Chemistry 12

June 2001 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	S	CO	PLO	Q	K	C	S	CO	PLO
1.	B	U	1	1	A1	25.	C	K	1	4	K12
2.	B	U	1	1	A4	26.	C	U	1	4	L7
3.	D	K	1	1	B3	27.	B	U	1	4	L11
4.	D	K	1	1	B8	28.	C	U	2	4	L12
5.	B	U	2	1	B5	29.	A	K	1	4	M2
6.	C	H	1	1	C5	30.	C	U	1	4	M4
7.	A	U	2	2	D3	31.	B	U	1	4	N3
8.	A	K	1	2	D8	32.	A	U	2	4	O3
9.	A	U	1	2	E2	33.	C	U	1	4	O3
10.	D	H	1	2	E2, 5	34.	B	U	1	4	P2
11.	C	U	1	2	E4	35.	B	U	2	4	P6
12.	A	K	1	2	F2	36.	D	K	1	4	Q2
13.	C	U	1	2	F5	37.	A	U	1	4	R1
14.	C	U	2	2	F8	38.	A	U	1	5	S1
15.	C	K	1	3	H5	39.	C	H	2	5	S4
16.	D	K	1	3	G4	40.	D	U	1	5	S5
17.	A	H	2	3	G3	41.	A	U	1	5	S6
18.	B	K	1	3	G7	42.	C	U	1	5	T4
19.	C	U	2	3	H2	43.	B	U	2	5	U2
20.	A	U	1	3	I3	44.	A	H	1	5	U5
21.	D	K	1	4	J9	45.	C	U	1	5	U9
22.	D	K	1	4	J11	46.	B	K	1	5	U8
23.	B	K	1	4	K3, 4	47.	D	K	1	5	V3
24.	A	H	2	4	K5	48.	A	U	2	5	W4

Multiple Choice = 60 marks (48 questions)

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	4	1	A3
2.	2	U	2	2	D4
3.	3	U	4	2	F7
4.	4	U	4	3	I4
5.	5	U	4	3	I5
6.	6	U	2	4	K6
7.	7	U	5	4	M5
8.	8	U	4	4	P5
9.	9	K	2	4	R1
10.	10	U	3	5	T2, 6
11.	11	K	2	5	S1
12.	12	U	4	5	W2

Written Response = 40 marks

Multiple Choice = 60 (48 questions)
Written Response = 40 (12 questions)
EXAMINATION TOTAL = 100 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: 40 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.

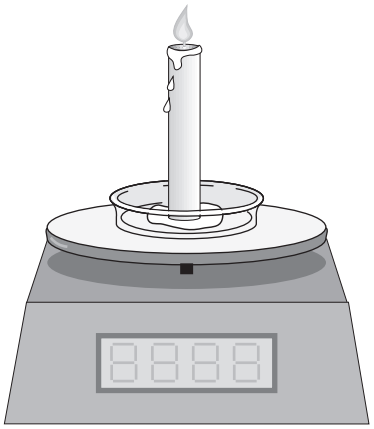
Your steps and assumptions leading to a solution must be written in the spaces below the questions.

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. The mass of a burning candle is monitored to determine the rate of combustion of paraffin. An accepted reaction for the combustion of paraffin is:

$$2\,C_{28}H_{58(s)} + 85\,O_{2(g)} \rightarrow 56\,CO_{2(g)} + 58\,H_2O_{(g)}$$



The following data is observed:

Time (min)	Mass of Candle (g)
0.0	25.6
6.0	25.1
12.0	24.5
18.0	23.9
24.0	23.4
30.0	22.8

a) Calculate the average rate of consumption of paraffin in g/min for the time interval 12.0 to 24.0 minutes. **(2 marks)**

Solution:

For Example:

$$r = \frac{\Delta \text{mass}}{\Delta t} \qquad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$= \frac{1.1\,\text{g}}{12.0\,\text{min}} \qquad \leftarrow \textbf{1 mark}$$

$$= 0.092\,\text{g/min} \qquad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

b) Calculate the rate of CO_2 production in mol/min for the time interval 12.0 to 24.0 minutes. **(2 marks)**

Solution:

For Example:

$$\text{rate} = 0.092\,\text{g/min} \times \frac{1\,\text{mol } C_{28}H_{58}}{394.0\,\text{g}} \times \frac{56\,\text{mol } CO_2}{2\,\text{mol } C_{28}H_{58}}$$

$$= 6.5 \times 10^{-3}\,\text{mol/min}$$

$\left.\begin{array}{l}\\\\\end{array}\right\} \leftarrow \textbf{2 marks}$

2. Write **four** statements that apply to all chemical equilibrium systems. **(2 marks)**

Solution:

