Chemistry 12

January 1996 Provincial Examination

ANSWER KEY / SCORING GUIDE

Topics:
1. Kinetics
2. Equilibrium
3. Solubility
4. Acids, Bases, Salts
5. Oxidation – Reduction

Part A: Multiple-choice

Q	C	T	K	S	CGR	Q	C	T	K	S	CGR
1.	U	1	A	1	I-A-2	25.	U	4	D	1	IV-E-3
2.	U	1	C	1	I-B-2	26.	U	4	C	1	IV-F-7
3.	K	1	D	1	I-B-3, D-3	27.	U	4	C	1	IV-F-8
4.	U	1	D	1	I-D-5	28.	H	4	A	1	IV-G-3, H-10
5.	U	1	C	1	I-D-5	29.	U	4	C	1	IV-H-2
6.	U	1	A	1	I-E-2	30.	K	4	B	1	IV-H-7
7.	U	2	B	1	II-C-3	31.	K	4	A	1	IV-J-1
8.	U	2	B	1	II-I-1	32.	U	4	D	1	IV-J-2
9.	U	2	A	1	II-E-2	33.	U	4	C	1	IV-J-5
10.	U	2	B	1	II-J-1	34.	U	4	C	1	IV-K-2
11.	U	2	B	1	II-G-2	35.	K	4	A	1	IV-L-4
12.	U	2	C	1	II-I-3, 2	36.	U	4	D	1	IV-I-4
13.	U	2	C	1	II-J-3	37.	U	5	B	1	V-A-1
14.	K	3	D	1	III-A-7	38.	K	5	C	1	V-A-6
15.	H	3	A	1	III-B-4, 3	39.	U	5	B	1	V-D-1
16.	U	3	B	1	III-B-6	40.	U	5	B	1	V-D-3
17.	U	3	B	1	III-C-3	41.	U	5	D	1	V-C-3
18.	U	3	A	1	III-D-3	42.	U	5	B	1	V-G-5
19.	H	3	C	1	III-D-6	43.	U	5	D	1	V-G-11
20.	H	3	C	1	III-E-1	44.	U	5	B	1	V-G-2
21.	U	4	C	1	IV-C-2	45.	U	5	A	1	V-H-3
22.	K	4	A	1	IV-D-10	46.	U	5	A	1	V-I-5
23.	U	4	C	1	IV-D-12	47.	U	5	D	1	V-C-1, G12
24.	U	4	C	1	IV-E-2	48.	H	5	C	1	V-B-2

Part B: Written-response

Q	B	C	T	S	CGR	Q	B	C	T	S	CGR
1.	1	U	1	2	I-D-2, 5	7.	7	U	4	2	IV-B-2, C-2, D-7
2.	2	K	1	2	I-E-1, 2	8.	8	H	4	3	IV-F-11, 13
3.	3	U	2	4	II-J-2	9.	9	U	4	5	IV-J-1, 3
4.	4	U	2	1	II-C-1	10.	10	U	5	4	V-E-2
5.	5	U	3	3	III-A-7, D-4	11.	11	U	5	3	V-G-1, 2, 5, 11
6.	6	U	3	3	III-D-5						

Multiple-choice = 48 (48 questions)
Written-response = 32 (11 questions)
Total = 80 marks

LEGEND:

Q = Question Number **C** = Cognitive Level **T** = Topic
K = Keyed Response **S** = Score **CGR** = Curriculum Guide Reference
B = Score Box Number

