Chemistry 12

April 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.	C	K	4	K12
2.	A	H	1	A3	26.	A	H	4	L4
3.	B	K	1	B1	27.	D	U	4	L6, L11
4.	D	U	1	B6	28.	A	H	4	L11
5.	A	K	1	C3	29.	D	K	4	M1
6.	D	U	1	C5	30.	A	U	4	M4
7.	D	K	2	D1, D4	31.	C	U	4	N3
8.	C	U	2	D9	32.	C	U	4	N4
9.	B	H	2	E2	33.	C	U	4	O5
10.	B	U	2	E2	34.	D	U	4	P5
11.	B	U	2	F2	35.	C	K	4	P6
12.	D	K	2	F4	36.	C	K	4	Q2
13.	C	U	2	F5	37.	C	K	4	R4
14.	C	K	3	G1	38.	B	K	5	S2
15.	A	K	3	G6	39.	D	U	5	S1
16.	D	U	3	G8	40.	D	U	5	S2
17.	B	U	3	H1, I4	41.	A	U	5	S4
18.	D	U	3	H3	42.	D	U	5	S6
19.	B	U	3	H5	43.	C	U	5	T1
20.	A	U	3	H6	44.	D	U	5	T5
21.	C	U	3	I4	45.	D	U	5	U4, U5
22.	A	U	4	J7	46.	B	U	5	U9
23.	C	K	4	J11	47.	D	K	5	W1
24.	B	U	4	K5, N4	48.	D	H	5	W4

Multiple Choice = 48 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	2	1	A3
2.	2	U	2	1	B1
3.	3	U	2	2	E3
4.	4	U	3	2	F7
5.	5	U	2	3	I6
6.	6	H	3	3	H4
7.	7	U	2	4	K1, K2
8.	8	U	4	4	M3
9.	9	U	4	4	P2, P6
10.	10	U	4	5	T2
11.	11	U	2	5	U2, U6
12.	12	K	2	5	V2, V3

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. Consider the following reaction:

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$$

A $0.024\,g$ sample of Mg reacts completely with HCl in $14.0\,s$. Calculate the average rate of consumption of HCl in mol/s. **(2 marks)**

Solution:

For Example:

$$\text{mol Mg} = 0.024\,g \times \frac{1\,mol}{24.3\,g} = 9.88 \times 10^{-4}\,mol$$

$$\text{mol HCl} = 2 \times \text{mol Mg} = 2 \times \left(9.88 \times 10^{-4}\,mol\right) = 1.98 \times 10^{-3}\,mol$$

← **1 mark**

$$\text{rate} = \frac{\text{mol HCl}}{\text{time}} = \frac{1.98 \times 10^{-3}\,mol}{14.0\,s} = 1.4 \times 10^{-4}\,mol/s$$

← **1 mark**

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

2. Using collision theory, give **two** reasons why an increase in temperature results in an increase in reaction rate. **(2 marks)**

Solution:

For Example:

- At a higher temperature there is a greater frequency of collisions. ← **1 mark**
- There is a higher percentage of collisions with sufficient energy. ← **1 mark**

3. Methanol, CH_3OH, is produced industrially by the following reaction:

$$CO_{(g)} + 2H_{2(g)} \rightleftarrows CH_3OH_{(g)} + \text{heat}$$

a) State **two** different methods of shifting the equilibrium to the right. **(1 mark)**

Solution:

For Example:

Any *two* ***of the following:***

- adding reactant
- removing methanol
- decreasing the temperature
- increasing the pressure by decreasing the volume

b) In terms of rates, explain why these methods cause the equilibrium to shift to the right. **(1 mark)**

Solution:

For Example:

The shift occurs because $\text{rate}_{(f)}$ must be greater than $\text{rate}_{(r)}$ as a result of the stress. } ← **1 mark**