For example any* four *of the following for* $\frac{1}{2}$ mark *each:

- system must be closed
- temperature is constant
- forward and reverse rates are equal
- macroscopic properties are constant
- can be achieved from either direction
- concentration of reactants and products are constant

3. Consider the following equilibrium system:

$$H_{2(g)} + Br_{2(g)} \rightleftarrows 2HBr_{(g)} \qquad K_{eq} = 14.8$$

A closed container was initially filled with equal moles of H_2 and Br_2.
When equilibrium is reached, the $[HBr]$ is $0.329\,\text{mol/L}$. What was the initial $[H_2]$?

(4 marks)

Solution:

For Example:

	$H_{2(g)}$	+	$Br_{2(g)}$	$\rightleftarrows$	$2HBr_{(g)}$
[I]	x		x		0
[C]	-0.1645		-0.1645		$+0.329$
[E]	$x - 0.1645$		$x - 0.1645$		0.329

← **2 marks**

$$K_{eq} = \frac{[HBr]^2}{[H_2][Br_2]}$$

$$14.8 = \frac{(0.329)^2}{(x - 0.1645)(x - 0.1645)}$$

$$x = 0.250\,\text{M}$$

$$[H_2] = 0.250\,\text{mol/L}$$

← **2 marks**

4. Calculate the molar solubility of SrF_2. **(4 marks)**

Solution:

For Example:

$$\begin{array}{ccccc} SrF_2 & \rightleftarrows & Sr^{2+} & + & 2F^- \\ & & s & & 2s \end{array}$$

← **1 mark**

$$K_{sp} = \left[Sr^{2+}\right]\left[F^-\right]^2$$
$$= (s)(2s)^2$$
$$= 4.3 \times 10^{-9}$$
$$s = 1.0 \times 10^{-3}\ \text{mol/L}$$

← **3 marks**

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

5. Does a precipitate form when $3.0\,\text{mL}$ of $1.0 \times 10^{-3}\,\text{M}$ NaBr is added to $2.0\,\text{mL}$ of $1.0 \times 10^{-3}\,\text{M}$ $\text{Pb}(\text{NO}_3)_2$? **(4 marks)**

Solution:

For Example:

$$\text{PbBr}_{2(s)} \rightleftarrows \text{Pb}^{2+}_{(aq)} + 2\text{Br}^{-}_{(aq)}$$

$$\left[\text{Pb}^{2+}\right] = \frac{2.0\,\text{mL}}{5.0\,\text{mL}} \times 1.0 \times 10^{-3}\,\text{M} = 4.0 \times 10^{-4}\,\text{M}$$

$$\left[\text{Br}^{-}\right] = \frac{3.0\,\text{mL}}{5.0\,\text{mL}} \times 1.0 \times 10^{-3}\,\text{M} = 6.0 \times 10^{-4}\,\text{M}$$

← **1 mark**

$$\text{Trial } K_{sp} = \left[\text{Pb}^{2+}\right]\left[\text{Br}^{-}\right]^2$$

$$= \left(4.0 \times 10^{-4}\right)\left(6.0 \times 10^{-4}\right)^2$$

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

← **2 marks**

Since Trial K_{sp} is less than $K_{sp}\left(6.6 \times 10^{-6}\right)$ no precipitate forms. ← **1 mark**

6. Write the equation for the predominant reaction between HSO_4^- and $H_2PO_4^-$.

(2 marks)

Solution:

$$HSO_4^- + H_2PO_4^- \rightleftarrows SO_4^{2-} + H_3PO_4$$ ← **2 marks**

7. A $0.20\,\text{M}$ solution of a weak acid, HA, has a $\text{pH} = 1.32$.
Use calculations and the table of "Relative Strengths of Brønsted-Lowry Acids and Bases" from the *Data Booklet* to determine the identity of the acid. **(5 marks)**

Solution:

For Example:

$$\text{pH} = 1.32$$
$$\left[\text{H}_3\text{O}^+\right] = 0.048\,\text{M}$$

← **1 mark**

	HA	+	H_2O	$\rightleftarrows$	H_3O^+	+	A^-
[I]	0.20				0		0
[C]	–0.048				+0.048		+0.048
[E]	0.152				0.048		0.048

