Chemistry 12

April 1999 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.	D	K	1	A1	25.	C	K	4	L2
2.	D	H	1	A3	26.	B	H	4	L4, 11
3.	D	H	1	A6	27.	A	U	4	L11
4.	A	U	1	B5	28.	B	U	4	M4
5.	C	U	1	B9	29.	B	U	4	N2
6.	B	K	1	C3	30.	D	U	4	N3, O2
7.	D	U	2	D2	31.	B	U	4	P1
8.	C	U	2	E2	32.	B	U	4	Q3
9.	C	U	2	E2, 4	33.	C	K	4	P1
10.	A	U	2	E3	34.	A	K	4	R3
11.	A	U	2	F3	35.	B	U	4	O3
12.	D	U	2	F4	36.	A	U	4	R1
13.	D	U	2	F5	37.	C	H	5	S1
14.	B	K	3	G1	38.	C	U	5	S2
15.	A	H	3	G2	39.	B	U	5	S3
16.	B	U	3	H1	40.	C	U	5	S5
17.	D	U	3	H2	41.	C	U	5	T2
18.	A	U	3	I3	42.	D	U	5	T4
19.	C	K	3	H5	43.	A	U	5	U3, U5
20.	C	U	3	I4	44.	B	U	5	T5
21.	A	K	4	J2	45.	C	H	5	U9
22.	D	K	4	J11	46.	C	K	5	V1
23.	A	U	4	K1	47.	D	U	5	W6
24.	A	U	4	K8	48.	B	U	5	W4

Multiple Choice = 48 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	4	1	A3
2.	2	K	2	2	D7
3.	3	H	2	2	F5
4.	4	U	2	3	G8
5.	5	U	4	3	I6
6.	6	U	2	4	K8
7.	7	U	4	4	M3
8.	8	U	4	4	P2
9.	9	U	3	5	T2
10.	10	K	2	5	W1
11.	11	U	3	5	S6

Written Response = 32 marks

Multiple Choice = 48 (48 questions)
Written Response = 32 (11 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.

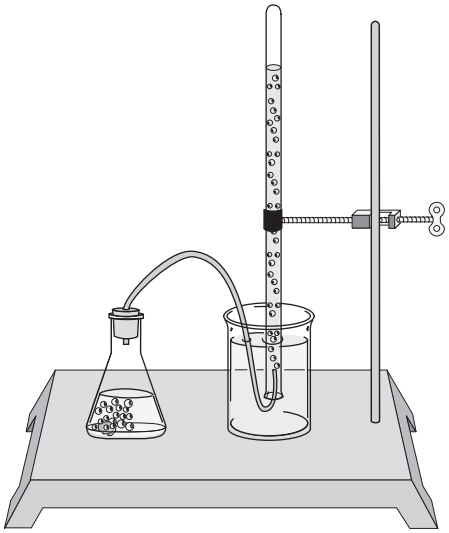
Your steps and assumptions leading to a solution must be written in the spaces below the questions.

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. An experiment is performed by displacement of water to determine the rate of the following reaction:

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + ZnCl_{2(aq)}$$



The following data is collected:

Time (s)	Volume of H_2 (mL)
0.0	0.0
10.0	21.1
20.0	40.9
30.0	60.0
40.0	77.6

a) Calculate the average rate of formation of H_2 in mL/s for the time interval between 20 and 40 seconds. **(2 marks)**

Solution:

$$\text{rate} = \frac{77.6\,\text{mL} - 40.9\,\text{mL}}{20.0\,\text{s}} = 1.84\,\text{mL/s}$$

↑ **1 mark** ↑ **1 mark**

b) How does the rate of this reaction change as the reaction proceeds? Explain why. **(2 marks)**

Solution:

***For Example*:**

The rate of the reaction decreases because the concentration of HCl decreases as the reaction proceeds. } ← **2 marks**

2. Describe how enthalpy and entropy change, in the forward direction, as an exothermic reaction reaches equilibrium. Explain your reasoning. **(2 marks)**

Solution:

