Chemistry 12

January 1998 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	U	1	A4	25.	C	H	4	L3, 4
2.	C	U	1	A2	26.	A	U	4	L7
3.	D	U	1	C5	27.	A	K	4	L10
4.	B	H	1	B9	28.	A	U	4	L12
5.	D	K	2	D5	29.	C	U	4	M4
6.	D	U	2	F3	30.	B	U	4	N3
7.	B	H	2	E2	31.	D	U	4	O3
8.	D	K	2	E4	32.	A	U	4	O5
9.	C	K	2	F2	33.	C	U	4	P3
10.	B	K	2	F4	34.	B	U	4	P5
11.	D	U	2	F6	35.	D	U	4	Q3
12.	A	U	2	F8	36.	B	K	4	R3
13.	A	U	3	G6	37.	B	U	5	S2
14.	C	K	3	G4	38.	A	U	5	S2
15.	A	U	3	H2	39.	C	U	5	S1, 2
16.	A	U	3	G8	40.	B	U	5	S2
17.	C	U	3	H6	41.	B	H	5	S4
18.	A	U	3	I3	42.	A	U	5	S6
19.	A	H	3	I6	43.	A	U	5	T3
20.	D	K	4	J2	44.	B	U	5	U2
21.	C	U	4	J7	45.	D	U	5	U3
22.	C	U	4	J11	46.	C	U	5	U7
23.	B	K	4	K7	47.	C	K	5	V1
24.	A	H	4	K9, L12	48.	D	U	5	W4

Multiple Choice = 48 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	H	4	1	C2, 5
2.	2	U	4	2	E2, F4, B6
3.	3	U	4	3	G5, I3
4.	4	U	2	3	H3
5.	5	K	2	4	K3, J6
6.	6	U	4	4	M1, 3
7.	7	U	4	4	N2, P4, 6
8.	8	U	3	5	T2
9.	9	U	2	5	U9
10.	10	U	3	5	W3, 4, 8

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. Consider the following overall reaction:

$$2NO + 2H_2 \rightarrow 2H_2O + N_2$$

a) Explain why the reaction is likely to involve more than one step. **(1 mark)**

Solution:

A 4 particle collision is unlikely. ← **1 mark**

b) A proposed mechanism for the reaction is:

Step 1: $NO + H_2 \rightarrow N + H_2O$

Step 2: ?

Step 3: $N_2O + H_2 \rightarrow N_2 + H_2O$

i) Write the equation for Step 2. **(2 marks)**

Solution:

$NO + N \rightarrow N_2O$ ← **2 marks**

ii) Identify all reaction intermediates. **(1 mark)**

Solution:

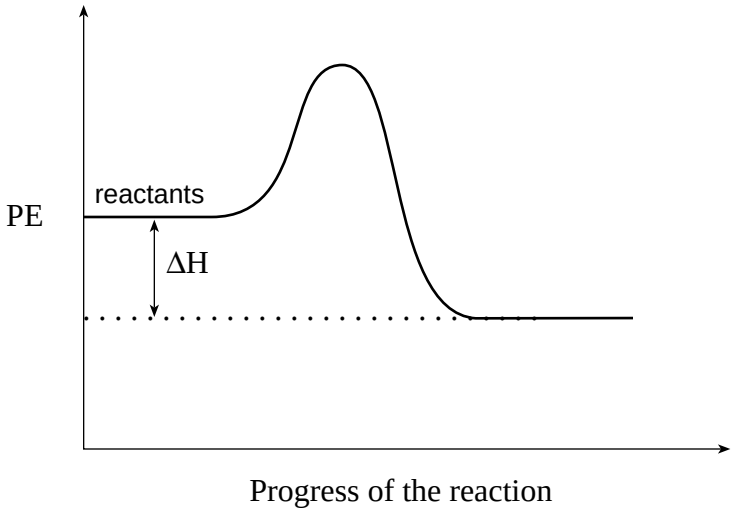
N and N_2O ← $\frac{1}{2}$ **mark for each**

2. Consider the following equilibrium:

$$CS_{2(g)} + 3Cl_{2(g)} \rightleftarrows CCl_{4(g)} + S_2Cl_{2(g)} \qquad \Delta H = -238 \text{ kJ}$$

a) Sketch a potential energy diagram for the reaction above and label ΔH. **(2 marks)**

Solution:



1 mark for general shape
1 mark for ΔH

b) Some CS_2 is added and equilibrium is then reestablished. State the direction of the equilibrium shift and the resulting change in $[Cl_2]$. **(1 mark)**

Solution:
For example:

The equilibrium shifts to the right $\left(\frac{1}{2}\right.$ **mark**$\left.\right)$ and $[Cl_2]$ decreases $\left(\frac{1}{2}\right.$ **mark**$\left.\right)$.

c) The temperature is decreased and equilibrium is then reestablished. What will the effect be on the value of K_{eq}? **(1 mark)**

Solution:

K_{eq} will increase. $\leftarrow$ **1 mark**

3. A 100.00 mL sample of a saturated solution of $Ca(OH)_2$ is evaporated to dryness. The mass of the solid residue is 0.125 g. Calculate the solubility product of $Ca(OH)_2$.

