Chemistry 12

August 2007 — Form A

Provincial Examination — Multiple-Choice Key

Cognitive Processes	Weightings	Question Types
K = Knowledge	11%	**50** = Multiple Choice (MC)
U = Understanding	78%	**8** = Written Response (WR)
H = Higher Mental Processes	11%	

Topics	Prescribed Learning Outcomes (PLOs)	Weightings
1. Reaction Kinetics	A, B, C	12%
2. Dynamic Equilibrium	D, E, F	16%
3. Solubility Equilibria	G, H, I	16%
4. Acids, Bases, and Salts	J, K, L, M, N, O, P, Q, R	33%
5. Oxidation – Reduction	S, T, U, V, W	23%

Question Number	Keyed Response	Cognitive Process	Mark	Topic	PLO	Question Type	Question Source
1.	C	K	1	1	A6	MC	
2.	A	U	1	1	A4	MC	
3.	A	H	1	1	A3	MC	
4.	B	U	1	1	C5	MC	
5.	D	U	1	1	C5, B2	MC	
6.	D	U	1	2	D2	MC	
7.	A	U	1	2	D8	MC	
8.	A	U	1	2	D9	MC	
9.	B	U	1	2	E2	MC	
10.	B	U	1	2	E5	MC	
11.	C	U	1	2	F2	MC	
12.	D	U	1	2	F4	MC	
13.	B	U	1	2	F6	MC	
14.	C	U	1	2	F8	MC	
15.	C	U	1	3	G1	MC	
16.	A	K	1	3	G6	MC	
17.	B	U	1	3	H2	MC	
18.	D	U	1	3	H3	MC	
19.	A	U	1	3	I2	MC	
20.	A	U	1	3	I3	MC	
21.	D	U	1	3	I7	MC	
22.	D	U	1	4	J2	MC	
23.	D	K	1	4	J5	MC	
24.	D	U	1	4	J7	MC	
25.	A	U	1	4	K2	MC	
26.	A	U	1	4	K6, J11	MC	

Question Number	Keyed Response	Cognitive Process	Mark	Topic	PLO	Question Type	Question Source
27.	D	K	1	4	L2	MC	
28.	C	U	1	4	L7	MC	
29.	D	U	1	4	L11	MC	
30.	A	U	1	4	M4	MC	
31.	C	H	1	4	N2, P4	MC	
32.	D	U	1	4	O1	MC	
33.	B	U	1	4	O5	MC	
34.	A	U	1	4	P2	MC	
35.	B	H	1	4	P4	MC	
36.	B	K	1	4	Q1	MC	
37.	B	U	1	4	Q3	MC	
38.	A	U	1	4	R1	MC	
39.	A	K	1	5	S1	MC	
40.	C	U	1	5	S2	MC	
41.	D	H	1	5	S4	MC	
42.	B	U	1	5	U9	MC	
43.	B	U	1	5	S6	MC	
44.	D	U	1	5	T3	MC	
45.	D	U	1	5	T5	MC	
46.	C	U	1	5	U2, 1	MC	
47.	B	H	1	5	U3, H2	MC	
48.	B	U	1	5	U6	MC	
49.	B	U	1	5	V3	MC	
50.	C	U	1	5	W5	MC	

Chemistry 12

August 2007

Provincial Examination — Written-Response Key

Cognitive Processes

K = Knowledge
U = Understanding
H = Higher Mental Processes

Question Types

50 = Multiple Choice (MC)
8 = Written Response (WR)

Topics		Prescribed Learning Outcomes (PLOs)	Weightings
1.	Reaction Kinetics	A, B, C	12%
2.	Dynamic Equilibrium	D, E, F	16%
3.	Solubility Equilibria	G, H, I	16%
4.	Acids, Bases, and Salts	J, K, L, M, N, O, P, Q, R	33%
5.	Oxidation – Reduction	S, T, U, V, W	23%

Question Number	Keyed Response	Cognitive Process	Mark	Topic	PLO	Question Type	Question Source
1.	–	U	4	1	C4, 5	WR	
2.	–	U	4	2	F7	WR	
3.	–	U	4	3	I4, 6	WR	
4.	–	U	3	4	K8	WR	
5.	–	U	5	4	N5	WR	
6.	–	U	3	4	P5	WR	
7.	–	U	4	4	T2	WR	
8.	–	U	3	5	W3, 5	WR	

