Chemistry 12

August 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.	A	U	1	1	A2	25.	D	U	2	4	K6
2.	C	U	1	1	A6	26.	A	U	1	4	L12
3.	D	K	1	1	B3	27.	B	U	1	4	L11
4.	C	H	2	1	C4	28.	A	H	1	4	L12
5.	B	U	1	1	B7	29.	C	K	1	4	M4
6.	D	K	1	1	C5	30.	D	K	1	4	M2
7.	C	K	1	2	D4	31.	A	U	2	4	N3
8.	B	U	2	2	D7	32.	D	U	1	4	O3
9.	A	H	1	2	E2; J3	33.	B	U	1	4	P2
10.	B	K	1	2	F2	34.	A	K	1	4	P4
11.	B	U	1	2	F5	35.	D	K	1	4	P6
12.	A	U	2	2	F8	36.	D	K	2	4	Q2
13.	A	K	1	2	H1	37.	D	K	1	4	R1
14.	C	U	1	3	G1	38.	D	U	1	5	S1
15.	A	U	2	3	H1	39.	B	U	1	5	S2
16.	D	K	1	3	I2	40.	A	U	2	5	S4
17.	A	U	1	3	I3	41.	A	U	1	5	S5
18.	D	U	1	3	I4	42.	A	K	1	5	S6
19.	C	H	2	3	I5	43.	A	U	1	5	T4
20.	B	H	1	3	I6	44.	C	H	1	5	U5
21.	B	U	1	4	J3	45.	C	U	1	5	U9
22.	B	U	2	4	J11	46.	D	K	1	5	U8
23.	D	K	1	4	K2	47.	A	K	2	5	W3
24.	B	U	1	4	K5	48.	C	U	2	5	W4

Multiple Choice = 60 marks (48 questions)

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	4	1	C2, 3, 5
2.	2	U	3	2	E2; F4
3.	3	U	4	2	F5
4.	4	U	3	3	H3, 7
5.	5	U	3	3	H4
6.	6	H	2	4	K9; P3
7.	7	U	4	4	M2; N2
8.	8	U	4	4	O2, 5
9.	9	U	3	4	N4
10.	10	U	6	5	T2, 6
11.	11	U	4	5	V3, 4

Written Response = 40 marks

Multiple Choice = 60 (48 questions)
Written Response = 40 (11 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. Consider the following proposed reaction mechanism:

Step 1	$Fe^{3+} + H_2O_2 \rightarrow FeH_2O_2^{3+}$
Step 2	$FeH_2O_2^{3+} \rightarrow FeOH^{3+} + HO$
Step 3	$HO + H_2O_2 \rightarrow H_2O + HO_2$
Step 4	$FeOH^{3+} + HO_2 \rightarrow Fe^{3+} + H_2O + O_2$

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

Solution:

For Example:

$2H_2O_2 \rightarrow 2H_2O + O_2$ ← **2 marks**

b) Define the term *catalyst* and identify a catalyst in the above mechanism. **(2 marks)**

Solution:

For Example:

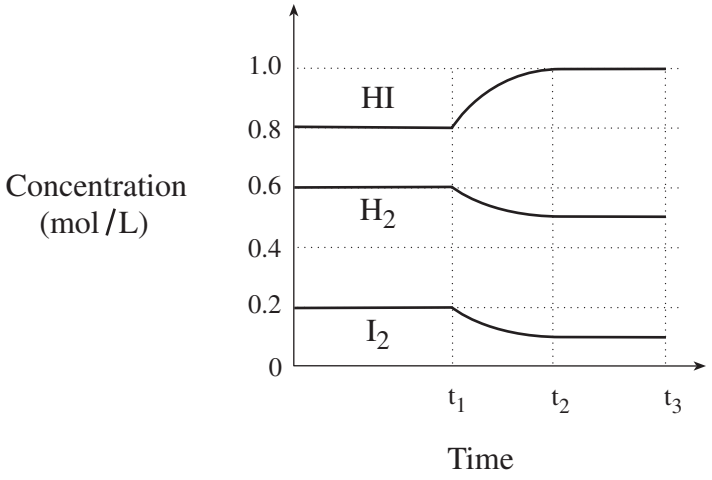
Definition: A species which speeds up a reaction by providing a lower energy pathway.