← **2 marks**

$$\text{K}_a = \frac{\left[\text{H}_3\text{O}^+\right]\left[\text{A}^-\right]}{[\text{HA}]} = \frac{(0.048)(0.048)}{0.152} = 1.5 \times 10^{-2}$$

← **1 mark**

The acid is: H_2SO_3 ← **1 mark**

8. Calculate the pH of a solution prepared by mixing 15.0 mL of 0.50 M HCl with 35.0 mL of 1.0 M NaOH. **(4 marks)**

Solution:

For Example:

$$\text{moles HCl} = 0.0150\,\text{L} \times 0.50\,\text{M} = 7.50 \times 10^{-3}\ \text{mol}$$

$$\text{moles NaOH} = 0.0350\,\text{L} \times 1.0\,\text{M} = 3.5 \times 10^{-2}\ \text{mol}$$

$$\text{excess moles NaOH} = 3.5 \times 10^{-2}\ \text{mol} - 7.50 \times 10^{-3}\ \text{mol} = 2.75 \times 10^{-2}\ \text{mol}$$

$$[\text{NaOH}] = \left[\text{OH}^-\right] = \frac{2.75 \times 10^{-2}\ \text{mol}}{0.050\,\text{L}} = 0.55\,\text{M}$$

$$\left[\text{H}_3\text{O}^+\right] = \frac{1.0 \times 10^{-14}}{0.55} = 1.8 \times 10^{-4}$$

$$\text{pH} = 13.74$$

← **4 marks**

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

9. Identify a gas which causes acid rain, and write an equation showing this gas reacting with water. **(2 marks)**

Solution:

For Example:

One of the following gases: SO_2, SO_3, NO_2 ← **1 mark**

$SO_2 + H_2O \rightarrow H_2SO_3$ **or**

$SO_3 + H_2O \rightarrow H_2SO_4$ **or**

$2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$

← **1 mark**

10. Balance the following redox reaction in acidic solution. **(3 marks)**

$$MnO_4^- + Fe^{2+} \rightarrow Mn^{2+} + Fe^{3+} \quad \text{(acidic)}$$

Solution:

For Example:

$$\begin{array}{r} 1 \times \left(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O\right) \\ 5 \times \left(Fe^{2+} \rightarrow Fe^{3+} + e^-\right) \\ \hline MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+} \end{array} \Bigg\} \leftarrow \textbf{3 marks}$$

11. Aluminum is a stronger reducing agent than copper. What is meant by the term *stronger reducing agent*? **(2 marks)**

Solution:

For Example:

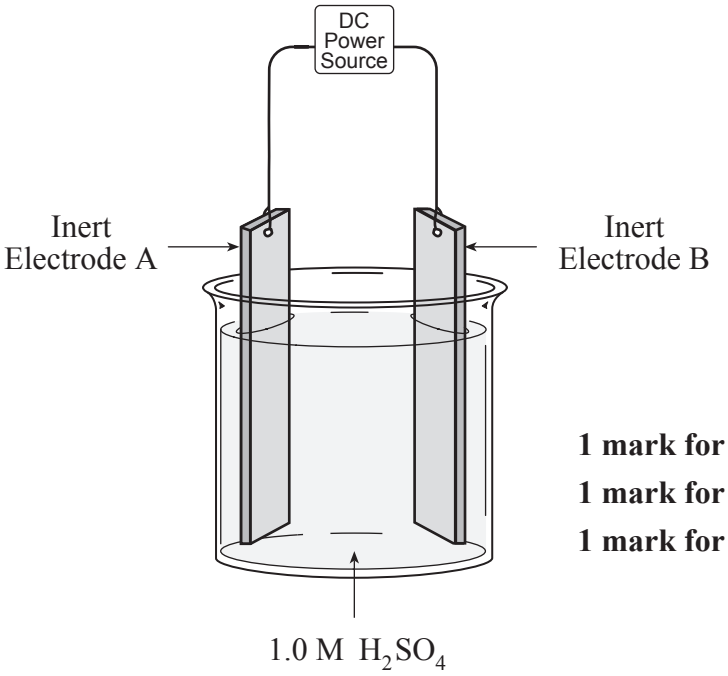
Species that more readily loses electrons. ← **2 marks**

12. Consider the electrolysis of water.

a) Draw and label the parts of an electrolytic cell capable of decomposing water. **(3 marks)**

Solution:

For Example:



1 mark for inert electrodes
1 mark for electrolytic cell
1 mark for suitable electrolyte

b) Identify the gas produced at the anode. **(1 mark)**

Solution:

O_2 ← **1 mark**

END OF KEY