Chemistry 12

January 2003 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	K	1	1	A5	25.	B	U	2	4	K8
2.	B	U	2	1	A3	26.	D	H	1	4	K9
3.	D	K	1	1	B1	27.	C	U	2	4	L3
4.	A	U	1	1	B2	28.	A	U	1	4	L6
5.	C	K	1	1	C3	29.	A	K	1	4	N1
6.	D	U	1	1	C4	30.	A	U	1	4	M1, N2
7.	D	K	1	2	D4	31.	B	U	1	4	N3
8.	B	U	1	2	D8	32.	D	H	1	4	O3
9.	C	U	1	2	E2, F3	33.	D	U	1	4	O4
10.	A	U	1	2	E4	34.	D	K	1	4	P1
11.	A	K	1	2	F2	35.	B	U	2	4	P3
12.	C	K	1	2	F3	36.	C	U	2	4	P4
13.	A	U	2	2	F4	37.	B	K	1	4	R3
14.	C	U	1	2	F7	38.	C	U	1	5	S2
15.	D	K	1	3	G2	39.	D	U	1	5	S1
16.	B	H	1	3	G6, E2	40.	C	U	1	5	S2
17.	B	U	2	3	H2	41.	D	H	2	5	S4
18.	A	U	1	3	H4	42.	D	H	2	5	T4
19.	A	U	1	3	H5	43.	D	K	1	5	U1
20.	B	K	1	3	I2	44.	A	U	1	5	U3, 5
21.	C	U	2	3	I4	45.	B	U	1	5	U4, 6
22.	D	U	2	3	I4	46.	D	U	1	5	U9
23.	C	U	1	4	J3	47.	C	U	2	5	W4
24.	B	U	1	4	K1, 2	48.	C	U	1	5	W4

Multiple Choice = 60 marks (48 questions)

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	3	1	B6
2.	2	U	3	1	C2, C5
3.	3	H	3	2	E2
4.	4	U	3	2	F5
5.	5	U	4	3	I6
6.	6	H	4	4	H3, J3
7.	7	U	2	4	K5, K11
8.	8	U	2	4	L11
9.	9	U	5	4	M5
10.	10	U	3	4	P6
11.	11	U	4	5	T2
12.	12	H	4	5	W4

Written Response = 40 marks

Multiple Choice = 60 (48 questions)
Written Response = 40 (12 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

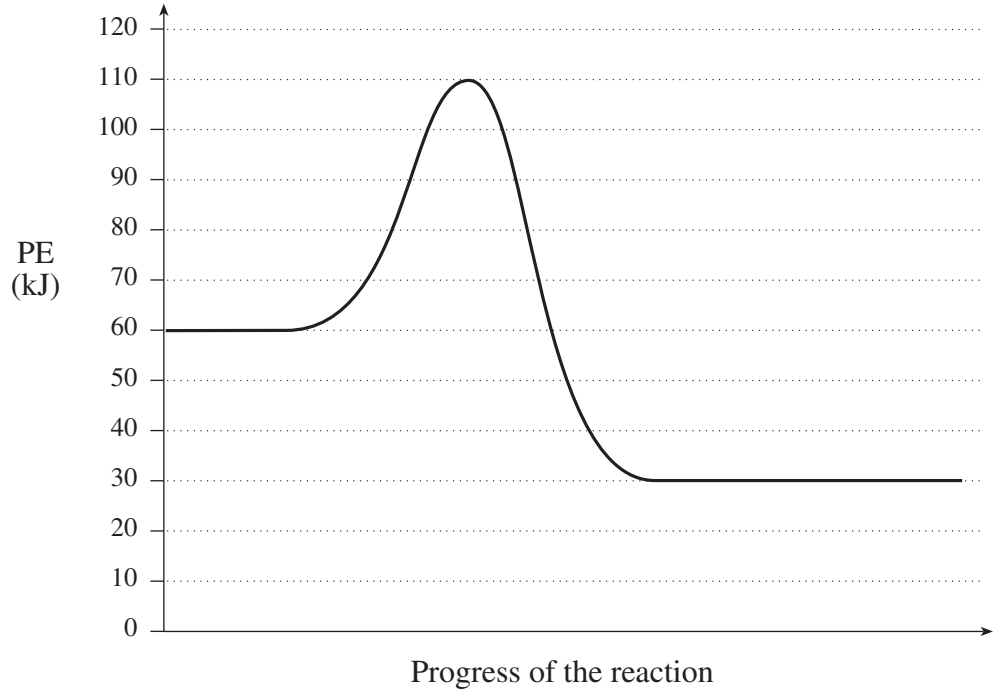
Value: 40 marks **Suggested Time: 50 minutes**

