Chemistry 12

August 2002 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.	C	U	1	1	A2	25.	C	U	1	4	J12
2.	B	K	1	1	A5	26.	A	U	1	4	K6
3.	D	U	1	1	B1, B5	27.	C	K	1	4	L4
4.	D	U	1	1	B6, B7	28.	B	U	1	4	L7
5.	D	H	2	1	C4	29.	B	K	1	4	M1
6.	A	U	1	1	C5	30.	B	U	1	4	N2
7.	C	U	1	2	D3	31.	A	U	2	4	N4
8.	A	U	2	2	D7	32.	B	K	1	4	O1
9.	C	U	1	2	E2, E4	33.	D	H	2	4	O5
10.	C	H	1	2	E3	34.	C	K	1	4	P1
11.	A	U	1	2	F1	35.	A	H	2	4	P2
12.	A	K	1	2	F2	36.	A	U	2	4	P4
13.	B	U	1	2	F4	37.	B	U	1	4	Q5
14.	B	U	2	2	F5	38.	B	U	2	5	S1
15.	C	K	1	3	G4	39.	D	U	1	5	S1
16.	D	U	1	3	G5	40.	B	U	1	5	S2
17.	D	U	1	3	H4	41.	B	K	1	5	S5
18.	B	U	1	3	H5	42.	D	U	1	5	S6
19.	C	U	1	3	I4	43.	D	U	1	5	T5
20.	B	U	2	3	I4	44.	D	H	2	5	U5
21.	A	U	2	3	I5	45.	C	U	1	5	U9
22.	C	H	1	3	I6	46.	C	U	2	5	V2
23.	D	K	1	4	J6	47.	B	U	1	5	W4
24.	C	U	1	4	J8	48.	B	U	1	5	W3

Multiple Choice = 60 marks (48 questions)

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	3	1	A3
2.	2	K	2	1	C3
3.	3	K	2	2	D5
4.	4	U	4	2	F8
5.	5	U	3	3	G8
6.	6	U	3	3	I7
7.	7	U	4	4	K8
8.	8	U	3	4	L6, L10
9.	9	U	4	4	M3
10.	10	U	3	4	P6
11.	11	U	4	5	T2
12.	12	K	2	5	U8
13.	13	K	3	5	V3

Written Response = 40 marks

Multiple Choice = 60 (48 questions)
Written Response = 40 (13 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 calculations, full marks will NOT be given for providing only an answer.**

1. Consider the reaction: **(3 marks)**

$$2H_2O_{(\ell)} \rightarrow 2H_{2(g)} + O_{2(g)}$$

The rate of production of O_2 is 1.2×10^{-2} mol/s . How many seconds will it take to decompose 100.0 g H_2O ?

Solution:

For Example:

$$\text{mol } H_2O = 100.0\,\text{g} \frac{1\,\text{mol}}{18.0\,\text{g}} = 5.556\,\text{mol}$$

$$\text{mol } O_2 = 5.556\,\text{mol } H_2O \times \frac{1\,\text{mol } O_2}{2\,\text{mol } H_2O}$$

$$= 2.778\,\text{mol}$$

$$\text{time} = \frac{\text{mol } O_2}{\text{rate}} = \frac{2.778\,\text{mol}}{1.2 \times 10^{-2}\,\text{mol/s}}$$

$$= 2.3 \times 10^2\,\text{s}$$

← **3 marks**

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

2. Define the term *catalyst*. **(2 marks)**

Solution:

For Example:

A catalyst is a substance that increases the rate of a chemical reaction and may be recovered at the end of the reaction. ← **2 marks**

3. Describe the nature of *dynamic equilibrium.* **(2 marks)**

Solution:

For Example:

In a dynamic equilibrium, the forward reaction and reverse reaction continue to proceed at equal rates. } ← **2 marks**

4. Consider the following: **(4 marks)**

$$N_2O_{4(g)} \rightleftarrows 2NO_{2(g)} \qquad K_{eq} = 9.5 \times 10^{-3}$$

Initially, $0.060\,\text{mol}$ N_2O_4 and $0.020\,\text{mol}$ NO_2 are placed into a $2.00\,\text{L}$ container. Use calculations to determine the direction in which the reaction proceeds in order to reach equilibrium.

Solution:

For Example:

$$[N_2O_4] = \frac{0.060\,\text{mol}}{2.00\,\text{L}} = 0.030\,\text{mol/L}$$

$$[NO_2] = \frac{0.020\,\text{mol}}{2.00\,\text{L}} = 0.010\,\text{mol/L}$$

$$K_{trial} = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(0.010)^2}{(0.030)} = 3.3 \times 10^{-3}$$

$K_{trial} < K_{eq}$

$\therefore$ The reaction proceeds to the right.

} ← **4 marks**

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

5. A 100.0 mL saturated solution of FeF_2 contains 0.0787 g of solute.
Determine $\left[Fe^{2+}\right]$ and $\left[F^{-}\right]$ in the solution. **(3 marks)**

Solution:

For Example:

$$\left[FeF_2\right] = 0.0787\,\text{g} \times \frac{1\,\text{mol}}{93.8\,\text{g}} \times \frac{1}{0.1000\,\text{L}}$$

$$= 8.39 \times 10^{-3}\,\text{M}$$

$$FeF_{2(aq)} \rightarrow Fe^{2+}_{(aq)} + 2F^{-}_{(aq)}$$

$$\left[Fe^{2+}\right] = 8.39 \times 10^{-3}\,\text{M}$$

$$\left[F^{-}\right] = 1.68 \times 10^{-2}\,\text{M}$$

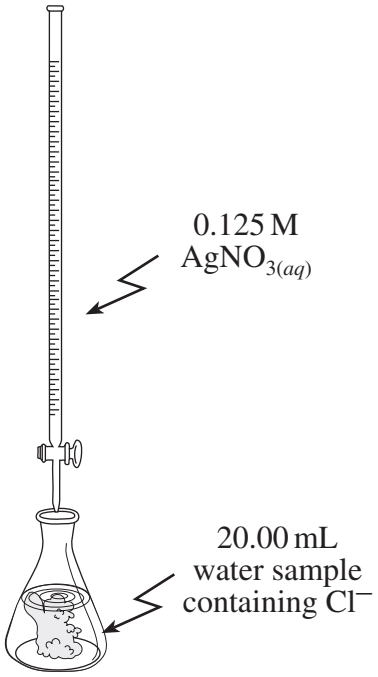
} ← **3 marks**

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

6. Consider the following information and accompanying diagram:

In a titration experiment, $AgNO_{3(aq)}$ was used to determine the $[Cl^-]$ in a water sample and the following data were recorded:

$[AgNO_3] = 0.125\,M$
Volume of water sample containing $Cl^- = 20.00\,mL$
Initial buret reading of $AgNO_3 = 5.15\,mL$
Final buret reading of $AgNO_3 = 37.15\,mL$



The equation for this reaction is

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

Using the above data, determine the $[Cl^-]$ in the water sample. **(3 marks)**

Solution:

For Example:

$$\text{Volume } AgNO_3 \text{ used} = 37.15\,mL - 5.15\,mL = 32.00\,mL$$

$$\text{mol } Ag^+ = 0.125\,mol/L \times 0.03200\,L$$

$$= 0.00400\,mol$$

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

$$= 0.00400\,mol$$

$$[Cl^-] = \frac{0.00400\,mol}{0.02000\,L}$$

$$= 0.200\,M$$

← **3 marks**

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

7. Consider the following equilibria:

I.	$CH_3COOH + OCN^- \rightleftarrows HOCN + CH_3COO^-$
II.	$CH_3COOH + ClO^- \rightleftarrows HClO + CH_3COO^-$

a) In equation **I** above, the reactants are favoured. Identify the stronger acid. **(1 mark)**

Solution:

HOCN ← **1 mark**

b) In equation **II** above, the products are favoured. Identify the stronger acid. **(1 mark)**

Solution:

CH_3COOH ← **1 mark**

c) Consider the following reaction:

$$HOCN + ClO^- \rightleftarrows OCN^- + HClO$$

Does this reaction favour reactants or products? Explain. **(2 marks)**

Solution:

For Example:

Products are favoured because HOCN is a stronger acid than HClO. } ← **2 marks**

8. At 60°C, the pH = 6.51 for pure water. Determine the value of K_w at this temperature. **(3 marks)**

Solution:

For Example:

$$\text{pH} = 6.51$$

$$\left[H_3O^+\right] = 3.09 \times 10^{-7}\ \text{M} = \left[OH^-\right]$$

$$K_w = \left[H_3O^+\right]\left[OH^-\right] = \left(3.09 \times 10^{-7}\right)\left(3.09 \times 10^{-7}\right) = 9.5 \times 10^{-14}$$

← **3 marks**

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

9. Calculate the pH of $0.35\,\text{M}\ H_2CO_3$. **(4 marks)**

Solution:

For Example:

	H_2CO_3	+	H_2O	$\rightleftarrows$	H_3O^+	+	HCO_3^-
[I]	0.35				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.35 - x$				x		x

← **1 $\frac{1}{2}$ marks**

$$K_a = \frac{\left[H_3O^+\right]\left[HCO_3^-\right]}{\left[H_2CO_3\right]} = 4.3 \times 10^{-7}$$

$$4.3 \times 10^{-7} = \frac{x^2}{0.35 - x}$$

$$x = \left[H_3O^+\right] = 3.88 \times 10^{-4}\ \text{M}$$

$$\text{pH} = 3.41$$

← **2 $\frac{1}{2}$ marks**

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

10. A strong acid–strong base titration has a pH = 7.0 at the equivalence point.
A weak acid–strong base titration has a pH > 7.0 at the equivalence point.

a) What causes the difference in these pH values? **(2 marks)**

Solution:

For Example:

A strong acid–strong base titration produces a neutral salt while a weak acid–strong base titration produces a basic salt. } ← **2 marks**

b) Select one indicator which could be used for both titrations. **(1 mark)**

Solution:

For Example:

Phenolphthalein ← **1 mark**

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

$$ClO_3^- + S_2O_3^{2-} \rightarrow S_4O_6^{2-} + Cl^- \qquad \text{(acidic)}$$

Solution:

For Example:

$$6e^- + 6H^+ + ClO_3^- \rightarrow Cl^- + 3H_2O$$

$$3 \times \left(2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-\right)$$

$$6H^+ + ClO_3^- + 6S_2O_3^{2-} \rightarrow Cl^- + 3H_2O + 3S_4O_6^{2-}$$

2 marks (1 for each half-reaction)
1 mark for balancing electrons
1 mark for addition

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

12. State two characteristics of the overall reaction in an electrochemical cell. **(2 marks)**

Solution:

For Example:

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

- redox reaction
- spontaneous
- +E° value
- exothermic

← **2 marks**

13. Describe two chemically different methods of preventing the corrosion of iron. Explain how each method works. **(3 marks)**

Solution:

For Example:

- Coating with paint or oil prevents contact between iron and oxygen.

- Attaching a more readily oxidized metal such as zinc—cathodic protection—turns the iron into a cathode, preventing oxidation.

} ← **1 $\frac{1}{2}$ marks**

} ← **1 $\frac{1}{2}$ marks**

END OF KEY