Chemistry 12
June 2002 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

Organizers Sub-Orgainers
1. Reaction Kinetics A, B, C
2. Dynamic Equilibrium D, E, F
5. Oxidation – Reduction S, T, U, V, W

Part A: Multiple Choice

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<tr>
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Multiple Choice = 60 marks (48 questions)
### Part B: Written Response

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**Written Response = 40 marks**

Multiple Choice = 60 (48 questions)

Written Response = 40 (13 questions)

**EXAMINATION TOTAL = 100 marks**

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**LEGEND:**

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<tr>
<th>Q</th>
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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. Consider the reaction:

\[2\text{Al}_{(s)} + 6\text{HCl}_{(aq)} \rightarrow 2\text{AlCl}_3_{(aq)} + 3\text{H}_2_{(g)}\]

A 10.0 g sample of Al reacts completely in excess HCl in 300.0 s. What is the rate of production of H₂ in mol/s?

Solution:

For Example:

\[
\text{mol Al} = 10.0 \text{ g} \times \frac{1 \text{ mol}}{27.0 \text{ g}} = 0.370 \text{ mol Al}
\]

\[
\text{mol H}_2 = 0.370 \text{ mol Al} \times \frac{3 \text{ mol H}_2}{2 \text{ mol Al}}
\]

\[
= 0.556 \text{ mol H}_2
\]

rate = \frac{\text{change in moles}}{\text{time}}

\[
= \frac{0.556 \text{ mol H}_2}{300.0 \text{ s}}
\]

\[
= 1.85 \times 10^{-3} \frac{\text{mol H}_2}{\text{s}}
\]

(Deduct \(\frac{1}{2}\) mark for incorrect significant figures.)
2. Using collision theory, give **two** reasons why reactions occur more rapidly at a higher temperature.  

Solution:

*For Example:*

There is a greater fraction of collisions with sufficient energy.

There are more frequent collisions. $\leftarrow 2$ marks
3. Chemical reactions tend toward a position of minimum enthalpy and maximum entropy.

a) What is meant by the term *enthalpy*? (1 mark)

**Solution:**

*For Example:*

Enthalpy is a measure of heat content. ← 1 mark

b) What is meant by the term *entropy*? (1 mark)

**Solution:**

*For Example:*

Entropy is a measure of randomness. ← 1 mark
4. Consider the following: (4 marks)

\[ \text{H}_2(g) + \text{Br}_2(g) \rightleftharpoons 2\text{HBr}(g) \quad K_{eq} = 12.0 \]

Initially, 0.080 mol H\(_2\) and 0.080 mol Br\(_2\) are placed into a 4.00 L container. What is the [HBr] at equilibrium?

**Solution:**

*For Example:*

\[
\begin{array}{c|ccc}
 & \text{H}_2 & + & \text{Br}_2 & \rightleftharpoons & 2\text{HBr} \\
[1] & 0.020 & 0.020 & 0 \\
[C] & -x & -x & +2x \\
[E] & 0.020 - x & 0.020 - x & 2x \\
\end{array}
\]

\[
K_{eq} = \frac{[\text{HBr}]^2}{[\text{H}_2][\text{Br}_2]} = \frac{(2x)^2}{(0.020 - x)^2} = 12.0
\]

\[
\sqrt{\frac{(2x)^2}{(0.020 - x)}} = \sqrt{12.0}
\]

\[x = 0.0127\]

\[[\text{HBr}] = 2x = 0.025 \text{ M}\]
5. Consider the following equilibrium and accompanying graph:

\[ \text{Zn(IO}_3\text{)}_{2(s)} \rightleftharpoons \text{Zn}^{2+}_{(aq)} + 2\text{IO}_3^{-}_{(aq)} \]

a) Identify the stress applied at \( t_1 \).

Solution:

*For Example:*

More \( \text{Zn}^{2+}_{(aq)} \) has been added. \( \leftarrow 1 \) mark

b) Complete the above graph from \( t_1 \) to \( t_3 \) for the \( \text{IO}_3^{-} \).

