Chemistry 12

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

Part B: Written Response

Q	B	C	T	S	CGR	Q	B	C	T	S	CGR
1.	1	K	1	4	I-E-2, 1	7.	7	H	4	2	IV-F-13
2.	2	K	2	2	II-A-3	8.	8	U	4	4	IV-H-14
3.	3	U	2	4	II-J-3	9.	9	U	4	2	IV-J-5
4.	4	U	3	2	III-B-5, 7	10.	10	U	5	3	V-E-1
5.	5	U	3	3	III-D-5	11.	11	U	5	4	V-J-3
6.	6	U	4	2	IV-B-2, 3						

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. One of the reactions in the production of smog involves the oxidation of nitrogen monoxide. A possible mechanism for this reaction is:

Step 1: $CO + OH \rightarrow CO_2 + H$

Step 2: $H + O_2 \rightarrow HOO$

Step 3: $HOO + NO \rightarrow OH + NO_2$

a) Write the balanced equation for the overall reaction. **(2 marks)**

Response:

$NO + CO + O_2 \rightarrow NO_2 + CO_2$ ← **2 marks**

b) Identify all reaction intermediates. **(1 mark)**

Response:

H and HOO ← **1 mark**

c) Identify the catalyst. **(1 mark)**

Response:

OH ← **1 mark**

2. Consider the following equilibrium:

$$2H_2O_{(g)} \rightleftarrows 2H_{2(g)} + O_{2(g)}$$

Identify two ways to increase the rate of the forward reaction. **(2 marks)**

Response:

For example:

Two of the following:

- Add more H_2O
- Add a catalyst
- Decrease the volume
- Increase the temperature

3. Consider the following:

$$H_{2(g)} + F_{2(g)} \rightleftarrows 2HF_{(g)} \qquad K_{eq} = 1.00 \times 10^2$$

A 1.00 L flask is initially filled with 2.00 mol H_2 and 2.00 mol F_2.
Calculate the $[H_2]$ at equilibrium. **(4 marks)**

Response:

	$H_{2(g)}$	+ $F_{2(g)}$	$\rightleftarrows$ $2HF_{(g)}$
[**I**]	2.00	2.00	0
[**C**]	$-x$	$-x$	$+2x$
[**E**]	$2.00 - x$	$2.00 - x$	$2x$

← **1 $\frac{1}{2}$ marks**

$$K_{eq} = \frac{[HF]^2}{[H_2][F_2]}$$

$$1.00 \times 10^2 = \frac{(2x)^2}{(2.00 - x)^2}$$

$$x = 1.67$$

← **1 $\frac{1}{2}$ marks**

$[H_2] = 2.00 - x = 2.00 - 1.67 = 0.33$ mol/L ← **1 mark**

4. A solution contains 0.20 M Cl^- and 0.20 M SO_4^{2-}.

a) Identify a cation that could be added to the solution to give a precipitate with only one of these anions. **(1 mark)**

Response:

For example:

Ca^{2+}

or

Sr^{2+}

or

Ba^{2+}

b) Write the net ionic equation for the precipitation reaction in part a). **(1 mark)**

Response:

For example:

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

or

$$Sr^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow SrSO_{4(s)}$$

or

$$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$$

5. Will a precipitate form when 25.0 mL of 0.15 M $AgNO_3$ is added to 15.0 mL of 0.20 M NaCl? Support your answer with appropriate calculations. **(3 marks)**

Response:

$$\left[Ag^+\right] = \frac{25.0\ \text{mL}}{40.0\ \text{mL}} \times 0.15\ \text{M} = 0.094 \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\left[Cl^-\right] = \frac{15.0\ \text{mL}}{40.0\ \text{mL}} \times 0.20\ \text{M} = 0.075\ \text{M} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\text{TIP}\left(\text{Trial } K_{sp}\right) = \left[Ag^+\right]\left[Cl^-\right] = (0.094)(0.075) = 7.0 \times 10^{-3} \qquad \leftarrow \textbf{1 mark}$$

Since $\text{TIP}\left(\text{Trial } K_{sp}\right) > K_{sp}\left(1.8 \times 10^{-10}\right)$, a precipitate **does** form. $\leftarrow$ **1 mark**

6. a) Write the balanced equation representing the reaction of HF with H_2O. **(1 mark)**

Response:

$HF + H_2O \rightleftarrows H_3O^+ + F^-$ ← **1 mark**

b) Identify the Brönsted-Lowry bases in the above equation. **(1 mark)**

Response:

H_2O and F^- ← **1 mark**

7. Consider the following data:

CHEMICAL SPECIES	FORMULA	IONIZATION CONSTANT
barbituric acid	$HC_4H_3N_2O_3$	$K_a = 9.8\times10^{-5}$
sodium propanoate	$NaC_3H_5O_2$	$K_b = 7.5\times10^{-10}$
propanoic acid	$HC_3H_5O_2$	?

