Chemistry 12

June 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.	A	K	1	A1	25.	A	U	4	K9
2.	D	K	1	A2	26.	B	U	4	L4, N3
3.	C	U	1	A3	27.	D	K	4	L6
4.	C	H	1	A5	28.	C	U	4	L11
5.	B	K	1	B5	29.	B	K	4	M1
6.	B	U	1	C5	30.	C	K	4	M2
7.	B	U	2	D6	31.	A	U	4	M4
8.	C	K	2	D9	32.	A	K	4	O2
9.	B	U	2	E2	33.	D	U	4	O4
10.	D	K	2	E2, 4	34.	B	U	4	P3
11.	C	K	2	F2	35.	C	U	4	P5
12.	C	H	2	F4	36.	A	U	4	P6
13.	A	U	2	F6	37.	B	H	4	Q5
14.	D	U	3	G5	38.	D	K	5	S1
15.	D	K	3	G8	39.	B	K	5	S2
16.	A	U	3	H2	40.	A	K	5	S2
17.	A	U	3	H4	41.	C	U	5	S3
18.	B	K	3	I2	42.	A	U	5	S6
19.	C	H	3	H2, I4	43.	C	K	5	T1
20.	D	H	3	I5	44.	D	U	5	T5
21.	D	K	4	J11	45.	B	H	5	U7
22.	C	K	4	K7	46.	D	U	5	U11
23.	D	U	4	J8	47.	B	U	5	V4
24.	A	U	4	K8	48.	A	U	5	W2

Multiple Choice = 48 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	3	1	C2, C5
2.	2	U	3	2	B6, E2
3.	3	U	3	2	F6
4.	4	U	3	3	I5
5.	5	H	3	3	E2, H5, K5
6.	6	U	4	4	M5
7.	7	U	5	4	N1, N2, N3
8.	8	U	4	5	S4, U7
9.	9	U	2	5	U2, U11
10.	10	U	2	5	W8

Written Response = 32 marks

Multiple Choice = 48 (48 questions)
Written Response = 32 (10 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) Complete the steps in the following mechanism. **($1\frac{1}{2}$ marks)**

Solution:

For Example:

Step 1	$NO + Pt \rightarrow \underline{NOPt}$	← **$\frac{1}{2}$ mark**
Step 2	$NOPt + NO \rightarrow \underline{N_2} + \underline{O_2Pt}$	← **1 mark**
Step 3	$O_2Pt \rightarrow O_2 + Pt$	
Overall	$2NO \rightarrow N_2 + O_2$	

b) Define the term *reaction intermediate* and give an example from the completed mechanism above. **($1\frac{1}{2}$ marks)**

Solution:

For Example:

Definition: A substance which forms in one step of a mechanism and is used up in a later step. } ← **1 mark**

Example: NOPt **or** O_2Pt ← **$\frac{1}{2}$ mark**

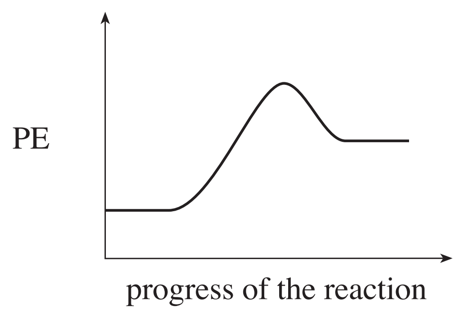
2. Consider the observations for the following equilibrium:

$$\underset{\text{(colourless)}}{N_2O_{4(g)}} \rightleftarrows \underset{\text{(brown)}}{2NO_{2(g)}}$$

Trial	Temperature °C	Colour
I.	10	light brown
II.	50	dark brown

a) Sketch the potential energy curve on the graph below for this equilibrium. **(1 mark)**

Solution:



← **1 mark**

b) Explain the colour change using Le Châtelier's Principle. **(1 mark)**

Solution:

For Example:

An increase in temperature causes the reaction to shift to the right and the $[NO_2]$ increases. ← **1 mark**

c) Other than changing temperature, what could be done to cause a shift to the left? **(1 mark)**

Solution:

For Example:

To cause a shift to the left add NO_2 **or** remove N_2O_4 **or** decrease the volume. ← **1 mark**

3. Consider the data obtained for the following equilibrium:

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

	$[Fe^{3+}]$	$[SCN^{-}]$	$[FeSCN^{2+}]$
Experiment 1	3.91×10^{-2}	8.02×10^{-5}	9.22×10^{-4}
Experiment 2	6.27×10^{-3}	3.65×10^{-4}	**?**

