Chemistry 12

August 1998 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	CO	PLO	Q	K	C	CO	PLO
1.	B	U	1	A2	25.	A	K	4	L5
2.	B	U	1	A5	26.	B	H	4	L3, 4
3.	D	U	1	B1	27.	A	H	4	L6, 9
4.	C	K	1	C4	28.	C	U	4	L11
5.	B	H	1	A5, E2	29.	A	U	4	M4
6.	C	K	2	D4	30.	B	K	4	N3
7.	D	U	2	D7	31.	B	U	4	O2
8.	C	U	2	E2	32.	A	U	4	O4
9.	C	U	2	F1	33.	C	U	4	P2
10.	B	K	2	F2	34.	B	U	4	P5
11.	D	U	2	F4	35.	B	K	4	Q2
12.	D	U	2	F8	36.	B	K	4	R2
13.	A	U	3	G8	37.	C	U	5	S1
14.	D	U	3	H1	38.	B	U	5	S1
15.	B	U	3	H2	39.	C	U	5	S2
16.	C	U	3	H5	40.	C	U	5	S2
17.	C	U	3	H7	41.	D	H	5	S4
18.	D	U	3	I4	42.	A	U	5	T3
19.	D	U	3	I4	43.	C	U	5	U2
20.	D	H	4	H2, J2	44.	C	U	5	U9
21.	C	K	4	J2	45.	D	U	5	U5
22.	B	U	4	J11	46.	A	U	5	W2, 4
23.	C	U	4	K6	47.	A	K	5	V3, 4
24.	C	U	4	K11	48.	D	U	5	T5

Multiple Choice = 48 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	3	1	B6
2.	2	U	4	2	F5, 7
3.	3	H	3	3	I6, L12
4.	4	U	3	3	I3
5.	5	U	3	4	J7, K9
6.	6	U	4	4	M5
7.	7	U	4	4	M4, N2, 4
8.	8	K	2	5	S1
9.	9	U	3	5	T1
10.	10	U	3	5	T6

Written Response = 32 marks

Multiple Choice = 48 (48 questions)
Written Response = 32 (10 questions)
EXAMINATION TOTAL = 80 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: 32 marks **Suggested Time: 50 minutes**

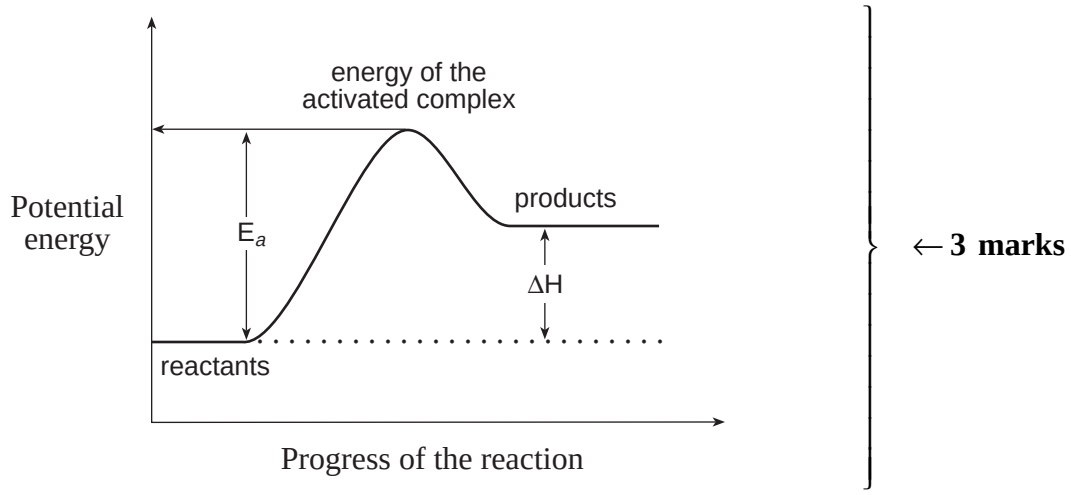
INSTRUCTIONS:	You will be expected to communicate your knowledge and understanding of chemical principles in a clear and logical manner. Your steps and assumptions leading to a solution must be written in the spaces below the questions. Answers must include units where appropriate and be given to the correct number of significant figures. **For questions involving calculation, full marks will NOT be given for providing only an answer.**

