Chemistry 12

August 1996 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	D	1	I-B-2	25.	K	4	C	1	IV-E-1
2.	U	1	C	1	I-A-4	26.	U	4	B	1	IV-F-9
3.	K	1	D	1	I-D-3	27.	U	4	D	1	IV-F-13, 14
4.	U	1	B	1	I-E-1	28.	U	4	A	1	IV-G-3
5.	U	1	B	1	I-F-1	29.	U	4	A	1	IV-H-3
6.	U	2	C	1	II-A-3	30.	K	4	A	1	IV-H-6, 7, 8
7.	U	2	B	1	II-B-1	31.	H	4	C	1	IV-H-2, 9
8.	U	2	B	1	II-C-1	32.	U	4	B	1	IV-H-10
9.	U	2	C	1	II-C-4	33.	U	4	A	1	IV-J-1
10.	U	2	D	1	II-D-1	34.	U	4	D	1	IV-J-1
11.	U	2	A	1	II-E-3	35.	U	4	A	1	IV-J-3
12.	H	2	A	1	II-E-2	36.	K	4	C	1	IV-L-1
13.	H	2	C	1	II-J-4	37.	U	5	B	1	V-A-1, 4
14.	U	3	B	1	III-A-5	38.	U	5	D	1	V-A-6
15.	U	3	C	1	III-B-3	39.	U	5	A	1	V-C-1
16.	H	3	B	1	III-C-1	40.	U	5	C	1	V-D-2
17.	U	3	B	1	III-D-3	41.	K	5	A	1	V-D-4
18.	U	3	D	1	III-D-5	42.	U	5	C	1	V-E-1
19.	U	3	B	1	III-D-7	43.	K	5	A	1	V-G-5
20.	U	3	B	1	III-E-2	44.	U	5	C	1	V-G-6
21.	U	4	D	1	IV-B-2	45.	U	5	C	1	V-G-11
22.	U	4	B	1	IV-C-2	46.	U	5	C	1	V-G-2
23.	U	4	A	1	IV-D-7	47.	U	5	A	1	V-I-3, 4
24.	K	4	A	1	IV-D-6	48.	K	5	B	1	V-J-3

Part B: Written Response

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

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

LEGEND:

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

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. A strip of magnesium was cut into 4 pieces, each of length 1.0 cm and mass of 0.00864 g. Each piece was placed into a test tube containing 5.0 mL of different concentrations of HCl. The time required for each piece of magnesium to be completely consumed was recorded:

TRIAL	$[HCl]$	TIME (s)
1	0.50 M	200
2	1.0 M	38
3	3.0 M	12
4	6.0 M	6

a) Calculate the rate of reaction for magnesium in $3.0\ M\ HCl$. **(1 mark)**

Response:

For example:

$0.00864\ g/12\ s = 0.00072\ g/s$

b) How does the $[HCl]$ affect the reaction rate? **(1 mark)**

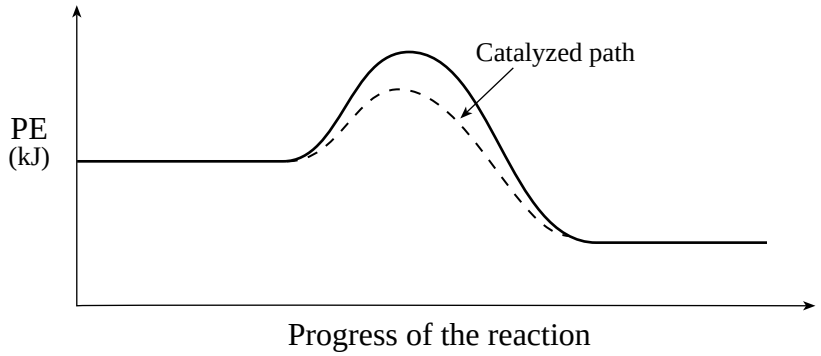
Response:

For example:

The higher the concentration of HCl, the faster the reaction rate.

2. Consider the following PE diagram for the uncatalyzed decomposition of hydrogen peroxide:

$$2H_2O_{2(\ell)} \rightarrow 2H_2O_{(\ell)} + O_{2(g)}$$



a) On the PE diagram, sketch a curve for the catalyzed decomposition of H_2O_2. **(1 mark)**

Response:

The catalyzed graph has a lower activation energy.

b) Compare the ΔH of the catalyzed and uncatalyzed reactions. **(1 mark)**

Response:

The ΔH for catalyzed and uncatalyzed reactions are the same.

3. Consider the following equilibrium:

$$PCl_{3(g)} + Cl_{2(g)} \rightleftarrows PCl_{5(g)} \qquad \Delta H = -88 \text{ kJ}$$

What happens to the $[PCl_3]$ when additional Cl_2 is added at constant temperature and volume? Explain. **(2 marks)**

Response:

For example:

The $[PCl_3]$ decreases when additional Cl_2 is added. The addition of Cl_2 causes the equilibrium to shift right.

