Chemistry 12

June 2004 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.	B	K	1	1	A2	31.	**D**	**E**	**L**	**E**	**T**	**E**	**D**
2.	B	U	1	1	A5	32.	D	U	1	4	K11
3.	D	H	1	1	B2, B5	33.	C	U	1	4	L3
4.	D	U	1	1	B6	34.	C	K	1	4	L8
5.	D	K	1	1	C3, 6	35.	A	U	1	4	L11
6.	A	U	1	2	D2	36.	C	U	1	4	M1
7.	D	U	1	2	D3	37.	A	U	1	4	M4
8.	A	U	1	2	D6	38.	C	U	1	4	N2
9.	C	U	1	2	D9	39.	C	U	1	4	N4
10	A	U	1	2	D9	40.	B	K	1	4	O2
11.	A	H	1	2	E2	41.	A	U	1	4	O5
12.	**D**	**E**	**L**	**E**	**T**	**E**	**D**	42.	A	H	1	4	P2
13.	C	U	1	2	E5	43.	D	U	1	4	P4
14.	C	U	1	2	F1	44.	B	U	1	4	P6
15.	D	K	1	2	F3	45.	B	K	1	4	Q1
16.	B	U	1	2	F5	46.	C	U	1	4	R2
17.	D	U	1	2	F6	47.	B	K	1	5	S1
18.	C	H	1	3	G1, K1	48.	A	K	1	5	S1, S2
19.	A	U	1	3	G4	49.	B	U	1	5	S2
20.	D	U	1	3	G8	50.	C	U	1	5	S6
21.	D	U	1	3	H2	51.	D	U	1	5	T1
22.	C	U	1	3	H7	52.	B	U	1	5	T2
23.	B	U	1	3	I2	53.	B	U	1	5	U1
24.	A	U	1	3	I3	54.	A	U	1	5	U2
25.	D	U	1	3	I4	55.	B	U	1	5	U5
26.	A	U	1	3	I6	56.	C	U	1	5	U9
27.	A	K	1	4	J2	57.	B	U	1	5	U6
28.	D	K	1	4	J5	58.	B	U	1	5	W5
29.	C	U	1	4	J7	59.	C	U	1	5	W4, 5
30.	C	U	1	4	K2	60.	D	U	1	5	W4, 8

Multiple Choice = 60 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	4	1	A4, B4
2.	2	U	4	2	F7
3.	3	U	3	3	G2, 6
4.	4	U	4	4	K1
5.	5	U	3	4	L1, 6
6.	6	U	5	4	M3, N2
7.	7	U	4	5	T6
8.	8	U	3	5	V2

Written Response = 30 marks

Multiple Choice = 60 (60 questions)
Written Response = 30 (8 questions)
EXAMINATION TOTAL = 90 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: 30 marks **Suggested Time: 40 minutes**

INSTRUCTIONS: You are 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. When solid sodium is placed in water at room temperature, an immediate, violent reaction occurs:

$$2Na_{(s)} + 2H_2O_{(\ell)} \rightarrow 2NaOH_{(aq)} + H_{2(g)} + \text{energy}$$

a) Describe two methods that could be used to experimentally determine the rate of reaction. **(2 marks)**

Method 1: _____

Method 2: _____

Solution:

For Example:

Any two of the following per unit time:

- Δ mass Na
- Δ volume H_2
- Δ temperature
- Δ pH
- Δ pressure

} ← **2 marks**

b) Would you expect the activation energy of this reaction to be high or low? Explain, using collision theory. **(2 marks)**

Solution:

For Example:

The reaction is very fast so many collisions at room temperature would have the needed energy to be successful. The activation energy of this reaction would be low.

} ← **2 marks**

2. Consider the following equilibrium:

$$N_{2(g)} + O_{2(g)} \rightleftarrows 2NO_{(g)} \qquad K_{eq} = 0.0095$$

Initially, $0.15\,\text{mol}$ N_2 and $0.15\,\text{mol}$ O_2 were placed in a $1.0\,\text{L}$ container.
Calculate the concentration of all species at equilibrium. **(4 marks)**

Solution:

For Example:

	N_2	+	O_2	$\rightleftarrows$	$2NO$
[I]	0.15		0.15		0
[C]	$-x$		$-x$		$+2x$
[E]	$0.15 - x$		$0.15 - x$		$2x$

← **1 mark**

$$K_{eq} = \frac{[NO]^2}{[N_2][O_2]}$$

$$0.0095 = \frac{(2x)^2}{(0.15 - x)^2}$$ ← **1 mark**

$$\sqrt{0.0095} = \sqrt{\frac{(2x)^2}{(0.15 - x)^2}}$$ ← **1 mark**

$$x = 6.97 \times 10^{-3}$$

$$[N_2] = [O_2] = 0.15 - x = 0.14\,\text{M}$$

$$[NO] = 2(x) = 0.014\,\text{M}$$ ← **1 mark**

3. a) How would a saturated solution be prepared at room temperature? **(1 mark)**

Solution:

For Example:

Add solute to solvent until no more solute dissolves. ← **1 mark**

b) Write a chemical equation to illustrate the equilibrium that exists in a saturated solution of $Be_3(PO_4)_2$. **(2 marks)**

Solution:

For Example:

$$Be_3(PO_4)_{2(s)} \rightleftarrows 3Be^{2+}_{(aq)} + 2PO_4{}^{3-}_{(aq)}$$ ← **2 marks**