1. Sketch a potential energy diagram for an endothermic reaction in the space below.

   On your diagram, label:

   i) the energy of the activated complex
   ii) the activation energy
   iii) ΔH **(3 marks)**

Solution:



← **3 marks**

2. Consider the following equilibrium:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)} \qquad K_{eq} = 49$$

A 1.00 L container is initially filled with 0.180 mol HI.
Calculate the concentration of HI at equilibrium. **(4 marks)**

Solution:

	$H_{2(g)}$	$I_{2(g)}$	$\rightleftarrows$ $2HI_{(g)}$	
[**I**]	0	0	0.180	← **1 ½ marks**
[**C**]	$+x$	$+x$	$-2x$	
[**E**]	x	x	$0.180 - 2x$	

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

$$= \frac{(0.180 - 2x)^2}{(x)^2} = 49$$

$$x = 0.020$$

← **1 ½ marks**

$$[HI] = 0.180 - 2x$$

$$= 0.140 \text{ mol/L}$$

← **1 mark**

3. What is the maximum $\left[Mg^{2+}\right]$ that can exist in a solution with a pOH of 2.00? **(3 marks)**

Solution:

$$\left[OH^-\right] = \text{antilog}(-2.00) = 0.010\,\text{M} \qquad \leftarrow \textbf{1 mark}$$

$$Mg(OH)_2 \rightleftarrows Mg^{2+} + 2OH^-$$
$$x \qquad 0.010$$

$$\left.\begin{aligned} K_{sp} &= \left[Mg^{2+}\right]\left[OH^-\right]^2 \\ &= (x)(0.010)^2 \\ &= 5.6\times10^{-12} \end{aligned}\right\} \leftarrow \textbf{1}\tfrac{\textbf{1}}{\textbf{2}}\ \textbf{marks}$$

$$\left[Mg^{2+}\right] = x = 5.6\times10^{-8}\ \text{M} \qquad \leftarrow \tfrac{\textbf{1}}{\textbf{2}}\ \textbf{mark}$$

4. When 1.00 L of a saturated solution of CaF_2 was evaporated to dryness, 2.66×10^{-2} g of residue was formed. Calculate the value of K_{sp}. **(3 marks)**

Solution:

$$\text{mol } CaF_2 = 2.66\times10^{-2}\text{ g}\left(\frac{1\text{ mol}}{78.1\text{ g}}\right) = 3.41\times10^{-4}$$

$$\text{Solubility} = \frac{3.41\times10^{-4}\text{ mol}}{1.00\text{ L}} = 3.41\times10^{-4}\text{ M}$$

} ← **1 mark**

$$CaF_{2(s)} \rightleftarrows Ca^{2+}_{(aq)} + 2F^-_{(aq)}$$

$$3.41\times10^{-4} \qquad 2\left(3.41\times10^{-4}\right) = 6.82\times10^{-4}$$

$$K_{sp} = \left[Ca^{2+}\right]\left[F^-\right]^2$$

$$= \left(3.41\times10^{-4}\right)\left(6.82\times10^{-4}\right)^2$$

$$= 1.58\times10^{-10}$$

} ← **2 marks**

5. Consider the reaction between HCO_3^- and $HC_2O_4^-$.

a) Write the equation for the predominant reaction. **(1 mark)**

Solution:

$HC_2O_4^- + HCO_3^- \rightleftarrows C_2O_4^{2-} + H_2CO_3$ ← **1 mark**

b) Identify the Brönsted-Lowry acids in the reaction above. **(1 mark)**

Solution:

$HC_2O_4^-$ and H_2CO_3 ← **1 mark**

c) Explain why products are favoured in the reaction above. **(1 mark)**

Solution:

For example:

$HC_2O_4^-$ is a stronger acid than H_2CO_3 ← **1 mark**

6. A 3.50×10^{-3} M sample of the unknown acid, HA, has a pH of 2.90.
Calculate the value of K_a and identify this acid. **(4 marks)**

Solution:

$$\left[H_3O^+\right] = \text{antilog}(-2.90) = 1.26\times10^{-3}\ \text{M}$$

	HA + H_2O ⇄	H_3O^+ +	A^-
[**I**]	3.50×10^{-3}	0	0
[**C**]	-1.26×10^{-3}	$+1.26\times10^{-3}$	$+1.26\times10^{-3}$
[**E**]	2.24×10^{-3}	1.26×10^{-3}	1.26×10^{-3}

← **2 marks**

$$K_a = \frac{\left[H_3O^+\right]\left[A^-\right]}{[HA]}$$

$$= \frac{\left(1.26\times10^{-3}\right)\left(1.26\times10^{-3}\right)}{\left(2.24\times10^{-3}\right)}$$

$$= 7.1\times10^{-4}$$

← **1 $\frac{1}{2}$ marks**

The unknown acid is citric acid. ← **$\frac{1}{2}$ mark**

7. a) Write two equations representing the acidic and basic hydrolysis of $NaHSO_{3(s)}$. **(2 marks)**

Solution:

Acidic: $HSO_3^- + H_2O \rightleftarrows H_3O^+ + SO_3^{2-}$ ← **1 mark**

Basic: $HSO_3^- + H_2O \rightleftarrows H_2SO_3 + OH^-$ ← **1 mark**

b) Use calculations to determine if the solution is acidic or basic. **(2 marks)**

Solution:

$K_a = 1.0 \times 10^{-7}$ ← **½ mark**

$$K_b = \frac{1.0 \times 10^{-14}}{1.5 \times 10^{-2}}$$
$$= 6.7 \times 10^{-13}$$

← **1 mark**

Since $K_a > K_b$, solution is acidic ← **½ mark**

8. Define the term *oxidation-reduction reaction*. **(2 marks)**

Solution:

For example:

A chemical reaction in which electrons are transferred from one chemical species to another chemical species. } ← **2 marks**

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

$$In_2O_3 \rightarrow In \quad \text{(basic)}$$

Solution:

$$\left.\begin{aligned} In_2O_3 + 6H^+ + 6e^- &\rightarrow 2In + 3H_2O \\ In_2O_3 + 3H_2O + 6e^- &\rightarrow 2In + 6OH^- \end{aligned}\right\} \leftarrow \textbf{3 marks}$$

10. Consider the following:

$$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

A 20.00 mL sample of a solution containing $\left[Fe^{2+}\right]$ was titrated using 0.0184 M $KMnO_4$ and the following data were collected.

	TRIAL 1	TRIAL 2	TRIAL 3
Volume of $KMnO_{4(aq)}$ used	29.07 mL	26.55 mL	26.45 mL

Calculate the concentration of Fe^{2+} in the solution. **(3 marks)**

Solution:

Volume of $KMnO_4 = 26.50$ mL ← **1 mark**

$$\text{mol } MnO_4^- = 0.0184 \text{ M} \times 0.02650 \text{ L} = 4.876 \times 10^{-4} \text{ mol}$$

$$\text{mol } Fe^{2+} = 5 \times 4.876 \times 10^{-4} \text{ mol}$$

$$= 2.438 \times 10^{-3} \text{ mol}$$

$$\left[Fe^{2+}\right] = \frac{2.438 \times 10^{-3} \text{ mol}}{0.02000 \text{ L}}$$

$$= 0.122 \text{ M}$$

← **2 marks**

END OF KEY