Chemistry 12

August 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.	B	K	1	A1	25.	C	K	4	L2
2.	B	U	1	A3	26.	D	U	4	L6, 7
3.	C	H	1	A6	27.	D	K	4	L4
4.	A	H	1	B5	28.	D	K	4	L11
5.	D	U	1	C4	29.	A	U	4	M1
6.	B	K	1	B7	30.	A	U	4	L11
7.	A	H	2	D3	31.	B	K	4	O1
8.	A	U	2	E2	32.	A	U	4	P1
9.	C	U	2	E2, F4	33.	B	U	4	P2
10.	A	U	2	E3	34.	B	U	4	P6
11.	A	U	2	F2	35.	B	K	4	Q6
12.	B	K	2	F4	36.	C	U	4	P3
13.	A	U	2	F5	37.	D	K	5	S1
14.	B	U	3	G1	38.	B	U	5	S2
15.	C	U	3	G8	39.	C	U	5	S2
16.	B	U	3	H2	40.	C	U	5	S6
17.	C	U	3	H5	41.	C	U	5	T1
18.	D	K	3	I2	42.	D	H	5	U3, 4, 5
19.	B	H	3	H5	43.	B	K	5	U6
20.	A	U	3	I5	44.	B	U	5	U9
21.	C	H	3	I6	45.	B	K	5	U11, W7
22.	C	K	4	J4	46.	C	U	5	T6
23.	D	U	4	J7	47.	D	U	5	W3
24.	D	U	4	K5	48.	D	U	5	W7

Multiple Choice = 48 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	3	1	A3
2.	2	U	2	2	D7
3.	3	U	3	2	F7
4.	4	U	2	3	G7, 8
5.	5	U	5	3	I4
6.	6	H	2	4	J7, K6
7.	7	U	3	4	N1, 2, M4
8.	8	U	4	4	P5
9.	9	U	3	5	T2
10.	10	U	2	5	V3
11.	11	U	3	5	W7

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.

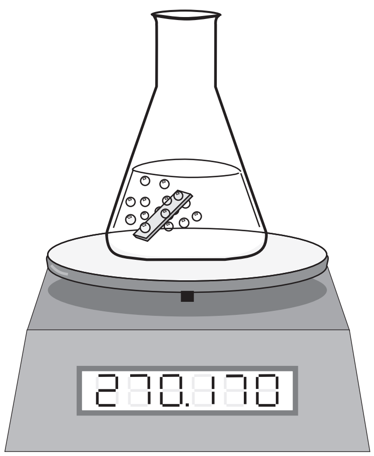
Your steps and assumptions leading to a solution must be written in the spaces below the questions.

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 done to determine the rate of the following reaction:

$$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 3H_{2(g)} + 2AlCl_{3(aq)}$$



The following data are collected:

TIME (s)	MASS OF FLASK PLUS CONTENTS (g)
0.0	270.230
30.0	270.200
60.0	270.170

Calculate the rate of consumption of Al in mol/min. **(3 marks)**

Solution:

$$\left.\text{rate} = \frac{0.060\text{ g } H_2}{60.0\text{ s}} = \frac{0.060\text{ g } H_2}{\text{min}}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned}\text{rate} &= \frac{0.060\text{ g } H_2}{\text{min}} \times \frac{1\text{ mol } H_2}{2.0\text{g}} \\ &= \frac{0.030\text{ mol } H_2}{\text{min}}\end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned}\text{rate} &= \frac{0.030\text{ mol } H_2}{\text{min}} \times \frac{2\text{ mol Al}}{3\text{ mol } H_2} \\ &= \frac{0.020\text{ mol Al}}{\text{min}}\end{aligned}\right\} \leftarrow \textbf{1 mark}$$

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

2. Consider the following equilibrium:

$$4HCl_{(g)} + O_{2(g)} \rightleftarrows 2H_2O_{(g)} + 2Cl_{2(g)} + \text{energy}$$

a) How does the **entropy** change in the forward direction? Explain your reasoning. **(1 mark)**

Solution:

For Example:

Entropy is decreasing. Five particles of gas (reactants) have more entropy than four particles of gas (products). } ← **1 mark**

b) How does the **enthalpy** change in the forward direction? Explain your reasoning. **(1 mark)**

Solution:

For Example:

Enthalpy is decreasing. The reaction is exothermic, so the enthalpy of the products is less than the enthalpy of the reactants. } ← **1 mark**

3. Consider the following equilibrium:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)} \qquad K_{eq} = 1.2 \times 10^{-2}$$

A $2.0\,L$ flask is filled with $0.10\,mol\ HI$. Calculate the concentration of H_2 at equilibrium.