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. Using the axes below, sketch a PE diagram for the reacting system where: **(3 marks)**

$\Delta H = -30\ kJ/mol$

$E_a = 50\ kJ/mol$



1 mark for exothermic diagram

1 mark for $\Delta H = -30kJ/mol$

1 mark for $E_a = 50kJ/mol$

Solution:

For Example:

See graph above.

2. Consider the following reaction mechanism:

Step 1	$2NO \rightarrow N_2O_2$
Step 2	$N_2O_2 + H_2 \rightarrow N_2O + H_2O$
Step 3	$N_2O + H_2 \rightarrow N_2 + H_2O$

a) Determine the overall reaction. **(2 marks)**

Solution:

Overall Reaction: $2NO + 2H_2 \rightarrow N_2 + 2H_2O$ ← { **1 mark for reactants** / **1 mark for products**

b) Identify a reaction intermediate. **(1 mark)**

Solution:

N_2O_2 **OR** N_2O ← **1 mark**

3. Consider the following equilibrium:

$$CH_{4(g)} + H_2O_{(g)} \rightleftarrows CO_{(g)} + 3H_{2(g)}$$

K_{eq}	Temperature
1.78×10^{-3}	800°C
4.68×10^{-2}	1000°C

Is the forward reaction in this equilibrium exothermic or endothermic?
Explain your answer. **(3 marks)**

Solution:

For Example:

This equilibrium is endothermic. ← **1 mark**

Since K_{eq} increases as a result of a temperature increase, equilibrium has shifted to the right. } ← **2 marks**

4. Consider the following equilibrium:

$$CO_{(g)} + Cl_{2(g)} \rightleftarrows COCl_{2(g)}$$

At equilibrium, the system contains 2.00 mol CO, 1.00 mol Cl_2 and 0.200 mol $COCl_2$ in a 2.0 L container. Calculate the value of K_{eq}. **(3 marks)**

Solution:

For Example:

$$K_{eq} = \frac{[COCl_2]}{[CO][Cl_2]} \quad \left.\right\} \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$= \frac{(0.200\,\text{mol}/2.0\,\text{L})}{(2.00\,\text{mol}/2.0\,\text{L})(1.00\,\text{mol}/2.0\,\text{L})} \quad \left.\right\} \leftarrow 1\tfrac{1}{2} \textbf{ mark}$$

$$= \frac{(0.100)}{(1.00)(0.500)}$$

$$= 0.20 \quad \leftarrow \textbf{1 mark}$$

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

5. Calculate the mass of NaI necessary to begin precipitation of Cu^+ from a 250.0 mL sample of 0.010 M $CuNO_3$.

Solution:

For Example:

$$CuI_{(s)} \rightleftarrows Cu^+_{(aq)} + I^-_{(aq)}$$

$$K_{sp} = \left[Cu^+\right]\left[I^-\right] = 1.3 \times 10^{-12}$$

$$\left[I^-\right] = \frac{K_{sp}}{\left[Cu^+\right]} = \frac{1.3 \times 10^{-12}}{0.010} = 1.3 \times 10^{-10}\,M$$

} ← **2 marks**

$$= \left[NaI\right]$$

$$\text{mass of NaI} = 1.3 \times 10^{-1}\,\text{mol/L} \times \frac{149.9\,g}{\text{mole}} \times 0.250\,L$$

$$= 4.9 \times 10^{-9}\,g$$

} ← **2 marks**

6. When a solution of $Na_2CO_{3(aq)}$ is mixed with a solution of $Ca(NO_3)_{2(aq)}$ a precipitate forms.

   a) Write the net ionic equation for the precipitation reaction. **(1 mark)**

Solution:

For Example:

$$Ca^{2+}_{(aq)} + CO_3{}^{2-}_{(aq)} \rightarrow CaCO_{3(s)}$$ ← **1 mark**

   b) Explain what happens to the precipitate when HCl is added. **(3 marks)**

Solution:

For Example:

Addition of HCl provides $H^+_{(aq)}$ which reacts with the $CO_3{}^{2-}_{(aq)}$.

$$H^+_{(aq)} + CO_3{}^{2-}_{(aq)} \rightarrow HCO_3{}^-_{(aq)}$$

This reduces the $\left[CO_3{}^{2-}_{(aq)}\right]$ in the solubility equilibrium,

$$CaCO_{3(s)} \rightleftarrows Ca^{2+}_{(aq)} + CO_3{}^{2-}_{(aq)}$$

causing more solid to dissolve to offset the stress caused by the reduction in concentration.

← **3 marks**

7. Write a chemical reaction showing an amphiprotic anion reacting as a base in water. **(2 marks)**

Solution:

For Example:

$HPO_4^{2-} + H_2O \rightleftarrows H_2PO_4^- + OH^-$ ← **2 marks**

8. Calculate the pOH of $0.25\,\text{M}\ \text{Sr(OH)}_2$. **(2 marks)**

Solution:

For Example:

$$\left[\text{OH}^-\right] = 2(0.25\,\text{M}) = 0.50\,\text{M} \qquad \leftarrow \textbf{1 mark}$$

$$\text{pOH} = -\log(0.50)$$

$$= 0.30 \qquad \leftarrow \textbf{1 mark}$$

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

9. A $2.00\,\text{M}$ diprotic acid has a pH of 0.50. Calculate its K_a value. **(5 marks)**

Solution:

For Example:

	H_2X	+	H_2O	$\rightleftarrows$	H_3O^+	+	HX^-
[I]	2.00				0		0
[C]	−0.316				+0.316		+0.316
[E]	1.684				0.316		0.316

← **2 marks**

$\text{pH} = 0.50;\ [H_3O^+] = 10^{-0.50} = 0.316\,\text{M}$ ← **1 mark**

$$K_a = \frac{[H_3O^+][HX^-]}{[H_2X]} = \frac{(0.316)^2}{1.684} = 5.9 \times 10^{-2}$$ ← **2 marks**

10. The following two experiments were conducted:

Titration A: A strong acid was titrated with a strong base.

Titration B: A weak acid was titrated with a strong base.

a) How does the pH at the equivalence point of Titration B compare with the pH at the equivalence point of Titration A? **(1 mark)**

Solution:

For Example:

The pH at the equivalence point of Titration A = 7.0.
The pH at the equivalence point of Titration B > 7.0.
} ← **1 mark**

b) Explain your answer to a). **(2 marks)**

Solution:

For Example:

Neutral salt formed in titration A, a basic salt is formed in titration B.
} ← **2 marks**

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

$$Sb + NO_3^- \rightarrow Sb_2O_5 + NO \qquad \text{(acidic)}$$

Solution:

For Example:

$$\left(5H_2O + 2Sb \rightarrow Sb_2O_5 + 10\,H^+ + 10e^-\right) \times 3$$

$$\left(3e^- + 4H^+ + NO_3^- \rightarrow NO + 2H_2O\right) \times 10$$

$$\cancel{15H_2O} + 6Sb + \cancel{40\,H^+} + 10\,NO_3^- \rightarrow 3Sb_2O_5 + \cancel{30\,H^+}\ 10\,NO + \cancel{20\,H_2O}$$

$$10\,H^+ + 6Sb + 10\,NO_3^- \rightarrow 3Sb_2O_5 + 10\,NO + 5H_2O$$

2 marks (1 mark for each half-reaction)

1 mark for electron balance

1 mark for overall reaction

12. A 1.0 M HCl solution is electrolyzed using a copper anode and an inert carbon cathode. Predict the half-reactions that will occur and describe what you would observe at each electrode. **(4 marks)**

Solution:

For Example:

Anode half-reaction: $Cu_{(s)} \rightarrow Cu^{2+} + 2e^-$

Anode observations:
Electrode is eaten away and solution turns blue.

← **2 marks**

Cathode half-reaction: $2H^+ + 2e^- \rightarrow H_{2(g)}$

Cathode observations:
Bubbles form, but no change to electrode.

← **2 marks**

END OF KEY