Chemistry 12

January 2000 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

Organizers	Sub-Organizers
1. Reaction Kinetics	A, B, C
2. Dynamic Equilibrium	D, E, F
3. Solubility Equilibria	G, H, I
4. Acids, Bases, and Salts	J, K, L, M, N, O, P, Q, R
5. Oxidation – Reduction	S, T, U, V, W

Part A: Multiple Choice

Q	K	C	CO	PLO	Q	K	C	CO	PLO
1.	B	U	1	A1	25.	A	H	4	L3
2.	C	U	1	A6	26.	B	U	4	L3, L6
3.	D	K	1	B3	27.	D	H	4	L11
4.	A	U	1	B6	28.	A	U	4	L12
5.	B	U	1	B9	29.	A	K	4	M1
6.	D	K	1	C3	30.	A	K	4	M2
7.	A	U	2	D3	31.	C	U	4	M4
8.	C	K	2	D5	32.	D	U	4	N3
9.	A	U	2	D7	33.	B	U	4	O4
10.	C	H	2	E2	34.	D	U	4	P3
11.	B	U	2	E2	35.	C	U	4	P5
12.	C	K	2	F2	36.	D	H	4	Q5
13.	B	U	2	F8	37.	D	K	4	R4
14.	B	K	3	G3	38.	B	U	5	S1
15.	B	U	3	G8	39.	B	U	5	S1
16.	C	U	3	H2	40.	D	U	5	S2
17.	D	H	3	H5	41.	B	U	5	S6
18.	A	U	3	I3	42.	C	U	5	T6
19.	C	U	3	I4	43.	C	K	5	U1
20.	D	U	3	I5	44.	C	U	5	U2, U4
21.	A	H	3	H5	45.	A	U	5	U7
22.	C	K	4	J2	46.	C	U	5	U9
23.	D	U	4	J8, N4	47.	A	K	5	V2
24.	A	U	4	K1, K6	48.	D	K	5	W2

Multiple Choice = 48 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	2	1	A4
2.	2	H	2	1	C2
3.	3	U	2	2	E3
4.	4	U	4	2	F6
5.	5	U	2	3	H3
6.	6	U	3	3	I7
7.	7	K	2	4	K10, K11
8.	8	U	4	4	M5
9.	9	U	3	4	P2
10.	10	U	2	5	S4
11.	11	U	4	5	T2
12.	12	U	2	5	W6

Written Response = 32 marks

Multiple Choice = 48 (48 questions)
Written Response = 32 (12 questions)
EXAMINATION TOTAL = 80 marks

LEGEND:

Q = Question Number **K** = Keyed Response **C** = Cognitive Level
B = Score Box Number **S** = Score **CO** = Curriculum Organizer
PLO = Prescribed Learning Outcome

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 student wishes to monitor the rate of the following reaction:

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(\ell)}$$

Identify **two** different properties that could be used to monitor the rate of the reaction. Describe and explain the changes that would occur. **(2 marks)**

Solution:

For Example:

Property: Mass ← $\frac{1}{2}$ **mark**

Change and Explanation: Mass decreases because $CO_{2(g)}$ leaves the system. ← $\frac{1}{2}$ **mark**

Property: pH ← $\frac{1}{2}$ **mark**

Change and Explanation: pH increases because HCl is consumed. ← $\frac{1}{2}$ **mark**

2. Consider the following reaction for the formation of HCl in the presence of light.

$$Cl_2 + CHCl_3 \rightarrow HCl + CCl_4$$

The following is the proposed reaction mechanism:

Step 1	$Cl_2 \rightarrow Cl + Cl$
Step 2	**?**
Step 3	$Cl + CCl_3 \rightarrow CCl_4$

Determine Step 2 of the reaction mechanism. **(2 marks)**

Solution:

$Cl + CHCl_3 \rightarrow HCl + CCl_3$ ← **2 marks**

3. Consider the following equilibrium:

$$\underset{\text{(yellow)}}{HInd} + H_2O \rightleftarrows H_3O^+ + \underset{\text{(blue)}}{Ind^-}$$

The system is yellow and turns blue on the addition of NaOH. In terms of the forward and reverse reaction rates, explain why this shift occurs. **(2 marks)**

Solution:

For Example:

Addition of OH^- decreases $\left[H_3O^+\right]$, decreasing the reverse rate. Since the forward rate is greater than the reverse rate, the system shifts to the right. } ← **2 marks**

4. Consider the following equilibrium:

$$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftarrows FeSCN^{2+}_{(aq)}$$

Initially, 50.0 mL of 0.10 M Fe^{3+} is added to 30.0 mL of 0.20 M SCN^{-}.
At equilibrium, the concentration of $FeSCN^{2+}$ is found to be 0.050 M.
Calculate the K_{eq} for the reaction. **(4 marks)**

Solution:

For Example:

$$\left[Fe^{3+}\right] = \frac{50.0\text{ mL}}{80.0\text{ mL}} \times 0.10\text{ M} = 0.0625\text{ M}$$

$$\left[SCN^{-}\right] = \frac{30.0\text{ mL}}{80.0\text{ mL}} \times 0.20\text{ M} = 0.0750\text{ M}$$

} ← **1 mark**

	Fe^{3+}	+	SCN^{-}	$\rightleftarrows$	$FeSCN^{2+}$
[I]	0.0625		0.0750		0
[C]	−0.0500		−0.0500		0.0500
[E]	0.0125		0.0250		0.0500

} ← **1 ½ marks**

$$K_{eq} = \frac{\left[FeSCN^{2+}\right]}{\left[Fe^{3+}\right]\left[SCN^{-}\right]}$$

$$= \frac{0.0500}{(0.0125)(0.0250)}$$

$$= 1.6 \times 10^{2}$$

} ← **1 ½ marks**

5. a) Write the balanced formula equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$.

(1 mark)

Solution:

$$2Na_3PO_{4(aq)} + 3CuCl_{2(aq)} \rightarrow 6NaCl_{(aq)} + Cu_3(PO_4)_{2(s)} \quad \leftarrow \textbf{1 mark}$$

b) Write the net ionic equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$. **(1 mark)**

Solution:

$$3Cu^{2+}_{(aq)} + 2PO_4^{3-}{}_{(aq)} \rightarrow Cu_3(PO_4)_{2(s)} \qquad \leftarrow \textbf{1 mark}$$

6. A saturated solution of nickel carbonate, $NiCO_3$, contains 0.090 g in 2.0 L of solution. Calculate K_{sp} for $NiCO_3$. **(3 marks)**

Solution:

$$[NiCO_3] = \frac{0.090\,g}{2.0\,L} \times \frac{1\,mol}{118.7\,g} = 3.79 \times 10^{-4}\ mol/L \qquad \leftarrow \textbf{1 mark}$$

$$NiCO_{3(s)} \rightleftarrows Ni^{2+}_{(aq)} + CO^{2}{}_{3}^{-}$$

$$3.79 \times 10^{-4}\ M \qquad 3.79 \times 10^{-4}\ M$$

$$K_{sp} = [Ni^{2+}][CO_3^{2-}]$$

$$= (3.79 \times 10^{-4})(3.79 \times 10^{-4})$$

$$= 1.4 \times 10^{-7}$$

$\leftarrow$ **2 marks**

(Deduct $\frac{1}{2}$ **mark** for incorrect significant figures.)

7. Define the term *amphiprotic*. Give an example of an ion which is amphiprotic. **(2 marks)**

Solution:

For Example:

The ability to act as either an acid or a base. ← **1 mark**

For example HPO_4^{2-}. ← **1 mark**

8. A $0.0200\,M$ solution of methylamine, CH_3NH_2, has a $pH = 11.40$.
Calculate the K_b for methylamine. **(4 marks)**

Solution:

For Example:

$$pOH = 2.60$$

$$\left[OH^-\right] = 2.51 \times 10^{-3}$$

← **1 mark**

	CH_3NH_2	+ H_2O ⇄	$CH_3NH_3^+$	+ OH^-
[I]	0.0200		0	0
[C]	-2.51×10^{-3}		$+2.51 \times 10^{-3}$	$+2.51 \times 10^{-3}$
[E]	0.01749		2.51×10^{-3}	2.51×10^{-3}

← **1 ½ marks**

$$K_b = \frac{\left[CH_3NH_3^+\right]\left[OH^-\right]}{\left[CH_3NH_2\right]}$$

$$= \frac{\left(2.51 \times 10^{-3}\right)\left(2.51 \times 10^{-3}\right)}{0.01749}$$

$$= 3.6 \times 10^{-4}$$

← **1 ½ marks**

(Deduct **½ mark** for incorrect significant figures.)

9. A titration was performed by adding $0.115\,M$ NaOH to a $25.00\,mL$ sample of H_2SO_4. Calculate the $[H_2SO_4]$ from the following data. **(3 marks)**

	Trial #1	Trial #2	Trial #3
Initial volume of NaOH (mL)	4.00	17.05	8.00
Final volume of NaOH (mL)	17.05	28.00	19.05

Solution:

$$2NaOH + H_2SO_4 \rightleftarrows Na_2SO_4 + 2H_2O$$

vol of NaOH $= 11.00\,mL$ ← **1 mark**

mol NaOH $= 0.01100\,L(0.115\,mol/L) = 1.265 \times 10^{-3}\,mol$ ← **½ mark**

mol $H_2SO_4 = \frac{1}{2}\left(1.265 \times 10^{-3}\,mol\ NaOH\right) = 6.325 \times 10^{-4}\,mol$ ← **1 mark**

$$[H_2SO_4] = \frac{6.325 \times 10^{-4}\,mol}{0.02500\,L} = 0.0253\,M$$ ← **½ mark**