(3 marks)

Solution:

	H_2 +	I_2 $\rightleftarrows$	$2HI$
[I]	0	0	0.050
[C]	$+x$	$+x$	$-2x$
[E]	x	x	$0.050 - 2x$

← **1 ½ marks**

$$K_{eq} = \frac{[HI]^2}{[H_2][I_2]} = 1.2 \times 10^{-2}$$ ← **½ mark**

$$= \frac{(0.050 - 2x)^2}{x^2} = 1.2 \times 10^{-2}$$

$$= \sqrt{\frac{(0.050 - 2x)^2}{x^2}} = \sqrt{1.2 \times 10^{-2}}$$

← **½ mark**

$$x = [H_2] = 0.024\,M$$ ← **½ mark**

4. The solubility of $Mn(IO_3)_2$ is 4.8×10^{-3} mol/L.

a) Write the net ionic equation that describes a saturated solution of $Mn(IO_3)_2$. **(1 mark)**

Solution:

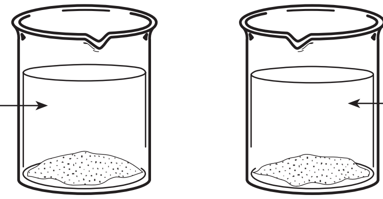
$$Mn(IO_3)_{2(s)} \rightleftarrows Mn^{2+}_{(aq)} + 2IO_3{}^-_{(aq)}$$ **← 1 mark**

b) Calculate the concentrations of the ions in a saturated solution of $Mn(IO_3)_2$. **(1 mark)**

Solution:

$$[Mn^{2+}] = 4.8\times10^{-3}\text{ M}$$
$$[IO_3{}^-] = 2\times4.8\times10^{-3}\text{ M} = 9.6\times10^{-3}\text{ M}$$
← 1 mark

5. Consider the following saturated solutions at $25°C$:



Using calculations, identify the solution with the greater $[Ag^+]$. **(5 marks)**

Solution:

$$AgCl \rightleftarrows Ag^+ + Cl^-$$
$$\quad\quad\quad s \quad\quad s$$

$$[Ag^+][Cl^-] = 1.8\times10^{-10}$$
$$s^2 = 1.8\times10^{-10}$$
$$s = 1.3\times10^{-5}\text{ M}$$
$$[Ag^+] = 1.3\times10^{-5}\text{ M}$$

← **2 marks**

$$Ag_2CO_3 \rightleftarrows 2Ag^+ + CO_3^{2-}$$
$$\quad\quad\quad 2s \quad\quad s$$

$$[Ag^+]^2[CO_3^{2-}] = 8.5\times10^{-12}$$
$$4s^3 = 8.5\times10^{-12}$$
$$s = 1.3\times10^{-4}\text{ M}$$
$$[Ag^+] = 2.6\times10^{-4}\text{ M}$$

← **2 marks**

Therefore $[Ag^+]$ in Ag_2CO_3 is higher than $[Ag^+]$ in $AgCl$. ← **1 mark**

6. Consider a Brönsted-Lowry acid-base equation, where HNO_2 is a reactant and $H_2PO_4^-$ is a product.

a) Complete the following equation. **(1 mark)**

Solution:

$$HNO_2 + \underline{\ HPO_4^{2-}\ } \rightleftarrows \underline{\ NO_2^-\ } + H_2PO_4^-$$ ← **1 mark**

b) Identify the weaker base in the equilibrium in part a). **(1 mark)**

Solution:

NO_2^- ← **1 mark**

7. A chemist prepares a solution by dissolving the salt $NaIO_3$ in water.

a) Write the equation for the dissociation reaction that occurs. **(1 mark)**

Solution:

$NaIO_{3(s)} \rightarrow Na^{+}_{(aq)} + IO_{3\,(aq)}^{-}$ $\leftarrow$ **1 mark**

b) Write the equation for the hydrolysis reaction that occurs. **(1 mark)**

Solution:

$IO_{3\,(aq)}^{-} + H_2O_{(l)} \rightleftarrows HIO_{3(aq)} + OH^{-}_{(aq)}$ $\leftarrow$ **1 mark**

c) Calculate the value of the equilibrium constant for the hydrolysis in part b). **(1 mark)**

Solution:

$$\left.\begin{aligned} K_b &= \frac{K_w}{K_a} \\ &= \frac{1.0\times10^{-14}}{1.7\times10^{-1}} \\ &= 5.9\times10^{-14} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

8. Calculate the pH of a solution prepared by adding $15.0\ \text{mL}$ of $0.500\ \text{M}$ H_2SO_4 to $35.0\ \text{mL}$ of $0.750\ \text{M}$ NaOH. **(4 marks)**