Chemistry 12

August 2007

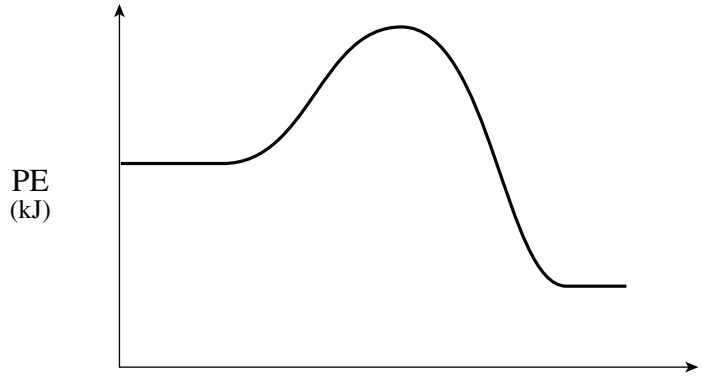
Provincial Examination — Scoring Guide

1. **(4 marks)**

A catalyzed decomposition of ozone (O_3) occurs in a series of steps as illustrated below:

Step 1	$O_3 + \text{sunlight} \rightarrow O_2 + O$
Step 2	$O_3 + NO \rightarrow NO_2 + O_2$
Step 3	$NO_2 + O \rightarrow NO + O_2$
Overall Reaction	
Catalyst	

Write the equation for the overall reaction and then identify the catalyst in the spaces above.
The PE diagram below represents the uncatalyzed decomposition of ozone. On the PE diagram, sketch a curve that could represent the mechanism for the catalyzed decomposition.

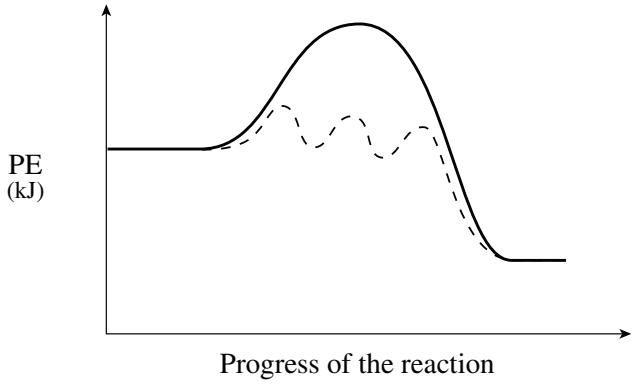


Solution:

For Example:

Overall reaction: $2\,O_3 \rightarrow 3\,O_2$ ← **1 mark**

Catalyst: NO ← **1 mark**



← **½ mark** $\left(E_{a(\,catalyzed\,)} < E_{a(\,uncatalyzed\,)}\right)$

← **½ mark** (three humps)

← **1 mark** $\left(PE_{(\,reactamts\,)}\right.$ and $\left.PE_{(\,products\,)}\right.$ unchanged$\left.\right)$

2. **(4 marks)**

Consider the following equilibrium:

$$H_2(g) + CO_2(g) \rightleftarrows CO(g) + H_2O(g) \qquad K_{eq} = 0.12$$

Initially, 1.0 mol of CO and 1.0 mol H_2O are placed in a 2.0 L container.
Calculate the equilibrium of [CO].

Solution:

For Example:

	$H_2(g)$	+	$CO_2(g)$	$\rightleftarrows$	$CO(g)$	+	$H_2O(g)$
[I]	0		0		0.50 M		0.50 M
[C]	$+x$		$+x$		$-x$		$-x$
[E]	x		x		$0.50 - x$		$0.50 - x$

← **1 mark**

$$K_{eq} = \frac{[CO][H_2O]}{[H_2][CO_2]}$$

$$\sqrt{0.12} = \sqrt{\frac{(0.50 - x)^2}{x^2}}$$ ← **1 mark**

$$x = 0.37\,M$$ ← **1 mark**

$$[CO] = 0.50 - x$$

$$= 0.13\,M$$ ← **1 mark**

3. **(4 marks)**

Consider the equilibrium for a saturated solution of $CaCO_3$:

$$CaCO_3(s) \rightleftarrows Ca^{2+} + CO_3^{2-}$$

What is the maximum $[Mg^{2+}]$ that can exist in a saturated solution of $CaCO_3$ without causing a precipitate to form?

