JANUARY 1995 CHEMISTRY 12 PROVINCIAL EXAMINATION
ANSWER KEY / SCORING GUIDE

TOPICS
1. Kinetics
2. Equilibrium
3. Solubility
4. Acids, Bases, Salts
5. Oxidation – Reduction

PART A: MULTIPLE-CHOICE

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PART B: WRITTEN-RESPONSE

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Multiple-choice = 48 (48 questions)
Written-response = 32 (13 questions)
**Total = 80 marks**
PART B: WRITTEN-RESPONSE

1. State two reasons why some collisions may not result in a chemical reaction. (2 marks)

   Reason I: 
   Reason II: 

Response:

For example:

   Reason I: unfavourable collision geometry/orientation ← 1 mark
   Reason II: insufficient collision energy/low KE ← 1 mark
2. Describe the relationship between activation energy and the rate of a chemical reaction. (2 marks)

Response:

For example:

If the activation energy is lower, then the rate of reaction is greater.
3. What is “equal” in a chemical reaction that has reached a state of equilibrium? (2 marks)

Response:

The rates of the forward and reverse reactions.
4. Consider the following equilibrium:

\[
N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad K_{eq} = 626 \text{ at } 200^\circ C
\]

At equilibrium, \([N_2]\) is 1.06 mol/L and \([H_2]\) is 0.456 mol/L. Calculate \([NH_3]\) in the equilibrium mixture. (2 marks)

Response:

\[
K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3} \quad \leftarrow \frac{1}{2} \text{ mark}
\]

\[
626 = \frac{[NH_3]^2}{(1.06)(0.456)^3} \quad \leftarrow \frac{1}{2} \text{ mark}
\]

\[
[NH_3] = 7.93 \quad \leftarrow 1 \text{ mark}
\]
5. A 1.0 M solution of sodium sulphite is added to a 1.0 M solution of copper(II) chloride resulting in the formation of a precipitate.

a) Identify the precipitate.  
Response:  
Copper(II) sulphite or \( \text{CuSO}_3 \)

b) Write the complete ionic equation for the reaction.  
Response:  
\[
2\text{Na}^{+}(aq) + \text{SO}_3^{2-}(aq) + \text{Cu}^{2+}(aq) + 2\text{Cl}^{-}(aq) \rightarrow \text{CuSO}_3(s) + 2\text{Na}^{+}(aq) + 2\text{Cl}^{-}(aq)
\]

or  
\[
\text{Na}^{+}(aq) + \text{SO}_3^{2-}(aq) + \text{Cu}^{2+}(aq) + \text{Cl}^{-}(aq) \rightarrow \text{CuSO}_3(s) + \text{Na}^{+}(aq) + \text{Cl}^{-}(aq)
\]

c) Identify all spectator ions.  
Response:  
\( \text{Na}^+ \), \( \text{Cl}^- \)
6. In an experiment, 100.0 mL samples containing silver ions are titrated with 0.200 M KSCN. The equation for the reaction is

$$\text{Ag}^{+}_{(aq)} + \text{SCN}^-_{(aq)} \rightarrow \text{AgSCN}_{(s)}$$

The following data are recorded.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Volume KSCN (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23.10</td>
</tr>
<tr>
<td>2</td>
<td>22.62</td>
</tr>
<tr>
<td>3</td>
<td>22.58</td>
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</tbody>
</table>

Calculate the concentration of the silver ion in the solution. (4 marks)

Response:

Average volume = \( \frac{22.62 + 22.58}{2} = 22.60 \text{ mL} \) ← 1 mark

mol SCN\(^-\) = 0.02260 L \times \frac{0.200 \text{ mol}}{L} ← 1 mark

= 0.00452 mol

mol Ag\(^+\) = 0.00452 mol ← 1 mark

\[ [\text{Ag}^+] = \frac{0.00452 \text{ mol}}{0.1000 \text{ L}} = 0.0452 \text{ M} \] ← 1 mark

NOTE: Deduct 1/2 point for incorrect significant figures.
7. a) Write the Brönsted-Lowry acid-base equation for the reaction between $\text{HCN}(aq)$ and $\text{NH}_3(aq)$.

Response:

$\text{HCN}(aq) + \text{NH}_3(aq) \rightleftharpoons \text{NH}_4^+(aq) + \text{CN}^-(aq)$

b) Write a conjugate acid-base pair from the equation above.

