Chemistry 12

January 1997 Provincial Examination

ANSWER KEY / SCORING GUIDE

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

Part A: Multiple Choice

Q	C	T	K	S	CGR	Q	C	T	K	S	CGR
1.	K	1	C	1	I-B-2	25.	U	4	C	1	IV-D-3
2.	U	1	D	1	I-A-2	26.	U	4	B	1	IV-F-6
3.	K	1	D	1	I-C-1	27.	U	4	B	1	IV-F-7
4.	H	1	B	1	I-D-5	28.	U	4	B	1	IV-H-9
5.	U	1	C	1	I-E-2	29.	U	4	A	1	IV-G-3, F-9
6.	U	2	B	1	II-B-1, A-3	30.	U	4	A	1	IV-G-2
7.	U	2	A	1	II-C-4	31.	K	4	B	1	IV-D-11
8.	U	2	D	1	II-D-1	32.	U	4	B	1	IV-J-2
9.	K	2	B	1	II-D-3	33.	K	4	D	1	IV-J-6
10.	U	2	C	1	II-G-2	34.	U	4	D	1	IV-H-9
11.	U	2	D	1	II-J-3	35.	H	4	C	1	IV-K-5
12.	U	2	C	1	II-I-1	36.	U	4	A	1	IV-L-3
13.	U	2	C	1	II-J-1	37.	U	5	C	1	V-A-1
14.	U	3	A	1	III-B-7	38.	U	5	A	1	V-A-3
15.	U	3	D	1	III-B-3, C-2	39.	U	5	B	1	V-A-7
16.	K	3	C	1	III-A-1	40.	U	5	A	1	V-C-2
17.	U	3	A	1	III-D-3	41.	H	5	C	1	V-D-2, 4
18.	K	3	C	1	III-A-4	42.	K	5	A	1	V-D-1
19.	U	3	D	1	III-A-8	43.	U	5	D	1	V-E-1
20.	U	3	D	1	III-E-1	44.	U	5	C	1	V-G-4
21.	K	4	B	1	IV-A-2	45.	K	5	A	1	V-H-2
22.	U	4	D	1	IV-A-3	46.	U	5	D	1	V-G-11
23.	K	4	D	1	IV-A-4	47.	U	5	A	1	V-I-5
24.	U	4	C	1	IV-B-2, C-3	48.	U	5	D	1	V-J-2

Part B: Written Response

Q	B	C	T	S	CGR	Q	B	C	T	S	CGR
1.	1	U	1	2	I-D-2, 4	7.	7	U	4	3	IV-E-3
2.	2	U	1	2	I-C-1, F-1	8.	8	U	4	3	IV-F-10
3.	3	K	2	2	II-C-1	9.	9	U	4	4	IV-J-5
4.	4	U	2	3	II-J-2	10.	10	U	5	3	V-F-1
5.	5	U	3	2	III-D-4	11.	11	H	5	5	V-G-1, 5, 11
6.	6	U	3	3	III-D-6						

Multiple Choice = 48 (48 questions)
Written Response = 32 (11 questions)
Total = 80 marks

LEGEND:
Q = Question Number   **C** = Cognitive Level   **T** = Topic
K = Keyed Response   **S** = Score   **CGR** = Curriculum Guide Reference
B = Score Box Number

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. Define the term *activated complex.* **(2 marks)**

Response:

An *activated complex* is a short-lived, unstable, high energy chemical species that forms when reactant particles change to products. } ← **2 marks**

2. Using collision theory, explain why a mixture of natural gas and air does not react at room temperature but explodes when a piece of platinum is placed in the gas mixture. **(2 marks)**

Response:

For example:

The platinum is acting as a catalyst, increasing the rate of this reaction by providing an alternate pathway that has a lower activation energy, therefore more particles undergo successful collisions. } ← **2 marks**

3. Identify four characteristics of a chemical equilibrium. **(2 marks)**

Response:

For example:

- Closed container.
- Constant temperature.
- Reversible reaction.
- Both reactants and products present.
- No changes in macroscopic properties.
- Rate of forward reaction equals rate of reverse reaction.
- Responds to imposed stresses.