Solution:

For Example:

For the $CaCO_3$:

$CaCO_3(s) \rightleftarrows Ca^{2+} + CO_3^{2-}$

$K_{sp} = [Ca^{2+}][CO_3^{2-}] = 5.0 \times 10^{-9}$ ← **1 mark**

$[CO_3^{2-}] = \sqrt{5.0 \times 10^{-9}}$

$[CO_3^{2-}] = 7.07 \times 10^{-5}\ M$ ← **1 mark**

For the $MgCO_3$:

$MgCO_3(s) \rightleftarrows Mg^{2+} + CO_3^{2-}$

$K_{sp} = [Mg^{2+}][CO_3^{2-}] = 6.8 \times 10^{-6}$ ← **1 mark**

$[Mg^{2+}] = \dfrac{6.8 \times 10^{-6}}{[CO_3^{2-}]}$

$[Mg^{2+}] = \dfrac{6.8 \times 10^{-6}}{[CO_3^{2-}]}$

$= \dfrac{6.8 \times 10^{-6}}{7.07 \times 10^{-5}}$ ← **1 mark**

$[Mg^{2+}] = 9.6 \times 10^{-2}\ M$

4. **(3 marks)**

Complete the following equilibrium, then predict whether reactants or products will be favoured and explain why.

$$HSO_3^- + H_2PO_4^- \rightleftarrows$$

Solution:

For Example:

$HSO_3^- + H_2PO_4^- \rightleftarrows H_3PO_4 + SO_3^{2-}$ ← **2 marks**

Reactants are favoured since:

$K_a(H_3PO_4) > K_a(HSO_3^-)$ } ← **1 mark**

5. **(5 marks)**

Calculate the pH of a $0.35\,M$ solution of the salt ammonium bromide.
Begin by writing the equation for the predominant equilibrium.

Solution:

For Example:

	$NH_4^+(aq)$	+	$H_2O(\ell)$	$\rightleftarrows$	$H_3O^+(aq)$	+	$NH_3(aq)$	
[I]	0.35				0		0	
[C]	$-x$				$+x$		$+x$	
[E]	$0.35 - x$				x		x	← **1 mark**

(assume x is negligible)

$$K_a = \frac{[H_3O^+][NH_3]}{[NH_4^+]}$$

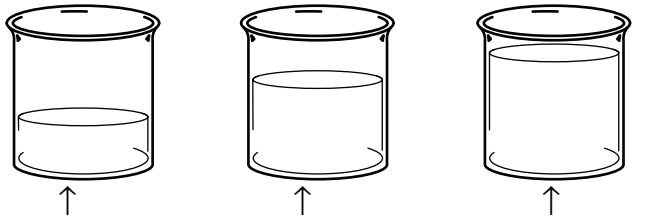
$$5.6 \times 10^{-10} = \frac{x^2}{0.35}$$ ← **1 mark**

$$x = [H_3O^+] = 1.4 \times 10^{-5}\,M$$ ← **1 mark**

$$pH = 4.85$$ ← **1 mark**

6. **(3 marks)**

The following three solutions are mixed together in a fourth container:



40.0 mL of 1.0 M HCl | 60.0 mL of 1.0 M HBr | 100.0 mL of 0.50 M NaOH

What pH results?

Solution: Mole Method

For Example:

$$\text{HCl}: 1.0\,\text{M} \times 0.040\,\text{L}$$
$$= 0.040\,\text{mol}$$
$$\text{HBr}: 1.0\,\text{M} \times 0.060\,\text{L}$$
$$= \underline{0.060\,\text{mol}}$$
$$\text{Total}\,\text{H}^+ = 0.100\,\text{mol}$$

$$\text{NaOH} = 0.50\,\text{M} \times 0.100\,\text{L}$$
$$= 0.050\,\text{mol}$$

← **1 $\frac{1}{2}$ marks**

$$\text{Excess}\,\text{H}^+ = 0.100\,\text{mol} - 0.050\,\text{mol}$$
$$= 0.050\,\text{mol}$$

← **$\frac{1}{2}$ mark**

$$\left[\text{H}^+\right] = \frac{0.050\,\text{mol}}{0.200\,\text{L}} = 0.25\,\text{M}$$

← **$\frac{1}{2}$ mark**

$$\text{pH} = 0.60$$

← **$\frac{1}{2}$ mark**

Solution: Concentration Method

For Example:

$$\left[\text{HCl}\right] = \frac{40.0\,\text{mol}}{200.0\,\text{mol}} \times 1.0\,\text{M} = 0.20\,\text{M} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\left[\text{HBr}\right] = \frac{60.0\,\text{mol}}{200.0\,\text{mol}} \times 1.0\,\text{M} = 0.30\,\text{M} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\text{Total}\left[\text{H}^+\right] = 0.50\,\text{M} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\left[\text{NaOH}\right] = \frac{100.0\,\text{mol}}{200.0\,\text{mol}} \times 0.50\,\text{M} = 0.25\,\text{M} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\left[\text{H}^+\right]\text{excess} = 0.50\text{M} - 0.25\,\text{M} = 0.25\,\text{M} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\text{pH} = 0.60 \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