Catalyst: Fe^{3+}

← **2 marks**

2. Consider the following graph for the reaction:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$$



The temperature is increased at t_1 and equilibrium is re-established at t_2.

a) On the above graph, sketch the line representing the $[HI]$ between time t_1 and t_3. **(1 mark)**

Solution:

For Example:

See graph above. ← **1 mark**

b) Calculate the value of K_{eq} after t_2. **(2 marks)**

Solution:

For Example:

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

$$= \frac{(1.0)^2}{(0.5)(0.1)}$$

$$= 20$$

← **2 marks**

3. Consider the following equilibrium system:

$$2SO_{2(g)} + O_{2(g)} \rightleftarrows 2SO_{3(g)}$$

A 1.00 L container is initially filled with 0.100 mol SO_2 and 0.100 mol O_2.
At equilibrium the O_2 concentration is 0.060 mol/L. Calculate the value of K_{eq}. **(4 marks)**

Solution:

For Example:

	$2SO_{2(g)}$	+	$O_{2(g)}$	$\rightleftarrows$	$2SO_{3(g)}$
[I]	0.100		0.100		0
[C]	−0.080		−0.040		+0.080
[E]	0.020		0.060		0.080

← **2 marks**

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

$$= \frac{(0.080)^2}{(0.020)^2(0.060)}$$

$$= 2.7 \times 10^2$$

← **2 marks**

4. Hard water, containing Ca^{2+} ions, forms a precipitate with sodium stearate $\left(NaC_{18}H_{35}O_2\right)$.

a) Write the net ionic reaction that represents this precipitation. **(2 marks)**

Solution:

$$Ca^{2+}_{(aq)} + 2C_{18}H_{35}O^{-}_{2(aq)} \rightarrow Ca\left(C_{18}H_{35}O_2\right)_{2(s)}$$ ← **2 marks**

b) Identify another compound that could be used to remove Ca^{2+} from hard water. **(1 mark)**

Solution:

For Example:

Na_2CO_3 ← **1 mark**

5. Calculate the mass of $SrCO_3$ dissolved in $1.00\,L$ of a saturated solution of $SrCO_3$. **(3 marks)**

Solution:

For Example:

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

$$K_{sp} = \left[Sr^{2+}\right]\left[{CO_3}^{2-}\right] = 5.6 \times 10^{-10}$$

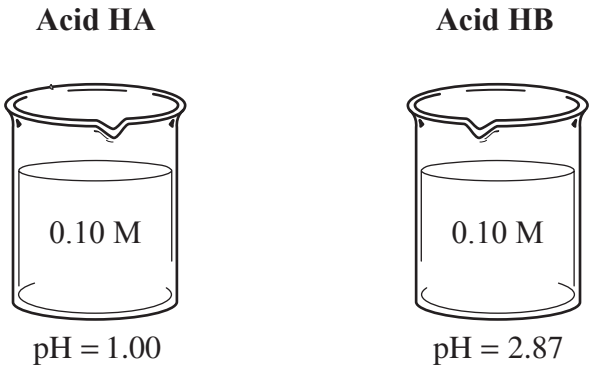
$$\left[Sr^{2+}\right] = \left[{CO_3}^{2-}\right] = 2.36 \times 10^{-5}$$

$$\text{Mass of } SrCO_3 \text{ dissolved in } 1.00\,L = 2.36 \times 10^{-5}\ \text{mol} \times \frac{147.6\,g}{\text{mol}}$$

$$= 3.5 \times 10^{-3}\,g$$

← **3 marks**

6. Consider the $0.10\,M$ solutions of the following two acids:



a) What can you conclude about the acids that will explain these different pH values? **(1 mark)**

Solution:

For Example:

Acid HA is strong.
Acid HB is weak.

} ← **1 mark**

b) Compare the volume of $0.10\,M$ $NaOH$ needed to neutralize equal volumes of each of these acid samples. **(1 mark)**

Solution:

For Example:

The same volume of $NaOH_{(aq)}$ is needed for each acid sample.