10. a) Indicate in the blank spaces on the following chart whether or not a reaction will occur when the metals are added to aqueous ions. **(1 mark)**

metal / ion	Pd	Rh	Pt
Pd^{2+}		***reaction***	***no reaction***
Rh^{2+}	no reaction		no reaction
Pt^{2+}	reaction	reaction	

Solution:

See table above.

b) List the oxidizing agents in order of strongest to weakest. **(1 mark)**

Solution:

$Pt^{2+} > Pd^{2+} > Rh^{2+}$

11. Balance the following redox reaction in **basic** solution: **(4 marks)**

$$Au + Cl^- + O_2 \rightarrow AuCl_4^- + OH^- \qquad \text{(basic)}$$

Solution:

For Example:

$$4 \times \left(Au + 4Cl^- \rightarrow AuCl_4^- + 3e^-\right)$$
$$3 \times \left(4e^- + 3H^+ + O_2 \rightarrow OH^- + H_2O\right)$$
$$4Au + 16Cl^- + 9H^+ + 3O_2 \rightarrow 4AuCl_4^- + 3OH^- + 3H_2O$$
$$+9OH^- \qquad\qquad +9OH^-$$
$$4Au + 16Cl^- + 6H_2O + 3O_2 \rightarrow 4AuCl_4^- + 12OH^-$$

1 mark for half-reactions

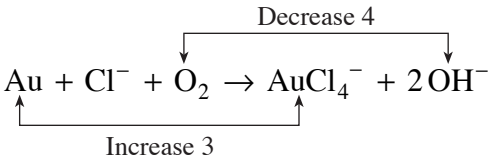
1 mark for balancing charges

1 mark for addition

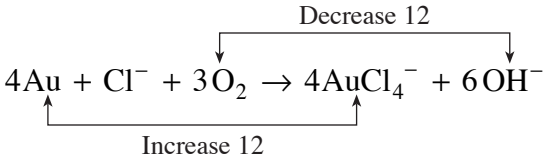
1 mark for basic

OR

For Example:



← **1 mark for oxidation numbers**



← **1 mark for balancing charges**

$$4Au + 16Cl^- + 3O_2 \rightarrow 4AuCl_4^- + 12OH^-$$

← **1 mark for basic charge**

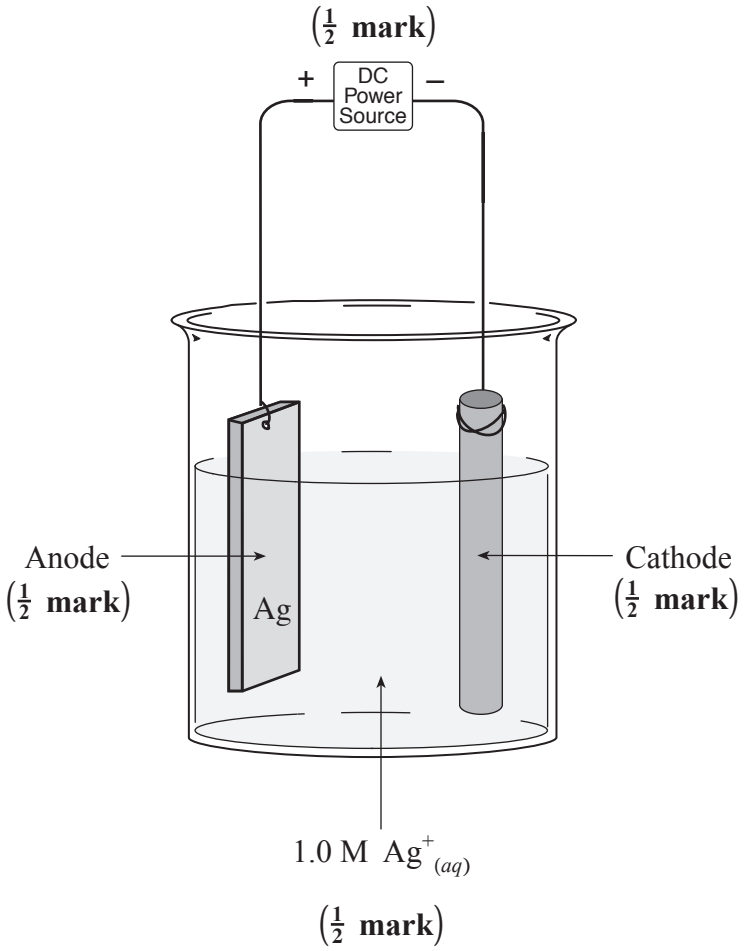
$$4Au + 6H_2O + 16Cl^- + 3O_2 \rightarrow 4AuCl_4^- + 12OH^-$$

← **1 mark for hydrogen (H_2O)**

12. Draw and label a simple electrolytic cell capable of electroplating an inert electrode with silver.
(2 marks)

Solution:

For Example:



END OF KEY