PART B: WRITTEN-RESPONSE

Value: 32 marks **Suggested Time: 50 minutes**

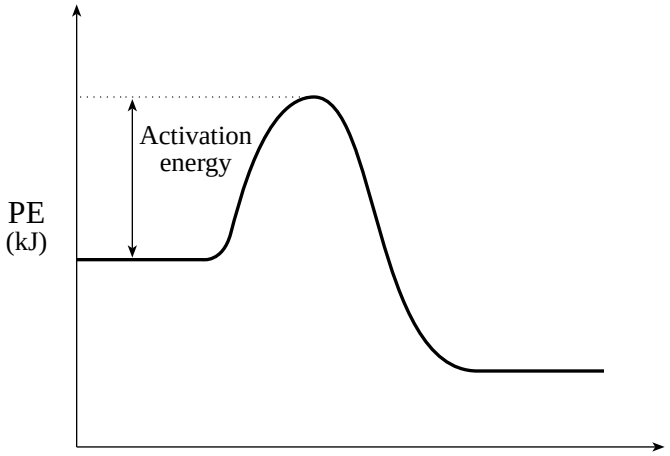
INSTRUCTIONS: You will be expected to communicate your knowledge and understanding of chemical principles in a clear and logical manner.

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) On the graph below, draw the potential energy diagram for an exothermic reaction and label the activation energy. **(1 mark)**



Response:

Potential energy diagram ← **½ mark**

Activation energy ← **½ mark**

b) Define the term *activation energy*. **(1 mark)**

Response:

For example:

The minimum amount of potential energy required to produce an activated complex. ← **1 mark**

2. Consider the following reaction mechanism:

Step 1: $NO_{(g)} + O_{2(g)} \rightarrow NO_{3(g)}$

Step 2: $NO_{3(g)} + NO_{(g)} \rightarrow 2NO_{2(g)}$

a) Identify a reaction intermediate. **(1 mark)**

Response:

A reaction intermediate is NO_3 ← **1 mark**

b) Write the equation for the overall reaction. **(1 mark)**

Response:

$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ ← **1 mark**

3. Consider the following equilibrium:

$$2CH_{4(g)} \rightleftarrows C_2H_{2(g)} + 3H_{2(g)}$$

A 0.180 mol sample of CH_4 is added to an empty 1.00 L container. At equilibrium, the $[C_2H_2]$ is 0.0800 mol/L. Calculate the equilibrium constant. **(4 marks)**

Response:

	$2CH_{4(g)}$	$\rightleftarrows$	$C_2H_{2(g)}$	+	$3H_{2(g)}$
[**I**]	0.180		0		0
[**C**]	−0.160		+0.0800		+0.240
[**E**]	0.020		0.0800		0.240

← **2 marks**

$$K_{eq} = \frac{[C_2H_2][H_2]^3}{[CH_4]^2}$$

$$= \frac{(0.0800)(0.240)^3}{(0.020)^2}$$

$$= 2.8$$

← **2 marks**

4. Consider the following equilibrium:

$$2\,NOCl_{(g)} \rightleftarrows 2\,NO_{(g)} + Cl_{2(g)}$$

A chemist places 2.00 mol NOCl in a 1.0 L container. Describe the changes in $[NOCl]$ and $[Cl_2]$ as the system approaches equilibrium. **(1 mark)**

Response:

$[NOCl]$ decreases as it approaches equilibrium.
$[Cl_2]$ increases as it approaches equilibrium.
} ← **1 mark**

5. A saturated solution of $BaSO_4$ is given to patients needing digestive tract x-rays.

a) Write an equation that represents the solubility equilibrium. **(1 mark)**

Response:

$$BaSO_{4(s)} \rightleftarrows Ba^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)} \quad \leftarrow \textbf{1 mark}$$

b) Calculate the $\left[Ba^{2+}\right]$ present in the saturated solution. **(2 marks)**

Response:

$$BaSO_{4(s)} \rightleftarrows Ba^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)}$$

$$[\ ] \qquad x \qquad x$$

$$K_{sp} = \left[Ba^{2+}\right]\left[SO_4{}^{2-}\right] \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$\left.\begin{aligned} 1.1\times10^{-10} &= (x)(x) \\ \sqrt{1.1\times10^{-10}} &= \sqrt{x^2} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left[Ba^{2+}\right] = x = 1.0\times10^{-5}\ \text{M} \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

6. Will a precipitate form when 90.0 mL of 1.00×10^{-2} M $Cu(NO_3)_2$ and 10.0 mL of 1.00×10^{-2} M $NaIO_3$ are mixed? Explain using appropriate calculations. **(3 marks)**