***For Example*:**

Enthalpy: is decreasing. ← $\frac{1}{2}$ **mark**

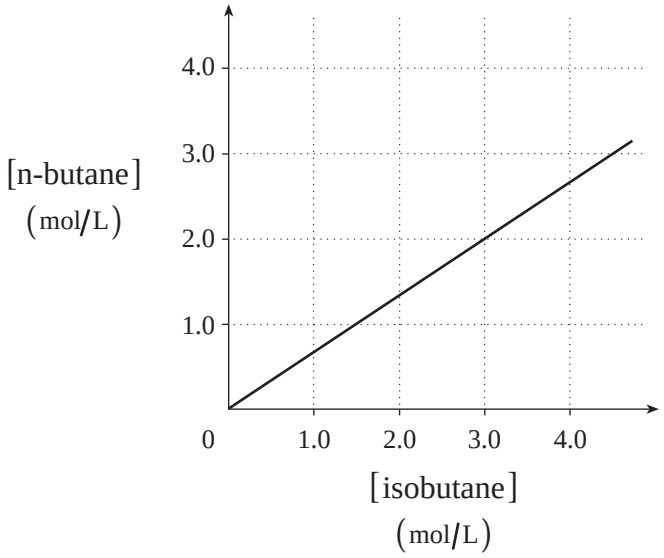
Entropy: is decreasing. ← $\frac{1}{2}$ **mark**

Explanation: Since the system reaches equilibrium, the drive to minimum enthalpy and maximum entropy must be opposing one another. ← **1 mark**

3. Consider the graph below representing the following equilibrium:

$$\underset{\text{n-butane}}{CH_3CH_2CH_2CH_{3(g)}} \rightleftarrows \underset{\text{isobutane}}{CH_3CH(CH_3)_{2(g)}}$$

Data for the graph was obtained from various equilibrium mixtures.



Calculate the value of K_{eq} for the equilibrium. **(2 marks)**

Solution:

$$K_{eq} = \frac{[\text{isobutane}]}{[\text{n - butane}]} \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$= \frac{3.0}{2.0} \quad \leftarrow \textbf{1 mark}$$

$$= 1.5 \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

4. A $100.0\,\text{mL}$ sample of $0.600\,\text{M}\ \text{Ca}(\text{NO}_3)_2$ is diluted by adding $400.0\,\text{mL}$ of water. Calculate the concentration of ions in the resulting solution. **(2 marks)**

Solution:

$$\left[\text{Ca}(\text{NO}_3)_2\right] = 0.600\,\text{M} \times \frac{100.0\ \text{mL}}{500.0\ \text{mL}} = 0.120\,\text{M} \quad \leftarrow \textbf{1 mark}$$

$$\left[\text{Ca}^{2+}\right] = 0.120\,\text{M}$$

$$\left[\text{NO}_3^{-}\right] = 0.240\,\text{M} \quad \leftarrow \textbf{1 mark}$$

5. A maximum of $0.60\,\text{g}$ $Pb(NO_3)_2$ can be added to $1.5\,\text{L}$ of $NaBr_{(aq)}$ without forming a precipitate. Calculate the $[NaBr]$. **(4 marks)**

Solution:

$$\left.\begin{aligned} \text{mol } Pb^{2+} = \text{mol } Pb(NO_3)_2 &= 0.60\,\text{g} \times \frac{1\,\text{mol}}{331.2\,\text{g}} \\ &= 1.81\times10^{-3}\,\text{mol} \\ \left[Pb^{2+}\right] &= \frac{1.81\times10^{-3}\,\text{mol}}{1.5\,\text{L}} \\ &= 1.208\times10^{-3}\,\text{M} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$PbBr_{2(s)} \rightleftarrows Pb^{2+}_{(aq)} + 2Br^-_{(aq)} \qquad K_{sp} = \left[Pb^{2+}\right]\left[Br^-\right]^2 = 6.6\times10^{-6}$$

$$\left.\begin{aligned} \left[Br^-\right] &= \sqrt{\frac{K_{sp}}{\left[Pb^{2+}\right]}} \\ &= \sqrt{\frac{6.6\times10^{-6}}{1.208\times10^{-3}}} \\ &= 0.074\,\text{M} \\ [NaBr] = \left[Br^-\right] &= 0.074\,\text{M} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

6. Consider the following amphiprotic anions reacting with each other:

$$HC_6H_5O_7^{2-} + HC_2O_4^- \rightleftarrows \quad \textbf{?}$$

a) Complete the Brönsted-Lowry acid-base equilibrium for the predominant reaction. **(1 mark)**

Solution:

$$HC_6H_5O_7^{2-} + HC_2O_4^- \rightleftarrows C_2O_4^{2-} + H_2C_6H_5O_7^-$$

↑

1 mark

b) Does the equilibrium above favour reactants or products? Explain. **(1 mark)**