} ← **1 mark**

7. Consider a 1.0 M solution of NH_4F.

a) Write both hydrolysis reactions that occur when NH_4F is dissolved in water. **(2 marks)**

Solution:

For Example:

$$NH_4^+{}_{(aq)} + H_2O_{(\ell)} \rightleftarrows NH_{3(aq)} + H_3O^+{}_{(aq)} \quad \leftarrow \textbf{1 mark}$$

$$F^-{}_{(aq)} + H_2O_{(\ell)} \rightleftarrows HF_{(aq)} + OH^-{}_{(aq)} \quad \leftarrow \textbf{1 mark}$$

b) Will the above NH_4F solution be acidic, basic, or neutral?
Support your answer with calculations. **(2 marks)**

Solution:

For Example:

K_a for $NH_4^+ = 5.6 \times 10^{-10}$

K_b for $F^- = \dfrac{K_w}{K_a} = \dfrac{1.0 \times 10^{-14}}{3.5 \times 10^{-4}} = 2.9 \times 10^{-11}$

Since $K_a > K_b$, the solution is acidic.

$\leftarrow$ **2 marks**

8. An indicator is often used during acid-base titrations.

a) Define the term *transition point* for an indicator. **(1 mark)**

Solution:

For Example:

The point where the indicator is halfway through the colour change.

OR

$[HInd] = [Ind^-]$

← **1 mark**

b) Calculate the K_a value for methyl red. **(1 mark)**

Solution:

For Example:

$$\text{Average pH} = \frac{4.8 + 6.0}{2} = 5.4$$

$$K_a = 1 \times 10^{-5.4}$$

$$= 4 \times 10^{-6}$$

← **1 mark**

c) A mixture of indicators is made by combining equal amounts of methyl orange and bromthymol blue. Complete the following table, showing the colour of each indicator and the mixture at pH of 5 and pH of 9. **(2 marks)**

	Colour of methyl orange	Colour of bromthymol blue	Colour of mixture
pH=5	yellow	yellow	yellow
pH=9	yellow	blue	green

← **2 marks**

9. Will $HC_2O_4^-$ act predominantly as an acid or as a base in solution? Support your answer with calculations. **(3 marks)**

Solution:

For Example:

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{5.9 \times 10^{-2}} = 1.7 \times 10^{-13}$$ ← **1 ½ marks**

Since $K_a = 6.4 \times 10^{-5}$ which is greater than K_b, the ions act as an acid. ← **1 ½ marks**

10. Consider the following redox reaction in acidic solution:

$$MnO_4^- + H_2O_2 \rightarrow Mn^{2+} + O_2 \qquad \text{(acidic)}$$

a) Write a balanced equation for the above reaction. **(4 marks)**

Solution:

For Example:

$$\begin{array}{r} 2 \times \left(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O\right) \\ 5 \times \left(H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-\right) \\ \hline 2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2 \end{array}$$

← **4 marks**

b) The above reaction was used for a redox titration. At the equivalence point 5.684×10^{-4} mol $KMnO_4$ was required to titrate 5.00 mL of H_2O_2 solution. Calculate the $[H_2O_2]$. **(2 marks)**

Solution:

For Example:

$$\text{mol } H_2O_2 = 5.684 \times 10^{-4} \text{ mol } MnO_4^- \times \frac{5 \text{ mol } H_2O_2}{2 \text{ mol } MnO_4^-} = 1.421 \times 10^{-3} \text{ mol}$$

$$[H_2O_2] = \frac{1.421 \times 10^{-3} \text{ mol}}{0.00500 \text{ L}} = 0.284 \text{ M}$$

← **2 marks**

11. Cathodic protection is one method used to inhibit the corrosion of iron.

a) Explain the principle of *cathodic protection*. **(2 marks)**

Solution:

For Example:

The process of protecting a metal from oxidation by placing it in electrical contact with another metal that is a stronger reducing agent. The protected metal becomes a cathode and the other becomes a sacrificial anode. ← **2 marks**

b) Identify **two** methods, other than cathodic protection, that could be used to inhibit the corrosion of iron. **(2 marks)**

Solution:

For Example:

Coating with paint or grease. ← **1 mark**

Keep in totally dry atmosphere. ← **1 mark**

END OF KEY