Calculate the $[FeSCN^{2+}]$ in experiment #2. **(3 marks)**

Solution:

$$\left.\begin{aligned} K_{eq} &= \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^{-}]} \\ &= \frac{9.22 \times 10^{-4}}{(3.91 \times 10^{-2})(8.02 \times 10^{-5})} \\ &= 2.94 \times 10^{2} \end{aligned}\right\} \leftarrow \mathbf{1\tfrac{1}{2}\ mark}$$

$$\left.\begin{aligned} 2.94 \times 10^{2} &= \frac{x}{(6.27 \times 10^{-3})(3.65 \times 10^{-4})} \\ [FeSCN^{2+}] &= x = 6.73 \times 10^{-4}\ \text{M} \end{aligned}\right\} \leftarrow \mathbf{1\tfrac{1}{2}\ mark}$$

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

4. At $25°C$, will a precipitate form when $25.0\ \text{mL}$ of $0.010\ \text{M}$ $Pb(NO_3)_2$ is combined with $75.0\ \text{mL}$ of $0.010\ \text{M}$ NaI? Support your answer with calculations. **(3 marks)**

Solution:

For Example:

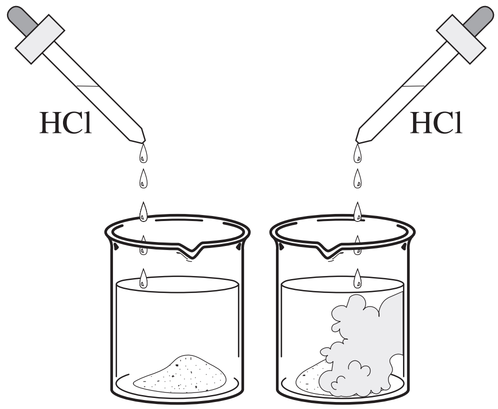
$$PbI_{2(s)} \rightleftarrows Pb^{2+}_{(aq)} + 2I^{-}_{(aq)}$$

$$\left.\begin{aligned}\left[Pb^{2+}\right] &= 0.010\ \text{M} \times \frac{25.0\ \text{mL}}{100.0\ \text{mL}} = 0.00250\ \text{M} \\ \left[I^{-}\right] &= 0.010\ \text{M} \times \frac{75.0\ \text{mL}}{100.0\ \text{mL}} = 0.00750\ \text{M}\end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned}\text{Trial } K_{sp} &= \left[Pb^{2+}\right]\left[I^{-}\right]^2 \\ &= (0.00250)(0.00750)^2 \\ &= 1.4 \times 10^{-7}\end{aligned}\right\} \leftarrow \textbf{1 mark}$$

Since Trial K_{sp} $\left(1.4 \times 10^{-7}\right) > K_{sp}\left(8.5 \times 10^{-9}\right)$ a precipitate does form. $\} \leftarrow$ **1 mark**

5. When HCl is added to a saturated solution of CuC_2O_4, some precipitate dissolves. However, when HCl is added to a saturated solution of $PbCl_2$, additional precipitate forms.



Explain these observations. Support your explanation with chemical equations. **(3 marks)**

Solution:

For Example:

$CuC_2O_{4(s)} \rightleftarrows Cu^{2+}_{(aq)} + C_2O_4{}^{2-}_{(aq)}$ ← **½ mark**

H^+ from the acid reacts with the $C_2O_4{}^{2-}$ to form $HC_2O_4{}^-$ reducing the $[C_2O_4{}^{2-}]$ and causing a shift to the product side. } ← **1 mark**

$Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightleftarrows PbCl_{2(s)}$ ← **½ mark**

The common ion effect causes a shift to the right. ← **1 mark**

6. A 0.100 M solution of an unknown weak acid, HX, has a pH = 1.414.
What is the K_a for HX? **(4 marks)**

Solution:

For Example:

$[H_3O^+] = 0.03855\text{ M}$ ← **1 mark**

	HX	+	H_2O	⇄	H_3O^+	+	X^-
[I]	0.100				0		0
[C]	–0.03855				+0.03855		+0.03855
[E]	0.061				0.03855		0.03855

← **2 marks**

$$K_a = \frac{[H_3O^+][X^-]}{[HX]}$$ ← **1 mark**

$$K_a = \frac{(0.03855)(0.03855)}{0.061}$$

$$= 0.024$$

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

7. Consider the salt ammonium acetate, NH_4CH_3COO.

a) Write the equation for the dissociation of NH_4CH_3COO. **(1 mark)**

Solution:

$NH_4CH_3COO_{(s)} \rightarrow NH_4{}^{+}{}_{(aq)} + CH_3COO^{-}{}_{(aq)}$ ← **1 mark**

b) Write equations for the hydrolysis reactions which occur. **(2 marks)**

Solution:

$NH_4{}^{+} + H_2O \rightleftarrows H_3O^{+} + NH_3$

and $CH_3COO^{-} + H_2O \rightleftarrows CH_3COOH + OH^{-}$

← **2 marks**

c) Explain why a solution of NH_4CH_3COO has a $pH = 7.00$.
Support your answer with calculations. **(2 marks)**

Solution:

K_a for $NH_4{}^{+} = 5.6 \times 10^{-10}$

K_b for $CH_3COO^{-} = \dfrac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$

the K_a for $NH_4{}^{+} = K_b$ for CH_3COO^{-}

∴ the acidic cation is completely neutralized by the basic anion.

← **2 marks**

8. The metals Rh, Ti, Cr and Pd are individually placed in 1.0 M solutions of Rh^{2+}, Ti^{2+}, Cr^{2+} and Pd^{2+} and the cell voltages of the spontaneous reactions are determined.

Metal \ Ion	Rh^{2+}	Ti^{2+}	Pd^{2+}	Cr^{2+}
Rh		no reaction	0.35 V	no reaction
Ti	2.23 V		2.58 V	**?**
Pd	no reaction	no reaction		no reaction
Cr	1.51 V	no reaction	1.86 V	

a) Arrange the metals in order of **increasing** strength as reducing agents. **(2 marks)**

Solution:

For Example:

2 marks

weakest reducing agent Pd, Rh, Cr, Ti strongest reducing agent

b) Determine the cell voltage for Ti in a 1.0 M solution of Cr^{2+}. **(2 marks)**

Solution:

For Example:

$$Ti + Rh^{2+} = 2.23\,V$$

$$Cr + Rh^{2+} = 1.51\,V$$

$$\text{Cell voltage of } Ti + Cr^{2+} = 2.23\,V - 1.51\,V$$

$$= 0.72\,V$$

← **2 marks**

9. Consider the following reactions for a fuel cell :

cathode:	$O_{2(g)} + 2H_2O_{(\ell)} + 4e^- \rightarrow 4OH^-_{(aq)}$
anode:	?
overall:	$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(\ell)}$

a) Write the reaction at the anode. **(1 mark)**

Solution:

For Example:

$2H_{2(g)} + 4OH^-_{(aq)} \rightarrow 4H_2O_{(\ell)} + 4e^-$ ← **1 mark**

b) Discuss the advantage of a fuel-cell powered vehicle over an internal combustion powered vehicle by comparing the products formed. **(1 mark)**

Solution:

For Example:

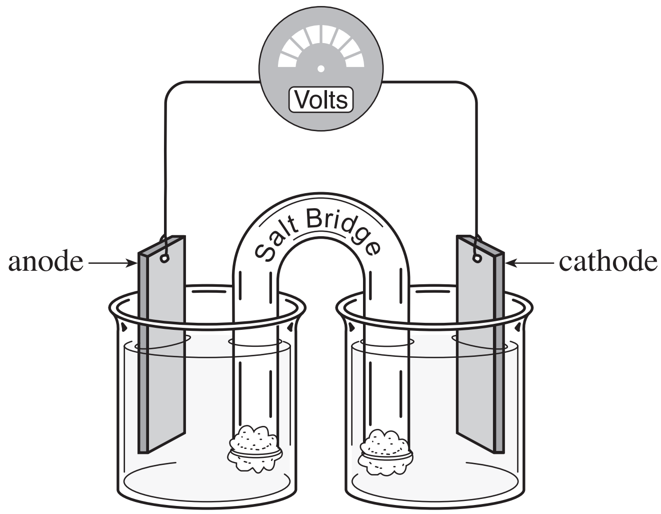
The NO_x produced by internal combustion cars is a source of acid rain. The H_2O from a fuel-cell car is non-polluting. } ← **1 mark**

10. Draw and label an electrochemical cell using a copper anode and having an E° value > 1.00 V.

(2 marks)

Solution:

For Example:



$\frac{1}{2}$ mark for suitable cathode — Au for example.
$\frac{1}{2}$ mark for suitable ions — Au^{3+} and Cu^{2+} for example.
1 mark for diagram being an electrochemical cell, not an electrolytic cell.

END OF KEY