Solution:

For Example:

$$\left[H_3O^+\right] = 2\times\left[H_2SO_4\right] = 2\times 0.500\ \text{M}\times\frac{15.0\ \text{mL}}{50.0\ \text{mL}}$$

$$= 0.300\ \text{M}$$

$$\left[OH^-\right] = [\text{NaOH}] = 0.750\ \text{M}\times\frac{35.0\ \text{mL}}{50.0\ \text{mL}}$$

$$= 0.525\ \text{M}$$

$\leftarrow$ **2 marks**

$$\text{Excess } \left[OH^-\right] = 0.525\ \text{M} - 0.300\ \text{M}$$

$$= 0.225\ \text{M}$$

$\leftarrow$ **1 mark**

$$\text{pOH} = -\log(0.225)$$

$$= 0.648$$

$$\text{pH} = 14.00 - 0.648$$

$$= 13.352$$

$\leftarrow$ **1 mark**

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

9. Balance the following redox reaction in basic solution. **(3 marks)**

$$MnO_4^{-} + C_2O_4^{2-} \rightarrow MnO_2 + CO_2 \qquad (\text{basic})$$

Solution:

$$2 \times \left(2H_2O + 3e^{-} + MnO_4^{-} \rightarrow MnO_2 + 4OH^{-}\right)$$
$$3 \times \left(C_2O_4^{2-} \rightarrow 2CO_2 + 2e^{-}\right)$$

} 2 marks

$$4H_2O + 2MnO_4^{-} + 3C_2O_4^{2-} \rightarrow 6CO_2 + 2MnO_2 + 8OH^{-}$$

← **1 mark**

10. Describe **two** chemically different methods that can be used to prevent corrosion of iron and explain why each method works. **(2 marks)**

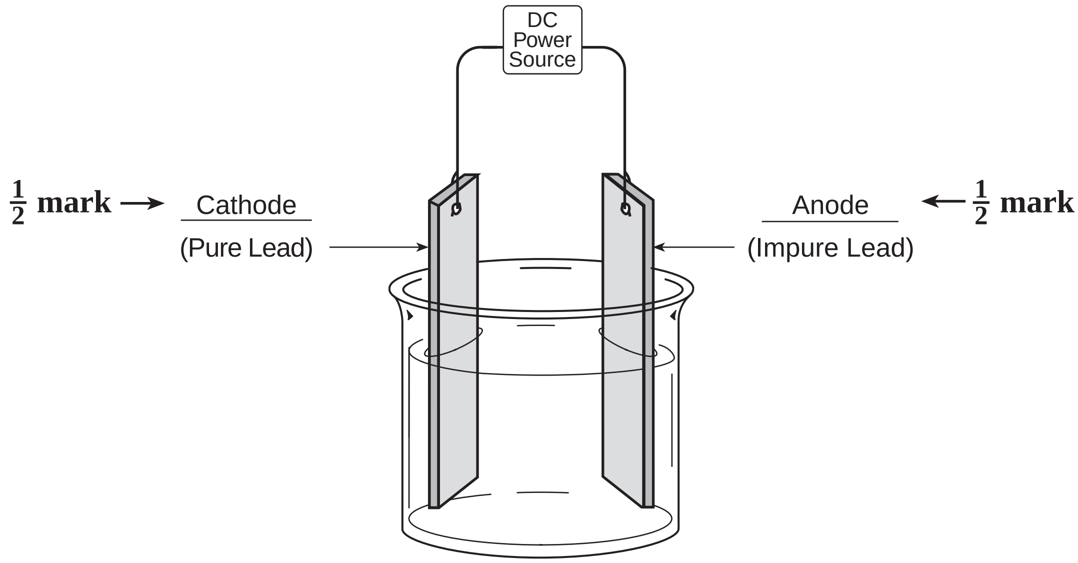
Solution:

For Example:

(Any **two** of the following for **2 marks**. $\frac{1}{2}$ **mark** for each method, $\frac{1}{2}$ **mark** for each explanation.)

- paint the iron — prevents collision of O_2 and H_2O molecules with iron so that rust cannot form
- attach a material such as magnesium — provides cathodic protection (i.e., it is more readily oxidized than the iron)
- provide a small current through the iron object (e.g., boat hull) — prevents or reverses the reaction forming rust

11. Consider the following diagram for the electrorefining of lead:



a) On the diagram above, label the anode and the cathode. **(1 mark)**

Solution:

See diagram above.

b) Write the formula for a suitable electrolyte. **(1 mark)**

Solution:

For Example:

$Pb(NO_3)_2$ ← **1 mark**

c) Write the equation for the reduction half-reaction. **(1 mark)**

Solution:

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

END OF KEY