Response:

$$\left[Cu(NO_3)_2\right] = 1.00\times10^{-2}\,\text{M}\times\frac{90.0\text{ mL}}{100.0\text{ mL}} = 9.00\times10^{-3}\,\text{M}$$

$$\left[NaIO_3\right] = 1.00\times10^{-2}\,\text{M}\times\frac{10.0\text{ mL}}{100.0\text{ mL}} = 1.00\times10^{-3}\,\text{M}$$

← **1 mark**

$$Cu(IO_3)_2 \rightleftarrows Cu^{2+} + 2IO_3^-$$

9.00×10^{-3} M 1.00×10^{-3} M

$$\text{TIP} = \left[Cu^{2+}\right]\left[IO_3^-\right]^2$$

$$= \left(9.00\times10^{-3}\right)\left(1.00\times10^{-3}\right)^2$$

$$= 9.00\times10^{-9}$$

← **1 mark**

$$\text{TIP}\left(9.00\times10^{-9}\right) < K_{sp}\left(6.9\times10^{-8}\right)$$

Therefore, a precipitate does not form.

← **1 mark**

7. Consider the following equilibrium:

$$H_2Se_{(aq)} + HTe^-_{(aq)} \rightleftarrows HSe^-_{(aq)} + H_2Te_{(aq)}$$

The reactants are favoured in this equilibrium.

a) Identify the stronger acid. **(1 mark)**

Response:

The stronger acid is H_2Te ← **1 mark**

b) Identify the weaker base. **(1 mark)**

Response:

The weaker base is HTe^- ← **1 mark**

8. The hydrogen carbonate ion can act as an acid or a base. Use calculations to determine if a solution containing 0.10 M hydrogen carbonate ion is acidic or basic. **(3 marks)**

Response:

$$K_a \text{ for } HCO_3^- = 5.6\times10^{-11}$$

$$K_b \text{ for } HCO_3^- = \frac{K_w}{K_a \text{ of } H_2CO_3} = \frac{1.0\times10^{-14}}{4.3\times10^{-7}}$$