Which is the stronger acid, propanoic acid or barbituric acid? Explain, using appropriate calculations. **(2 marks)**

Response:

For propanoic acid:

$$K_a = \frac{K_w}{K_b}$$

$$= \frac{1.0\times10^{-14}}{7.5\times10^{-10}}$$

$$= 1.3\times10^{-5}$$

← **1 mark**

$$9.8\times10^{-5} > 1.3\times10^{-5}$$

Therefore, barbituric acid is a stronger acid than propanoic acid.

← **1 mark**

8. A solution of 0.100 M HOCN has a pH of 2.24. Calculate the K_a value for this acid. **(4 marks)**

Response:

$$\left[H_3O^+\right] = \text{antilog}\left(-2.24\right) = 5.75\times10^{-3}\ \text{M} \qquad \leftarrow \textbf{1 mark}$$

$$HOCN_{(aq)} + H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + OCN^-$$

[**I**]	0.100	0	0
[**C**]	-5.75×10^{-3}	$+5.75\times10^{-3}$	$+5.75\times10^{-3}$
[**E**]	0.0942	5.75×10^{-3}	5.75×10^{-3}

$\leftarrow$ **1 $\frac{1}{2}$ marks**

$$K_a = \frac{\left[H_3O^+\right]\left[OCN^-\right]}{\left[HOCN\right]}$$

$$= \frac{\left(5.75\times10^{-3}\right)^2}{\left(0.0942\right)}$$

$$= 3.5\times10^{-4}$$

$\leftarrow$ **1 $\frac{1}{2}$ marks**

Note to markers: $\frac{1}{2}$ mark deduction for incorrect significant figures.

9. Calculate the pH of a 25.0 mL solution formed by mixing 0.0300 mol HNO_3 and 0.0280 mol NaOH. **(2 marks)**

Response:

For example:

$$\left.\begin{aligned} \text{Excess } HNO_3 &= 0.0300 \text{ mol} - 0.0280 \text{ mol since reaction is } 1:1 \\ &= 0.0020 \text{ mol} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} [HNO_3] = [H^+] &= 0.0020 \text{ mol} \div 0.0250 \text{ L} \\ &= 0.080 \text{ M} \\ \text{pH} &= 1.10 \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

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

$$CrO_4^{2-} \rightarrow Cr(OH)_3 \qquad \text{(basic)}$$

Response:

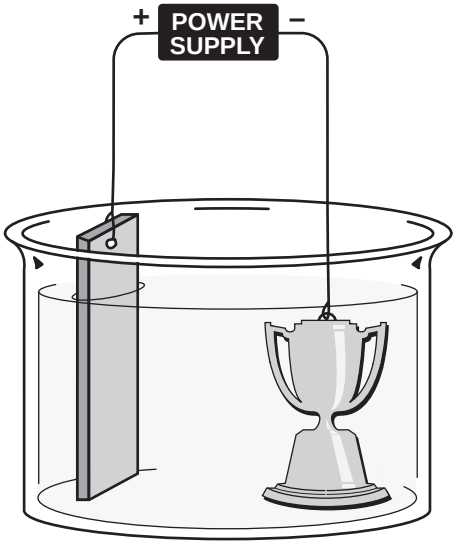
Balance O $\leftarrow$ **$\frac{1}{2}$ mark**

Balance H $\leftarrow$ **$\frac{1}{2}$ mark**

Balance charge $\leftarrow$ **1 mark**

$$\left.\begin{aligned} CrO_4^{2-} + 5H^+ + 3e^- &\rightarrow Cr(OH)_3 + H_2O \qquad \text{(acid)} \\ CrO_4^{2-} + 4H_2O + 3e^- &\rightarrow Cr(OH)_3 + 5OH^- \qquad \text{(base)} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

11. A trophy manufacturer electroplates an iron trophy with gold.



a) Write the equation for the half-reaction that occurs at the iron trophy. **(1 mark)**

Response:

$Au^{3+}_{(aq)} + 3e^- \rightarrow Au_{(s)}$ ← **1 mark**

b) Identify an appropriate electrolyte. **(1 mark)**

Response: For example:

$Au(NO_3)_3$ ← **1 mark**

c) Identify the cathode. **(1 mark)**

Response: For example:

Iron trophy. ← **1 mark**

d) Explain how to maintain a constant metal ion concentration in the electrolyte. **(1 mark)**

Response:

Use a gold anode **or** Add $Au(NO_3)_3$ ← **1 mark**

END OF KEY