} **any four for $\frac{1}{2}$ mark each**

4. At high temperature, 0.500 mol HBr was placed in a 1.00 L container where it decomposed to give the equilibrium:

$$2HBr_{(g)} \rightleftarrows H_{2(g)} + Br_{2(g)}$$

At equilibrium, the $[Br_2]$ is 0.0855 mol/L. What is the value of the equilibrium constant? **(3 marks)**

Response:

	$2HBr_{(g)}$	$\rightleftarrows$ $H_{2(g)}$	+ $Br_{2(g)}$
[I]	0.500	0	0
[C]	−0.171	+0.0855	+0.0855
[E]	0.329	0.0855	0.0855

← **1½ marks**

$$K_{eq} = \frac{[H_2][Br_2]}{[HBr]^2}$$

$$= \frac{(0.0855)(0.0855)}{(0.329)^2}$$

$$= 6.75 \times 10^{-2}$$

← **1½ marks**

5. A saturated solution of BaF_2 has a $\left[Ba^{2+}\right]$ of $3.6\times10^{-3}\,M$.
Calculate the K_{sp} value. **(2 marks)**

Response:

$$BaF_{2(s)} \rightleftarrows Ba^{2+}{}_{(aq)} + 2F^{-}{}_{(aq)}$$

$$3.6\times10^{-3}\,M \quad 7.2\times10^{-3}\,M$$

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

$$= \left(3.6\times10^{-3}\right)\left(7.2\times10^{-3}\right)^2$$

$$= 1.9\times10^{-7}$$

← **2 marks**

6. Calculate the maximum mass of Na_2SO_4 which can be dissolved in 2.0 L of 1.5 M $Ca(NO_3)_2$ without a precipitate forming. **(3 marks)**

Response:

$$CaSO_{4(s)} \rightleftarrows Ca^{2+}{}_{(aq)} + SO_4{}^{2-}{}_{(aq)}$$

1.5 M $\quad x$

$$K_{sp} \text{ for } CaSO_4 = \left[Ca^{2+}\right]\left[SO_4{}^{2-}\right]$$

$$7.1\times10^{-5} = (1.5)(x)$$

$$x = \left[SO_4{}^{2-}\right] = \left[Na_2SO_4\right] = 4.7\times10^{-5}\,M$$

← **2 marks**

$$\text{mass of } Na_2SO_4 \text{ required} = 4.7\times10^{-5} \text{ mol/L} \times 142.1 \text{ g/mol} \times 2.0 \text{ L}$$

$$= 1.3\times10^{-2}\,g$$

← **1 mark**

7. a) Write two equations showing the amphiprotic nature of water as it reacts with HCO_3^-. **(2 marks)**

Response:

For example:

$H_2O + HCO_3^- \rightarrow H_3O^+ + CO_3^{2-}$ ← **1 mark**

$H_2O + HCO_3^- \rightarrow H_2CO_3 + OH^-$ ← **1 mark**

b) Calculate the K_b for HCO_3^-. **(1 mark)**

Response:

$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{4.3 \times 10^{-7}} = 2.3 \times 10^{-8}$ ← **1 mark**

8. Calculate the $[H_3O^+]$ in 0.550 M C_6H_5COOH. **(3 marks)**

Response:

$$C_6H_5COOH_{(aq)} + H_2O \rightleftarrows H_3O^+{}_{(aq)} + C_6H_5COO^-{}_{(aq)}$$

	C_6H_5COOH	H_3O^+	$C_6H_5COO^-$
[I]	0.550	0	0
[C]	$-x$	$+x$	$+x$
[E]	$0.550 - x$	x	x

← **1 ½ marks**

$$K_a = \frac{[H_3O^+][C_6H_5COO^-]}{[C_6H_5COOH]}$$

$$\frac{x^2}{0.550 - x} = 6.5 \times 10^{-5}$$

assume $x << 0.550$

$$\frac{x^2}{0.550} = 6.5 \times 10^{-5}$$

$$x = 0.0060$$

$$[H_3O^+] = 6.0 \times 10^{-3} \text{ M}$$

← **1 ½ marks**

Note: (**½ mark deduction for incorrect significant figures.**)

9. Calculate the pH of the solution formed by mixing 20.0 mL of 0.500 M HCl with 30.0 mL 0.300 M NaOH. **(4 marks)**

Response:

For example:

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

$$\left.\begin{array}{r} \text{mol HCl} = 0.500\ \text{M} \times 0.0200\ \text{L} = 0.0100\ \text{mol} \\ \text{mol NaOH} = 0.300\ \text{M} \times 0.0300\ \text{L} = 0.00900\ \text{mol} \end{array}\right\} \leftarrow \textbf{1 mark}$$

$$\text{Excess mol HCl} = \text{mol } H_3O^+ = 0.0010\ \text{mol} \qquad \leftarrow \textbf{1 mark}$$

$$\left[H_3O^+\right] = \frac{0.0010\ \text{mol}}{0.0500\ \text{L}} = 0.020\ \text{M} \qquad \leftarrow \textbf{1 mark}$$

$$\text{pH} = -\log(0.020) = 1.70 \qquad \leftarrow \textbf{1 mark}$$

10. Consider the following reaction:

$$Cr_2O_7^{2-} + 6Br^- + 14H^+ \rightarrow 2Cr^{3+} + 3Br_2 + 7H_2O$$

In a redox titration, 15.58 mL of 0.125 M $Cr_2O_7^{2-}$ was needed to completely oxidize the Br^- in a 25.00 mL sample of NaBr. Calculate the $\left[Br^-\right]$ in the original solution. **(3 marks)**