$$= 2.3\times10^{-8}$$

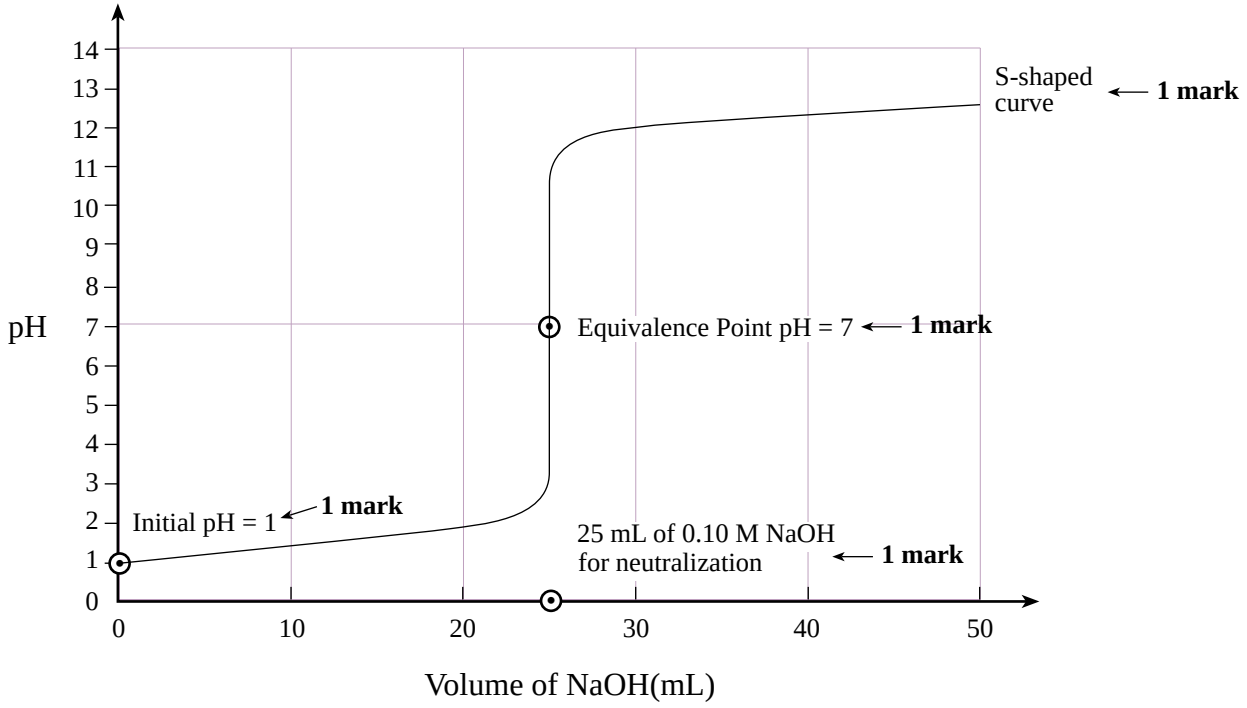
← **2 marks**

Since $K_b > K_a$ for HCO_3^-, the solution is basic. ← **1 mark**

9. In a titration, 25.00 mL of 0.10 M HCl was neutralized by slowly adding 50.00 mL of 0.10 M NaOH.

a) Sketch the titration curve for the reaction and label:
– the initial pH of the HCl,
– the volume of NaOH required to neutralize the HCl, and
– the pH at the equivalence point. **(4 marks)**

Response:



b) Select a suitable indicator for this titration. **(1 mark)**

Response:

For example:

Phenolphthalein ← **1 mark**

10. Balance the following redox reaction: **(4 marks)**

$$TcO_4^- + MnO_4^{2-} \rightarrow Tc + MnO_4^- \qquad \text{(acidic)}$$

Response:

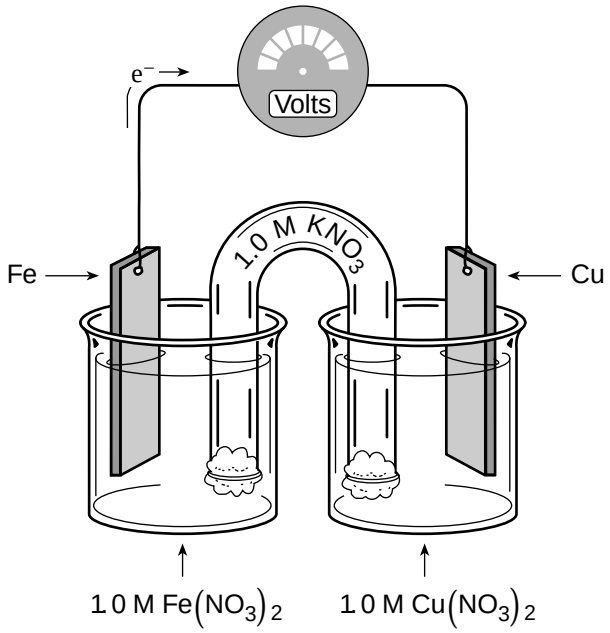
For example:

$TcO_4^- + 8H^+ + 7e^- \rightarrow Tc + 4H_2O$ ← **1 mark** for each half-reaction

$\left(MnO_4^{2-} \rightarrow MnO_4^- + e^-\right) \times 7$ ← **1 mark** for $\times 7$

$TcO_4^- + 7MnO_4^{2-} + 8H^+ \rightarrow Tc + 7MnO_4^- + 4H_2O$ ← **1 mark** for addition

11. Consider the following electrochemical cell:



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

Response:

See above diagram.

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

Response:

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

c) What is the initial cell voltage? **(1 mark)**

Response:

$$\begin{array}{r} 0.45\ V \\ +0.34\ V \\ \hline +0.79\ V \end{array}$$ ← **1 mark**

END OF KEY