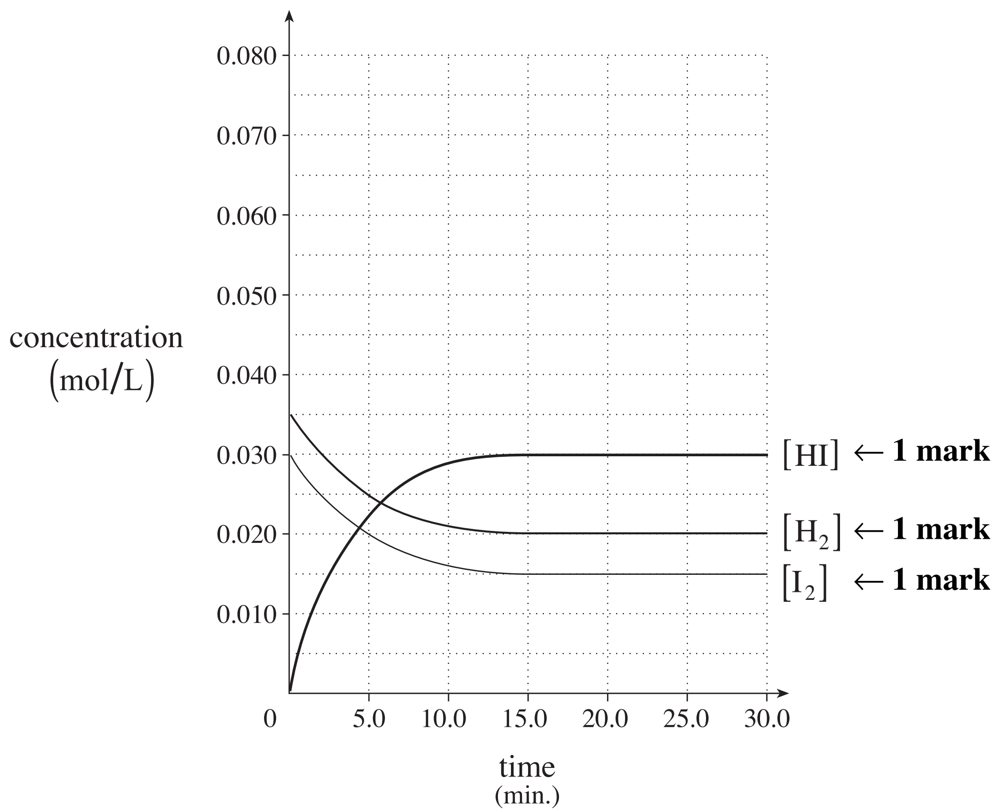
4. Consider the following equilibrium:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$$

A 2.0 L container is filled with 0.070 mol of H_2 and 0.060 mol of I_2. Equilibrium is reached after 15.0 minutes at which time there is 0.060 mol of HI present.

Sketch and label the graphs for the changes in concentrations of H_2, I_2, and HI for the time period of 0 to 30.0 minutes. **(3 marks)**

Solution:



Explanation of graph (not for marks).

	$H_{2(g)}$	+	$I_{2(g)}$	$\rightleftarrows$	$2HI_{(g)}$
[I]	0.035 M		0.030 M		–
[C]	–0.015 M		–0.015 M		+0.030 M
[E]	0.020 M		0.015 M		0.030 M

5. Calculate the maximum concentration of Pb^{2+} that can exist in 3.0×10^{-2} M Na_2SO_4 without forming a precipitate. **(2 marks)**

Solution:

For Example:

$$PbSO_{4(s)} \rightleftarrows Pb^{2+} + SO_4^{\ 2-}$$ ← **½ mark**

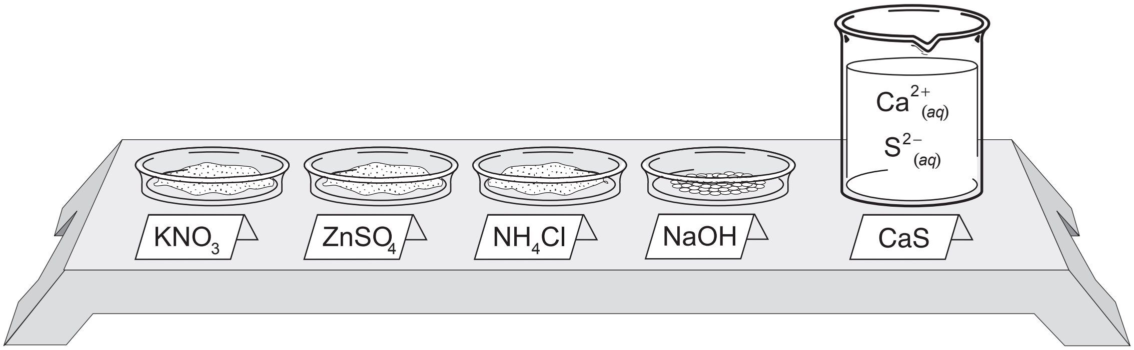
$$K_{sp} = [Pb^{2+}][SO_4^{\ 2-}]$$

$$1.8 \times 10^{-8} = (x)(3.0 \times 10^{-2})$$

$$[Pb^{2+}] = x = 6.0 \times 10^{-7}\text{ M}$$

← **1½ marks**

6. Consider the following:



a) Which two solid samples could be added to the CaS solution in order to remove first one ion and then the other from the solution. Indicate the order in which to add them. **(2 marks)**