Response:

$\text{HCN}$ and $\text{CN}^-$ or $\text{NH}_4^+$ and $\text{NH}_3$
8. a) Write the formula of an amphiprotic anion that will act as an acid when added to water. (1 mark)

Response:
For example:

\[ \text{H}_2\text{PO}_4^- \]

or

\[ \text{HSO}_3^- \]

b) Write a hydrolysis equation to represent the anion selected in part (a) above behaving as an acid. (1 mark)

Response:
For example:

\[ \text{H}_2\text{PO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HPO}_4^{2-} \]

or

\[ \text{HSO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{SO}_3^{2-} \]
9. Calculate the pH of a solution prepared by dissolving 0.050 mol of NaOH in enough water to make 500.0 mL of solution. (2 marks)

Response:

For example:

\[
[\text{OH}^-] = \frac{0.050 \text{ mol}}{0.500 \text{ L}} = 0.100 \text{ M} \quad \leftarrow \frac{1}{2} \text{ mark}
\]

\[K_w = [H_3O^+][OH^-] \quad \leftarrow \frac{1}{2} \text{ mark}\]

\[
(0.10\text{M})[H_3O^+] = 1.0 \times 10^{-14} \quad \leftarrow \frac{1}{2} \text{ mark}
\]

\[
[H_3O^+] = 1.0 \times 10^{-13} \text{M} \quad \leftarrow \frac{1}{2} \text{ mark}
\]

\[
\text{pH} = 13.00 \quad \leftarrow \frac{1}{2} \text{ mark}
\]

NOTE: Deduct \(\frac{1}{2}\) point for incorrect significant figures.
10. Calculate the pH of 0.50 M $H_2S$. (4 marks)

Response:

For example:

\[
\begin{array}{c|ccc}
 & H_2S & \overset{\rightleftharpoons}{\rightarrow} & H^+ & + & HS^- \\
I & 0.50 & 0 & 0 \\
\Delta C & -x & x & x \\
E & 0.50 - x & x & x \\
\end{array}
\]

\(x\) is small, therefore \(0.50 - x \approx 0.50\) \(\leftarrow 1\frac{1}{2}\) mark

\[
K_a = \frac{[H^+][HS^-]}{[H_2S]} \quad \leftarrow \frac{1}{2}\text{ mark for expression}
\]

\[
9.1 \times 10^{-8} = \frac{x^2}{0.50} \quad \leftarrow \frac{1}{2}\text{ mark for substitution}
\]

\[
x = 2.13 \times 10^{-4}\text{ M} = [H^+] \quad \leftarrow \frac{1}{2}\text{ mark for solving } [H^+]
\]

\[
pH = -\log[H^+] = 3.67 \quad \leftarrow \frac{1}{2}\text{ mark for calculating pH}
\]
11. Consider the following equation:

\[ 2\text{NO}_2 \rightarrow \text{N}_2\text{O}_4 \]

a) Does the above represent a redox reaction? ___________ (½ mark)

Response:

No.

b) Explain. (1½ marks)

Response:

The oxidation number of nitrogen in \( \text{NO}_2 \) and in \( \text{N}_2\text{O}_4 \) is +4. With no change in the oxidation number there is no loss or gain of electrons.
12. Balance the following half-reaction in acidic conditions. (2 marks)

\[ \text{Br}_2 \rightarrow \text{BrO}_3^- \]

Response:

\[ \text{Br}_2 + 6\text{H}_2\text{O} \rightarrow 2\text{BrO}_3^- + 12\text{H}^+ + 10e^- \leftarrow 2 \text{ marks} \]

One-half mark for each step: balancing bromine, balancing oxygen, balancing hydrogen, balancing charge.
13. Consider the electrolysis of **molten** magnesium chloride.

a) Identify the product formed at the anode. (1 mark)

Response:

Chlorine gas or \( \text{Cl}_2 \)

b) Write the equation for the reduction half-reaction. (1 mark)

Response:

\[ \text{Mg}^{2+} + 2e^- \rightarrow \text{Mg} \]

c) Write the equation for the overall reaction. (1 mark)

Response:

\[ \text{MgCl}_2(l) \rightarrow \text{Mg}(l) + \text{Cl}_2(g) \]

or

\[ \text{Mg}^{2+} + 2\text{Cl}^-(l) \rightarrow \text{Mg}(l) + \text{Cl}_2(g) \]