7. **(4 marks)**

Balance the following redox equation in acidic solution:

$$H_2O_2 + SCN^- \rightarrow NH_4^+ + H_2O + HCO_3^- + HSO_4^- \text{ (acidic)}$$

Solution:

For Example:

$$\begin{array}{r} \left(2e^- + 2H^+ + H_2O_2 \rightarrow 2H_2O\right) \times 4 \\ \left(7H_2O + SCN^- \rightarrow NH_4^+ + HCO_3^- + HSO_4^- + 8H^+ + 8e^-\right) \times 1 \\ \hline 8H^+ + 4H_2O_2 + 7H_2O + SCN^- \rightarrow 8H_2O + NH_4^+ + HCO_3^- + HSO_4^- + 8H^+ \\ 4H_2O_2 + SCN^- \rightarrow H_2O + NH_4^+ + HCO_3^- + HSO_4^- \end{array} \quad \left.\begin{array}{l} \\ \\ \\ \\ \end{array}\right\} \leftarrow \textbf{4 marks}$$

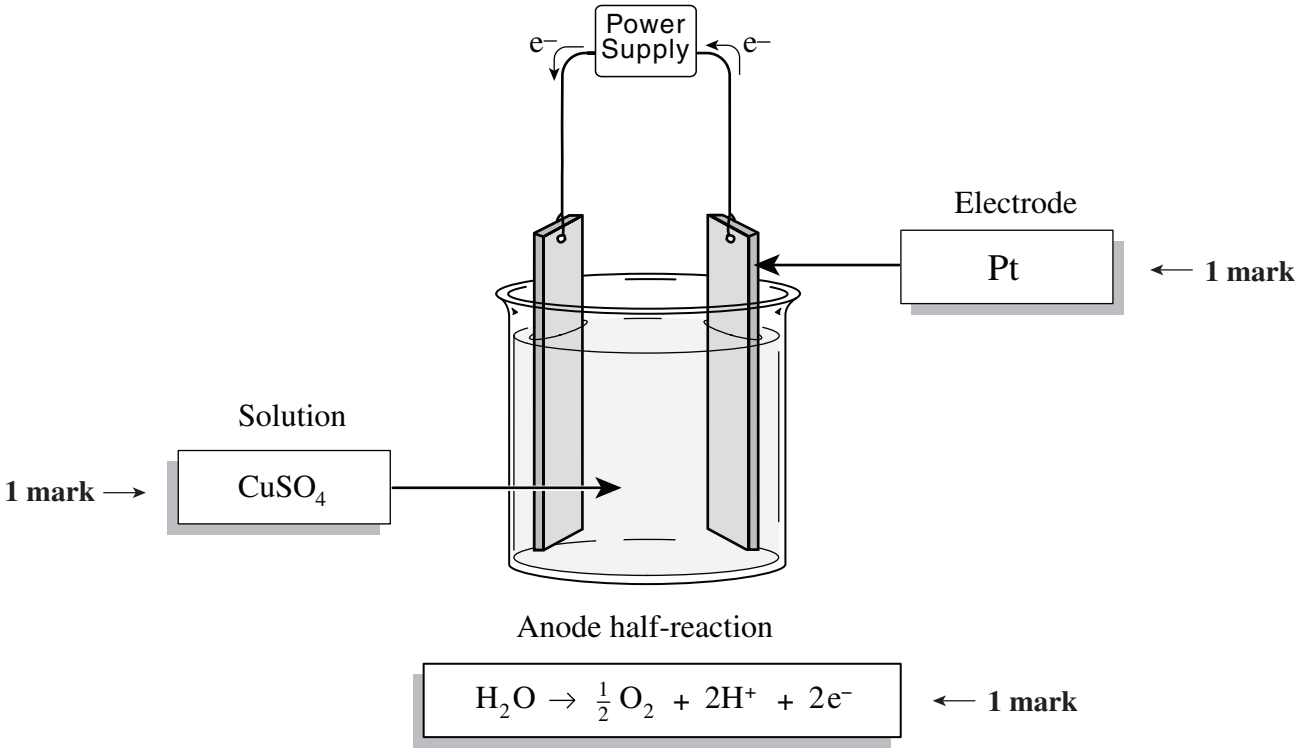
(Note: 1 mark if a student only uses guess and check, or inspection.)

8. **(3 marks)**

During the electrolysis of an ionic solution it was observed that gas bubbles formed on the anode, and a solid formed on the cathode. On the diagram below, provide possible substances for the two parts indicated, and the anode half-reaction.

Solution:

For Example:



END OF KEY