(4 marks)

Solution:

$$\text{Moles of } Ca(OH)_2 = 0.125 \text{ g} \left(\frac{1 \text{ mol}}{74.1 \text{ g}} \right) = 1.687 \times 10^{-3} \text{ mol}$$

$$\text{Solubility} = \frac{1.687 \times 10^{-3} \text{ mol}}{0.10000 \text{ L}}$$

$$= 1.687 \times 10^{-2} \text{ mol/L}$$

} ← **2 marks**

$$Ca(OH)_2 \rightleftarrows Ca^{2+} + 2OH^-$$

$$K_{sp} = \left[Ca^{2+}\right]\left[OH^-\right]^2$$

$$= \left(1.687 \times 10^{-2}\right)\left(3.374 \times 10^{-2}\right)^2$$

$$= 1.92 \times 10^{-5}$$

} ← **2 marks**

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

4. Write the net ionic equation representing the reaction that occurs when equal volumes of 0.20 M H_2SO_4 and 0.20 M $Ba(NO_3)_2$ are mixed together. **(2 marks)**

Solution:

$Ba^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)} \rightarrow BaSO_{4(s)}$ ← **2 marks**

5. Define the term *strong Brönsted-Lowry acid*. **(2 marks)**

Solution:

A strong Brönsted-Lowry acid is a species that donates a proton **(1 mark)** 100% to a receptive base **(1 mark)**.

6. Nicotinic acid, $HC_6H_4NO_2$, is a weak acid found in vitamin B.
Calculate the pH of 0.010 M $HC_6H_4NO_2$ $\left(K_a = 1.4\times10^{-5}\right)$. **(4 marks)**

Solution:

$$HC_6H_4NO_2 + H_2O \rightleftarrows H_3O^+ + C_6H_4NO_2^-$$

[**I**]	0.010	0	0
[**C**]	$-x$	$+x$	$+x$
[**E**]	$0.010 - x$	x	x
	≈ 0.010		

} ← **1 $\frac{1}{2}$ marks**

$$K_a = \frac{\left[H_3O^+\right]\left[C_6H_4NO_2^-\right]}{\left[HC_6H_4NO_2\right]}$$

$$1.4\times10^{-5} = \frac{(x)(x)}{(0.010)}$$

$$x = \left[H_3O^+\right] = 3.74\times10^{-4}\,\text{M}$$

} ← **1 $\frac{1}{2}$ marks**

$$\text{pH} = -\log\left(3.74\times10^{-4}\right) = 3.43 \qquad \leftarrow \textbf{1 mark}$$

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

7.

A solution of NaOH is used to neutralize separate solutions of HF and HBr.

a) Write the formula equation for the neutralization of HF. **(1 mark)**

Solution:

$NaOH + HF \rightarrow NaF + H_2O$ ← **1 mark**

b) Write the net ionic equation for the neutralization of HBr. **(1 mark)**

Solution:

$H^+ + OH^- \rightarrow H_2O$ ← **1 mark**

c) One of the neutralization reactions above produces a salt that undergoes hydrolysis. Identify the salt and write the net ionic equation for the hydrolysis reaction. **(2 marks)**

Solution:
For example:

NaF ← **$\frac{1}{2}$ mark**

$F^- + H_2O \rightleftarrows HF + OH^-$ ← **1 $\frac{1}{2}$ marks**

8. Balance the following redox reaction: **(3 marks)**

$$Sb + HSO_4^- \rightarrow Sb_2O_3 + SO_2 \quad (\text{acid})$$

Solution:
For example:

1 mark for e^- balance

$$2Sb + 3H_2O \rightarrow Sb_2O_3 + 6H^+ + 6e^- \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$3\times\left(HSO_4^- + 3H^+ + 2e^- \rightarrow SO_2 + 2H_2O\right) \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$2Sb + 3HSO_4^- + 3H^+ \rightarrow Sb_2O_3 + 3SO_2 + 3H_2O \quad \leftarrow \textbf{1 mark}$$

9. Consider the following redox reaction:

$$H_2Se + SO_4^{2-} + 2H^+ \rightarrow Se + H_2SO_3 + H_2O$$

Calculate the E° for the reaction above. **(2 marks)**

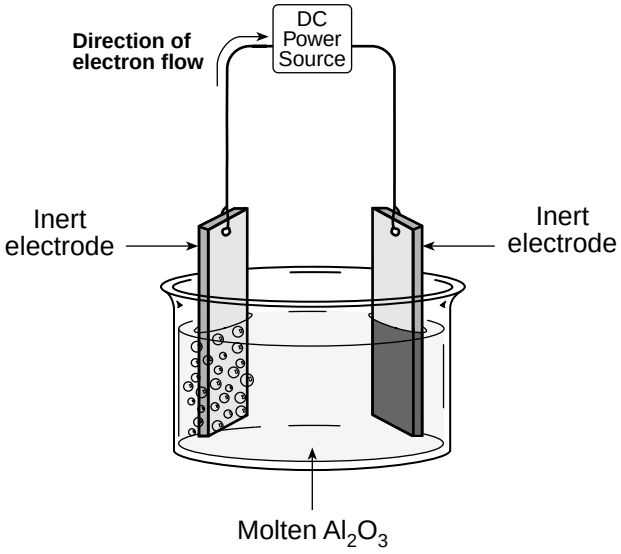
Solution:

$$H_2Se \rightarrow Se + 2H^+ + 2e^- \qquad E^\circ = +0.40\text{ V} \quad \leftarrow \textbf{1 mark}$$

$$SO_4^{2-} + 4H^+ + 2e^- \rightarrow H_2SO_3 + H_2O \qquad E^\circ = +0.17\text{ V} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$E^\circ = +0.57\text{ V} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

10. Consider the following electrolytic cell used for the electrolysis of molten aluminum oxide.



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

Solution:

$2O^{2-} \rightarrow O_2 + 4e^-$ ← **1 mark**

b) Write the equation for the half-reaction taking place at the cathode. **(1 mark)**

Solution:

$Al^{3+} + 3e^- \rightarrow Al$ ← **1 mark**

c) Clearly indicate on the diagram above, the direction of electron flow. **(1 mark)**

Solution:

Electrons flow from left to right through the wire. ← **1 mark**
See diagram above.

END OF KEY