Solution:

*For Example:*

See graph above.
6. Calculate the solubility of SrSO₄ in grams per litre. (3 marks)

Solution:

For Example:

\[
\text{SrSO}_4(s) \rightleftharpoons \text{Sr}^{2+} \text{(aq)} + \text{SO}_4^{2-} \text{(aq)}
\]

\[
K_{sp} = [\text{Sr}^{2+}][\text{SO}_4^{2-}] = 3.4 \times 10^{-7}
\]

\[
= 3.4 \times 10^{-7}
\]

Solubility = \( s = 5.8 \times 10^{-4} \text{ M} \)

Solubility in g/L = \( 5.8 \times 10^{-4} \text{ mol/L} \times \frac{183.7 \text{ g}}{\text{mol}} \)

= 0.11 g/L

\( \leftarrow 3 \text{ marks} \)
7. The cyanide ion, CN\(^{-}\), is a Brønsted-Lowry base.

a) Define *Brønsted-Lowry base*. (1 mark)

Solution:

*For Example:*

A Brønsted-Lowry base is a proton acceptor. ← 1 mark

b) Write the equation representing the reaction of CN\(^{-}\) with water. (2 marks)

Solution:

*For Example:*

\[
\text{CN}^{-} + \text{H}_2\text{O} \rightleftharpoons \text{HCN} + \text{OH}^{-}
\] ← 2 marks

c) Identify a conjugate pair in b) above. (1 mark)

Solution:

*For Example:*

CN\(^{-}\) and HCN OR H\(_2\)O and OH\(^{-}\) ← 1 mark
8. Write an equation to show the ionization of water. (2 marks)

Solution:

For Example:

\[ 2\text{H}_2\text{O}(\ell) \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{OH}^-_{(aq)} \] ← 2 marks
9. Calculate the pH of 1.50 M NH₃.

Solution:

*For Example:*

\[
\begin{array}{c|ccc}
 & \text{NH}_3 & + & \text{H}_2\text{O} \\ 
[I] & 1.50 & & 0 \\ 
[C] & -x & +x & +x \\ 
[E] & 1.50 - x & x & x \\
\end{array}
\]

\[
K_b = \frac{1.0 \times 10^{-14}}{5.6 \times 10^{-10}} = 1.79 \times 10^{-5}
\]

\[
K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]}
\]

\[
= \frac{x^2}{1.50 - x}
\]

\[
x = [\text{OH}^-] = 5.18 \times 10^{-3}
\]

\[
p\text{OH} = 2.29
\]

\[
p\text{H} = 11.71
\]

(Deduct \(\frac{1}{2}\) mark for incorrect significant figures.)
10. Consider the following buffer equilibrium: 

\[
\text{HF}(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_3\text{O}^+(aq) + \text{F}^-(aq)
\]

Using Le Châtelier’s Principle, explain what happens to the pH of the buffer solution when a small amount of NaOH is added.

Solution:

For Example:

NaOH causes \([\text{H}_3\text{O}^+]\) to decrease. ← 1 mark

The equilibrium shifts right. ← 1 mark

The pH almost returns to the former value. ← 1 mark
11. Balance the following redox equation: (4 marks)

\[ \text{Ag} + \text{NO}_3^- \rightarrow \text{Ag}^+ + \text{NO} \quad \text{acidic} \]

Solution:

For Example:

\[ 3 \times \left( \text{Ag} \rightarrow \text{Ag}^+ + 3e^- \right) \]
\[ 3e^- + 4H^+ + \text{NO}_3^- \rightarrow \text{NO} + 2\text{H}_2\text{O} \]
\[ 3\text{Ag} + \text{NO}_3^- + 4H^+ \rightarrow \text{NO} + 2\text{H}_2\text{O} + 3\text{Ag}^+ \]

\[ \leftarrow 2 \text{ marks (1 mark for each half-reaction)} \]
\[ \leftarrow 1 \text{ mark for balancing electrons} \]
\[ \leftarrow 1 \text{ mark for addition} \]
12. Draw a diagram of an operating electrolytic cell used to extract pure lead from an impure lead sample. Identify the electrolyte and the material used for the anode. (3 marks)

Solution:

*For Example:*

```
1 mark →
```

```
Anode (impure lead) ← 1 mark
```

```
1.0 M Pb(NO₃)₂ ← 1 mark
```

```
DC Power Source
```

```
+ → −
```

13. A sample of copper is placed in \( \text{HNO}_3(aq) \) and another sample of copper is placed in \( \text{HCl}(aq) \).

a) In which acid does the copper react? \( \frac{1}{2} \) mark

Solution:

*For Example:*

Copper reacts in \( \text{HNO}_3(aq) \). \( \leftarrow \frac{1}{2} \) mark

b) Calculate \( E^\circ \) for the reaction that occurs. \( 1 \frac{1}{2} \) marks

Solution:

*For Example:*

\( E^\circ \) is +0.62 volts \( \leftarrow 1 \frac{1}{2} \) marks

END OF KEY