Solution:

***For example*:**

Products are favoured because reactants contain the stronger acid. ← **1 mark**

7. Calculate the pH of a $1.5\,\text{M}$ H_2S solution. **(4 marks)**

Solution:

	H_2S	+	H_2O	$\rightleftarrows$	H_3O^+	+	HS^-
[I]	1.5				0		0
[C]	$-x$				$+x$		$+x$
[E]	$1.5-x$				x		x

← **1 $\frac{1}{2}$ marks**

$$K_a = \frac{[H_3O^+][HS^-]}{[H_2S]}$$

$$= \frac{(x)(x)}{1.5-x}$$

$$= \frac{(x)(x)}{1.5} \text{ (assume } x \text{ is negligible)}$$

$$= 9.1\times10^{-8}$$

$$x = [H_3O^+] = 3.69\times10^{-4}\ \text{M}$$

← **1 $\frac{1}{2}$ marks**

$$\text{pH} = -\log 3.69\times10^{-4}\ \text{M} = 3.43$$

← **1 mark**

NOTE: ($\frac{1}{2}$ mark) is deducted for incorrect significant figures.

8. Consider the following reaction:

$$2HCl_{(aq)} + Ba(OH)_{2(s)} \rightarrow BaCl_{2(aq)} + 2H_2O_{(\ell)}$$

When $3.16\,g$ samples of $Ba(OH)_2$ were titrated to the equivalence point with an HCl solution, the following data were recorded:

	Volume of HCl added
Trial 1	$37.80\,mL$
Trial 2	$35.49\,mL$
Trial 3	$35.51\,mL$

Using the data above, calculate the original $[HCl]$. **(4 marks)**

Solution:

$$\text{Volume of HCl needed} = \frac{35.51\,mL + 35.49\,mL}{2} = 35.50\,mL \qquad \leftarrow \textbf{1 mark}$$

$$\text{mol } Ba(OH)_2 \text{ reacted} = 3.16\,g \times \frac{1\text{ mol}}{171.3\,g} = 0.0184\,mol \qquad \leftarrow \textbf{1 mark}$$

$$\text{mol HCl reacted} = 0.0184\,mol \times \frac{2\text{ mol HCl}}{1\text{ mol } Ba(OH)_2} = 0.0369\,mol \qquad \leftarrow \textbf{1 mark}$$

$$[HCl] = \frac{0.0369\,mol}{0.03550\,L} = 1.04\,M \qquad \leftarrow \textbf{1 mark}$$

NOTE: $\left(\frac{1}{2}$ mark$\right)$ is deducted for incorrect significant figures.

9. Balance the following redox reaction in acid:

$$N_2O_4 + In \rightarrow HNO_2 + In^{3+} \qquad (\text{acid}) \qquad \textbf{(3 marks)}$$

Solution:

$$3\times\left(N_2O_4 + 2H^+ + 2e^- \rightarrow 2HNO_2\right) \qquad \leftarrow \textbf{1}\,\tfrac{1}{2}\textbf{ marks for half reactions}$$

$$\underline{2\times\left(In \rightarrow In^{3+} + 3e^-\right)} \qquad \leftarrow \tfrac{1}{2}\textbf{ mark for balancing electrons}$$

$$3N_2O_4 + 6H^+ + 2In \rightarrow 6HNO_2 + 2In^{3+} \qquad \leftarrow \textbf{1 mark}$$

10. What is an *electrolytic cell*? **(2 marks)**

Solution:

***For Example*:**

A cell which depends on an external source of electricity to cause a non-spontaneous redox reaction to occur. } ← **2 marks**

11. A solution contains either acidified IO_3^- or acidified SO_4^{2-}. Why could the solution be identified using $I^-_{(aq)}$? Provide equations to support your answer. **(3 marks)**

Solution:

***For Example*:**

I^- reacts with acidified IO_3^- but not with acidified SO_4^{2-}. ← **1 mark**

$$2\times\left(IO_3^- + 6H^+ + 5e \rightarrow \tfrac{1}{2}I_2 + 3H_2O\right)$$
$$5\times\left(2I^- \rightarrow I_2 + 2e^-\right)$$
$$2IO_3^- + 12H^+ + 10I^- \rightarrow 6I_2 + 6H_2O$$
$$IO_3^- + 6H^+ + 5I^- \rightarrow 3I_2 + 3H_2O$$

← **2 marks**

END OF KEY