Solution:

For Example:

First add: NaOH

Then add: $ZnSO_4$

} ← **2 marks**

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

Solution:

For Example:

Any** one **of the following:

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

or

$$Zn^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow ZnS_{(s)}$$

} ← **1 mark**

7. A sample of a weak acid was found to conduct an electric current better than a sample of a strong acid. Explain these results in terms of ion concentration. **(2 marks)**

Solution:

For Example:

The greater the conductivity, the higher the concentration of ions. Since the weaker acid conducts better, it must contain a higher concentration of ions. } ← **2 marks**

8. Calculate the $\left[OH^-\right]$ of $0.10\,M\ NH_3$. **(4 marks)**

Solution:

For Example:

	NH_3	+	H_2O	$\rightleftarrows$	NH_4^+	+	OH^-
[I]	0.10				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.10-x$				x		x

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

$$K_b = \frac{1.0 \times 10^{-14}}{5.6 \times 10^{-10}} = 1.8 \times 10^{-5}$$

$\leftarrow$ **1 mark**

$$K_b = \frac{\left[NH_4^+\right]\left[OH^-\right]}{\left[NH_3\right]}$$

$$= \frac{(x)(x)}{(0.10-x)}$$

assume x ´ 0.10

$$1.8 \times 10^{-5} = \frac{x^2}{0.10}$$

$$x = \left[OH^-\right] = 1.3 \times 10^{-3}\ M$$

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

9. A titration was performed by adding $0.175\,M$ $H_2C_2O_4$ to a $25.00\,mL$ sample of NaOH. The following data was collected:

	Trial #1	Trial #2	Trial #3
Final volume of $H_2C_2O_4$ (mL)	23.00	39.05	20.95
Initial volume of $H_2C_2O_4$ (mL)	4.85	23.00	5.00

a) Calculate the [NaOH]. **(3 marks)**

Solution:

$$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$$

$$\text{vol } H_2C_2O_4 = 16.00\,\text{mL}$$ ← **1 mark**

$$\text{mol } H_2C_2O_4 = 0.01600\,\text{L}\left(0.175\,\text{mol/L}\right) = 2.800 \times 10^{-3}\,\text{mol}$$ ← **½ mark**

$$\text{mol NaOH} = 2 \times \text{mol } H_2C_2O_4 = 5.600 \times 10^{-3}\,\text{mol}$$ ← **1 mark**

$$[\text{NaOH}] = \frac{5.600 \times 10^{-3}\,\text{mol}}{0.02500\,\text{L}} = 0.224\,\text{M}$$ ← **½ mark**

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

b) Explain why the pH at the equivalence point is greater than 7. **(1 mark)**

Solution:

For example:

The $C_2O_4^{\,2-}$ ion resulting from the dissociation of $Na_2C_2O_4$ hydrolyzes to form a basic solution. ← **1 mark**

10. Balance the following redox reaction in a basic solution. **(4 marks)**

$$As \rightarrow AsH_3 + H_2AsO_4^- \qquad \text{(basic)}$$

Solution:

For Example:

$$5 \times \left(3e^- + 3H^+ + As \rightarrow AsH_3\right)$$ ← **1 mark for half-reactions**

$$3 \times \left(4H_2O + As \rightarrow H_2AsO_4^- + 6H^+ + 5e^-\right)$$ ← **1 mark for balancing electrons**

$$12H_2O + 8As \rightarrow 5AsH_3 + 3H_2AsO_4^- + 3H^+$$ ← **1 mark for addition, cancellation**

BASIC Add $3OH^-$ to each side.