Response:

$$\text{mol } Cr_2O_7^{2-} = (0.01558 \text{ L})(0.125 \text{ M}) = 1.9475 \times 10^{-3} \text{ mol } Cr_2O_7^{2-}$$ **← 1 mark**

$$\text{mol } Br^- = \left(1.9475 \times 10^{-3} \text{ mol } Cr_2O_7^{2-}\right)\left(\frac{6 \text{ mol } Br^-}{1 \text{ mol } Cr_2O_7^{2-}}\right)$$

$$= 1.1685 \times 10^{-2} \text{ mol } Br^-$$ **← 1 mark**

$$\left[Br^-\right] = \frac{1.1685 \times 10^{-2} \text{ mol } Br^-}{0.02500 \text{ L}}$$

$$= 4.67 \times 10^{-1} \text{ M}$$ **← 1 mark**

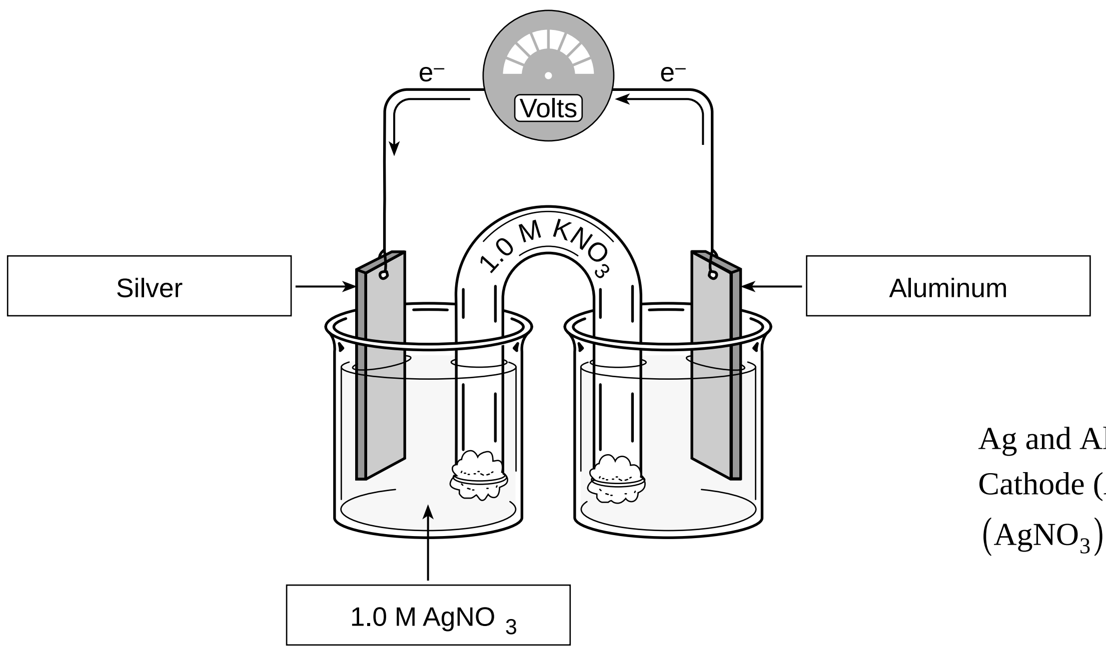
Note: $\left(\frac{1}{2}\right.$ **mark deduction for incorrect significant figures.**$\left.\right)$

11. Consider the following materials and cell diagram:

- silver, aluminum and nickel electrodes
- 1.0 M solutions of $AgNO_3$, $Al(NO_3)_3$ and $Ni(NO_3)_2$

a) From the above list, select the materials that are capable of producing the greatest voltage, then label the diagram below. **(3 marks)**

Response:



Ag and Al: ← **1 mark**

Cathode (Ag): ← **1 mark**

$(AgNO_3)$ ← **1 mark**

b) Calculate the initial voltage for the electrochemical cell in part a). **(1 mark)**

Response:

Initial cell voltage $= 0.80 + 1.66 = 2.46$ V ← **1 mark**

c) Which two metals from the above list would produce an electrochemical cell with the smallest initial voltage? **(1 mark)**

Response:

Ag and Ni ← **1 mark**

END OF KEY