{2 \times 2.60 \times 10^{-5}\,\text{mol}}{0.0200\,\text{L}} = 2.6 \times 10^{-3}\,\text{M} \qquad \leftarrow \textbf{1 mark}$$

$$K_{sp} = \left[Pb^{2+}\right]\left[I^{-}\right]^2 = \left(1.3 \times 10^{-3}\right)\left(2.6 \times 10^{-3}\right)^2 = 8.8 \times 10^{-9} \qquad \leftarrow \textbf{1 mark}$$

6. a) Write the equation for the predominant reaction of $HC_2O_4^-$ with HSO_3^-. **(1 mark)**

Solution:

$$\underset{\text{base}}{HC_2O_4^-} + \underset{\text{acid}}{HSO_3^-} \rightleftarrows \underline{C_2O_4^{2-}} + \underline{H_2SO_3}$$

← **1 mark**

b) Identify a Brønsted-Lowry conjugate acid base pair from the above reaction. **(1 mark)**

Solution:

$HC_2O_4^-$ / $C_2O_4^{2-}$

acid base

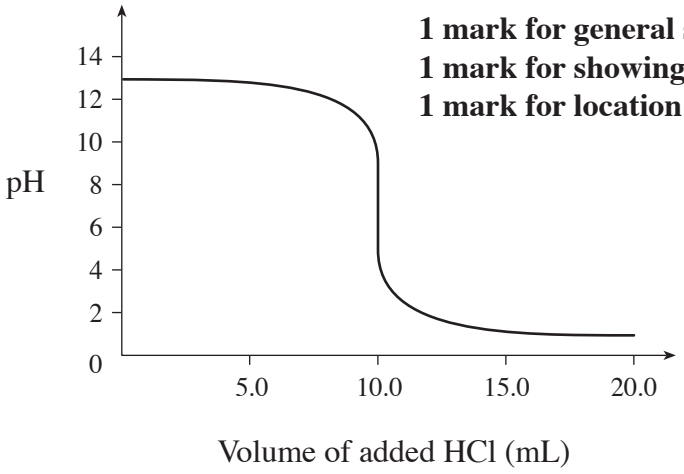
OR

HSO_3^- / H_2SO_3

base acid

← **1 mark**

7. a) In the space below, sketch the titration curve for the reaction when 0.10 M HCl is added to 10.0 mL of 0.10 M NaOH. **(3 marks)**



1 mark for general shape
1 mark for showing curve drop
1 mark for location of equivalence point

Solution:

For Example:

See graph above. ← **3 marks**

b) Describe two changes in the titration curve that would result from using 0.10 M CH_3COOH in place of the HCl. **(2 marks)**

Solution:

For Example:

*Any **two** of the following for **1 mark** each.*

The equivalence point is > 7.
The vertical part of the curve is shorter.
Buffer region.

8. Calculate the $\left[OH^-\right]$ in 0.50 M $NH_{3(aq)}$. **(5 marks)**

Solution:

For Example:

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{5.6 \times 10^{-10}} = 1.79 \times 10^{-5}$$ ← **1 mark**

	NH_3	+	H_2O	$\rightleftarrows$	NH_4^+	+	OH^-
[I]	0.50				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.50 - x$				x		x

← **2 marks**

$$K_b = \frac{\left[NH_4^+\right]\left[OH^-\right]}{\left[NH_3\right]} = \frac{(x)(x)}{(0.50 - x)} = 1.79 \times 10^{-5}$$

Use assumption that $0.50 - x \approx 0.50$ or use the quadratic formula.

$x = \left[OH^-\right] = 3.0 \times 10^{-3}$ M

← **2 marks**

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

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

$$MnO_4^- + C_2O_4^{2-} \rightarrow MnO_2 + CO_3^{2-} \qquad \text{(basic)}$$

Solution:

For Example:

$$\begin{array}{r} 2 \times \left(3e^- + 4H^+ + MnO_4^- \rightarrow MnO_2 + 2H_2O\right) \\ 3 \times \left(2H_2O + C_2O_4^{2-} \rightarrow 2CO_3^{2-} + 4H^+ + 2e^-\right) \\ \hline 2H_2O + 2MnO_4^- + 3C_2O_4^{2-} \rightarrow 2MnO_2 + 6CO_3^{2-} + 4H^+ \end{array}$$

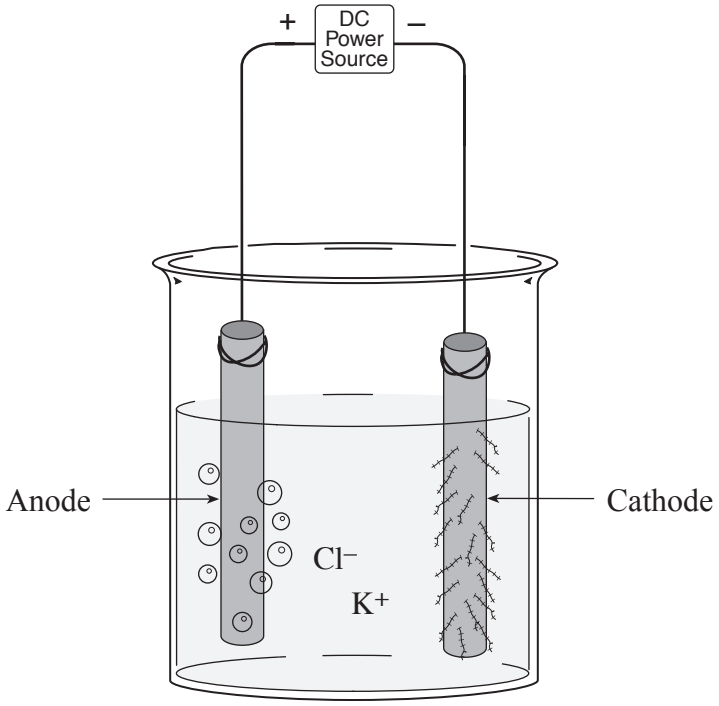
2 marks (1 mark for each half cell)
1 mark for multiplication
1 mark for addition
1 mark for basic

$$4OH^- + 2MnO_4^- + 3C_2O_4^{2-} \rightarrow 2MnO_2 + 6CO_3^{2-} + 2H_2O$$

10. a) Draw and label the parts of an operating electrolytic cell during the electrolysis of molten potassium chloride $KCl_{(\ell)}$. **(3 marks)**

Solution:

For Example:



1 mark for single container
1 mark for power supply
1 mark for electrodes

b) Define the term *oxidizing agent*. **(1 mark)**

Solution:

For Example:

An oxidizing agent is a species which causes another to lose electrons. ← **1 mark**

END OF KEY