4. Consider the following equilibrium:

$$2CO_{2(g)} \rightleftarrows 2CO_{(g)} + O_{2(g)}$$

Initially, a 1.0 L container is filled with 0.050 mol of CO_2. At equilibrium, the $[CO_2]$ is $0.030\ \text{mol/L}$. Calculate the value of K_{eq}. **(3 marks)**

Response:

	$2CO_2$	$\rightleftarrows$	$2CO$	+	O_2
$[\mathbf{I}]$	0.050		0		0
$[\mathbf{C}]$	−0.020		+0.020		+0.010
$[\mathbf{E}]$	0.030		0.020		0.010

← **1 ½ marks**

$$K_{eq} = \frac{[CO]^2[O_2]}{[CO_2]^2}$$

$$= \frac{(0.020)^2(0.010)}{(0.030)^2}$$

$$= 4.4 \times 10^{-3}$$

← **1 ½ marks**

Deduct ½ mark for incorrect significant figures.

5. a) Identify a compound that could be used to precipitate both the $Mg^{2+}_{(aq)}$ and $Ca^{2+}_{(aq)}$ from "hard water". **(1 mark)**

Response:

For example:

Add NaOH to precipitate Mg^{2+} and Ca^{2+}

b) Write the net ionic equations for the reactions. **(2 marks)**

Response:

For example:

$Mg^{2+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Mg(OH)_{2(s)}$ ← **1 mark**

$Ca^{2+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Ca(OH)_{2(s)}$ ← **1 mark**

6. How many grams of $CaSO_4$ (Plaster of Paris) are dissolved in 100.0 mL of a saturated $CaSO_4$ solution at $25°C$? **(3 marks)**

Response:

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

$$x \qquad x$$

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

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

$$7.1\times10^{-5} = x^2$$

$$x = 8.4\times10^{-3}\ \text{M}$$

← **2 marks**

$$\text{g } CaSO_4 = 8.4\times10^{-3}\ \text{M} \times 136.2\ \text{g/mol} \times 0.1000\ \text{L}$$

$$= 1.1\times10^{-1}\ \text{g}$$

← **1 mark**

7. Lactic acid, $HC_3H_5O_3$, is a compound that accumulates in muscle tissue during exertion. Write the equation and the K_a expression for the ionization of lactic acid in water. **(2 marks)**

Response:

For example:

$$HC_3H_5O_{3(aq)} + H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + C_3H_5O_3^-{}_{(aq)} \quad \leftarrow \textbf{1 mark}$$

$$K_a = \frac{\left[H_3O^+\right]\left[C_3H_5O_3^-\right]}{\left[HC_3H_5O_3\right]} \quad \leftarrow \textbf{1 mark}$$

8. The ionization constant for water, K_w, is 9.6×10^{-14} at $60°C$.

a) Write an equation including the heat term representing the ionization of water. **(2 marks)**

Response:

For example:

$$2H_2O + \text{Heat} \rightleftarrows H_3O^+ + OH^-$$

b) Calculate the pH for water at $60°C$. **(2 marks)**

Response:

For example:

$$K_w = [H_3O^+][OH^-] = 9.6 \times 10^{-14}$$

$$[H_3O^+] = [OH^-] = \sqrt{9.6 \times 10^{-14}}$$

$$[H_3O^+] = 3.10 \times 10^{-7}$$

$$pH = 6.51$$

← **2 marks**

9. Four monoprotic acids of the same concentration are labelled as follows:

SOLUTION	LABEL
A	$\left[OH^-\right] = 5.0 \times 10^{-11}$ M
B	$\left[H^+\right] = 0.20$ M
C	pOH = 11.30 M
D	pH = 1.20 M

List the four solutions in order of decreasing acidity. Use calculations to support your answer. **(4 marks)**

Response:

For example:

Solution A: $\left[H_3O^+\right] = \dfrac{1.00 \times 10^{-14}}{5.0 \times 10^{-11}\ \text{M}} = 2.0 \times 10^{-4}$

Solution B: $\left[H_3O^+\right] = 0.20\ \text{M} = 2.0 \times 10^{-1}$

Solution C: $\text{pH} = 14.00 - 11.30 = 2.70$

$\left[H_3O^+\right] = -\text{antilog}\ 2.70 = 2.0 \times 10^{-3}$

Solution D: $\left[H_3O^+\right] = -\text{antilog}\ 1.20 = 6.3 \times 10^{-2}$

← **3 marks**

Decreasing acidity: B > D > C > A ← **1 mark**

10. a) Write the balanced equation for the redox reaction that occurs when $H_2S_{(g)}$ is bubbled into an acidified solution of $Cr_2O_7^{2-}$. **(3 marks)**

Response:

$$\left(Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftarrows 2Cr^{3+} + 7H_2O\right) \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

1 mark → **for balancing electrons**

$$3\left(H_2S \rightleftarrows S + 2H^+ + 2e^-\right) \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$Cr_2O_7^{2-} + 3H_2S + 8H^+ \rightarrow 2Cr^{3+} + 3S + 7H_2O \quad \leftarrow \textbf{1 mark}$$

b) Calculate the $E°$ for this reaction. **(1 mark)**

Response:

+1.09 V

11. The metals A, B and C were separately placed in solutions containing the metallic ions A^{2+}, B^{+} and C^{2+}. It was found that A reacted with B^{+}, but A did not react with C^{2+}.

a) Identify the strongest oxidizing agent. **(1 mark)**

Response:

B^{+}

b) List the metals in order of increasing strength as reducing agents. **(1 mark)**

Response:

B, A, C

c) Identify the ion(s) that will react with metal C. **(1 mark)**

Response:

B^{+} and A^{2+}

END OF KEY