$$9H_2O + 3OH^- + 8As \rightarrow 5AsH_3 + 3H_2AsO_4^-$$ ← **1 mark for basic**

For Example:

$$3H_2O + 3e^- + As \rightarrow AsH_3 + 3OH^-$$ ← **1 mark for basic half-reaction**

$$6OH^- + As \rightarrow H_2AsO_4^- + 5e^- + 2H_2O$$ ← **1 mark for basic half-reaction**

$$\overset{9}{\cancel{15}}H_2O + \cancel{15e^-} + 5As \rightarrow 5AsH_3 + \cancel{15OH^-}$$

$$\overset{3}{\cancel{18}}OH^- + 3As \rightarrow 3H_2AsO_4^- + \cancel{15e^-} + \cancel{6H_2O}$$

$$9H_2O + 3OH^- + 8As \rightarrow 5AsH_3 + 3H_2AsO_4^-$$

← **2 marks for balancing electrons, addition and cancellation**

For Example:

Decrease 3

$$As + As \rightarrow AsH_3 + H_2AsO_4^-$$

Increase 5

← **1 mark for oxidation numbers**

Decrease 15

$$3As + 5As \rightarrow 5AsH_3 + 3H_2AsO_4^-$$

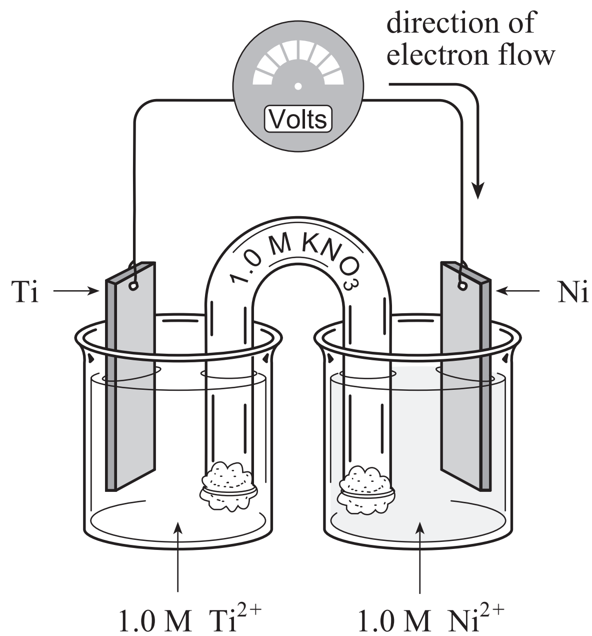
Increase 15

← **1 mark for multiplication**

$$3OH^- + \underset{(3As\,+\,5As)}{8As} \rightarrow 5AsH_3 + 3H_2AsO_4^-$$ ← **1 mark for basic charge**

$$9H_2O + 3OH^- + 8As \rightarrow 5AsH_3 + 3H_2AsO_4^-$$ ← **1 mark for hydrogen (H_2O)**

11. Consider the following electrochemical cell:



E° cell = 1.37 V

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

Solution:

$Ti \rightarrow Ti^{2+} + 2e^-$ ← **1 mark**

b) Calculate the reduction potential of Ti^{2+}. **(1 mark)**

Solution:

For Example:

$$E^\circ_{(\textit{for cell})} = E^\circ_{(\textit{for reduction})} + E^\circ_{(\textit{for oxidation})}$$

$$Ni^{2+} + 2e^- \rightarrow Ni$$

$$E^\circ_{(\textit{for reduction})} = -0.26\text{ V}$$

$$1.37\text{ V} = (-0.26\text{ V}) + E^\circ_{(\textit{for oxidation})}$$

$$E^\circ_{(\textit{for oxidation})} = 1.63\text{ V}$$

Therefore, the reduction potential of Ti^{2+} is -1.63 V

← **1 mark**

12. Consider the following reaction for the formation of rust:

$$Fe_{(s)} + \frac{1}{2}O_{2(g)} + H_2O_{(\ell)} \rightarrow Fe(OH)_{2(s)}$$

Describe and explain two methods, using different chemical principles, to prevent the formation of rust. **(2 marks)**

Solution:

For Example:

Coating with zinc $\left(\frac{1}{2}\ \textbf{mark}\right)$. Zinc acts as a sacrificial anode $\left(\frac{1}{2}\ \textbf{mark}\right)$.

Painting $\left(\frac{1}{2}\ \textbf{mark}\right)$ prevents contact between Fe and O_2 $\left(\frac{1}{2}\ \textbf{mark}\right)$.

END OF KEY