4. Using calculations, show why the electrical conductivity of 1.0 M H_2CO_3 will be less than that for 0.10 M HCl. **(4 marks)**

Solution:

For Example:

For 0.10 M HCl, a strong acid: $HCl_{(aq)} + H_2O_{(\ell)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$ ← **1 mark**

$$\text{total ion concentration} = 0.10\,\text{M} + 0.10\,\text{M} = 0.20\,\text{M}$$

For 1.0 M H_2CO_3, a weak acid:

	$H_2CO_{3(aq)}$	+	$H_2O_{(\ell)}$	$\rightleftarrows$	$HCO_3^-{}_{(aq)}$	+	$H_3O^+_{(aq)}$
[I]	1.0				0		0
[C]	$-x$				$+x$		$+x$
[E]	$1.0 - x$				x		x

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

$$\frac{(x)(x)}{1.0 - x} = 4.3 \times 10^{-7}$$

$$x = 6.6 \times 10^{-4}\,\text{M} = \left[H_3O^+\right] = \left[HCO_3^-\right]$$

$$\text{Total ion concentration} = 6.6 \times 10^{-4}\,\text{M} + 6.6 \times 10^{-4}\,\text{M} = 1.3 \times 10^{-3}\,\text{M}$$

← **2 ½ marks**

Therefore, smaller ion concentration, lower conductivity. ← **½ mark**

5. Water, at $60°C$, has a $K_w = 9.55 \times 10^{-14}$.

a) Write an equation representing the ionization of water. Include the heat of reaction $(57.1\,kJ)$ in the equation. **(2 marks)**

Solution:

For Example:

$$2H_2O_{(\ell)} + 57.1\,kJ \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$$

← 2 marks

OR

$$H_2O_{(\ell)} + 57.1\,kJ \rightleftarrows H^+_{(aq)} + OH^-_{(aq)}$$

Note: Endothermic can be deduced from the data provided.
1 mark for the equation.
1 mark for determining endothermic.

b) If a small amount of $NaOH$ is added to water, what happens to the value of K_w ? **(1 mark)**

Solution:

For Example:

K_w remains unchanged. **← 1 mark**

6. Calculate the pH of $3.0\,\text{M}\ Na_2CO_3$. Start by writing the equation for the predominant equilibrium reaction. **(5 marks)**

Solution:

For Example:

$$\begin{array}{c|ccccc} & CO_3^{2-}{}_{(aq)} & + & H_2O_{(\ell)} & \rightleftarrows & HCO_3^{-}{}_{(aq)} + OH^-_{(aq)} \\ [\text{I}] & 3.0 & & & & 0 \quad 0 \\ [\text{C}] & -x & & & & +x \quad +x \\ \hline [\text{E}] & 3.0-x & & & & x \quad x \end{array}$$

(assume x is negligible)

} ← **1 mark**

} ← **1 mark**

$$K_b = \frac{K_w}{K_a} = \frac{1.0\times10^{-14}}{5.6\times10^{-11}} = 1.79\times10^{-4}$$

$$= \frac{\left[HCO_3^-\right]\left[OH^-\right]}{\left[CO_3^{2-}\right]}$$

} ← **1 mark**

$$1.79\times10^{-4} = \frac{(x)(x)}{(3.0)}$$

$$x = \left[OH^-\right] = 0.0232\,\text{M}$$

} ← **1 mark**

$$\text{pOH} = 1.64$$

$$\text{pH} = 12.36$$

} ← **1 mark**

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

7. An impure sample of CaC_2O_4 weighing $0.803\,g$ is titrated with $15.70\,mL$ of $0.101\,M$ $KMnO_4$. The net reaction is

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10\,CO_2 + 8H_2O$$

What is the percent by mass of the CaC_2O_4 in the original sample? **(4 marks)**

Solution:

For Example:

$$\text{Moles of } MnO_4^- = 0.01570\,L \times 0.101\,mol/L = 1.5857 \times 10^{-3}\,mol$$

$$\text{Moles of } C_2O_4^{2-} = 1.5857 \times 10^{-3}\,mol\,MnO_4^- \times \frac{5\,mol\ C_2O_4^{2-}}{2\,mol\ MnO_4^-} = 3.9643 \times 10^{-3}\,mol$$

$$\text{Moles } CaC_2O_4 = \text{Moles } C_2O_4^{2-}$$

$$\text{Mass of } CaC_2O_4 = 3.9643 \times 10^{-3}\,mol \times \frac{128.1\,g}{1\,mol} = 5.0782 \times 10^{-1}\,g\ CaC_2O_4$$

$$\%\ CaC_2O_4 = \frac{0.50782\,g}{0.803\,g} \times 100\% = 63.2\%$$

← **4 marks**

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

8. A sample of Zn corrodes in moist air.

a) Write the reduction half-reaction. **(1 mark)**

Solution:

For Example:

$$\tfrac{1}{2}O_{2(g)} + 2H^{+}\left(10^{-7}\,M\right) + 2e^{-} \rightarrow H_2O \qquad \leftarrow \textbf{1 mark}$$

b) What metal could be attached to the sample to prevent the corrosion of the zinc? Explain. **(2 marks)**

Solution:

For Example:

Metal: Magnesium (Mg)

Explanation: The magnesium is more easily oxidized than the zinc.

$\leftarrow$ **2 marks**

END OF KEY