Chemistry 12

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

Part B: Written Response

Q	B	C	T	S	CGR	Q	B	C	T	S	CGR
1.	1	U	1	2	I-E-2	7.	7	U	4	2	IV-A-2, D-2, 12
2.	2	U	1	1	I-D-8	8.	8	U	4	4	IV-H-3, H-15
3.	3	U	2	2	II-E-2	9.	9	H	4	3	IV-K-3, 6
4.	4	U	2	3	II-J-1, H-2	10.	10	U	5	4	V-J-4, 3
5.	5	U	3	4	III-D-3	11.	11	U	5	3	V-E-1
6.	6	U	3	4	III-D-7						

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. Consider the following reaction mechanism:

Step 1: $ClO_{2(g)} + F_{2(g)} \rightarrow FClO_{2(g)} + F_{(g)}$ (slow)

Step 2: $F_{(g)} + ClO_{2(g)} \rightarrow FClO_{2(g)}$ (fast)

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

Response:

$2ClO_2 + F_2 \rightarrow 2FClO_2$

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

Response:

F

2. Consider the decomposition of ammonia:

$$2NH_{3(g)} \rightarrow N_{2(g)} + 3H_{2(g)}$$

When 1.0 mol NH_3 reacts, 46 kJ of energy is absorbed. Rewrite the equation for this reaction, including the value of the heat term. **(1 mark)**

Response:

$2NH_3 + 92\ kJ \rightarrow N_2 + 3H_2$

3. Consider the following equilibrium:

$$2CrO_4^{2-}{}_{(aq)} + H_2O_{(\ell)} \rightleftarrows Cr_2O_7^{2-}{}_{(aq)} + 2OH^-_{(aq)}$$

yellow orange

When HCl is added drop-by-drop to the yellow solution above, the solution turns orange. Explain why this colour change occurs. **(2 marks)**

Response:

For example:

HCl neutralizes OH^- $\quad H^+ + OH^- \rightarrow H_2O$

$\therefore \left[OH^-\right]$ decreases, therefore equilibrium shifts right (orange).

} ← **2 marks**

4. Consider the following equilibrium:

$$2NO_{(g)} + O_{2(g)} \rightleftarrows 2NO_{2(g)}$$

At $227°C$ in a 2.00 L container there are 0.044 mol NO, 0.100 mol O_2 and 7.88 mol NO_2 at equilibrium. Calculate the equilibrium constant. **(3 marks)**

Response:

$$2NO + O_2 \rightleftarrows 2NO_2$$

	$\frac{0.044\ \text{mol}}{2.00\ \text{L}}$	$\frac{0.100\ \text{mol}}{2.00\ \text{L}}$	$\frac{7.88\ \text{mol}}{2.00\ \text{L}}$
$[E]$	$= 0.022$	$= 0.0500$	$= 3.94$

} ← **1 mark**

$$K_{eq} = \frac{[NO_2]^2}{[NO]^2[O_2]} = \frac{(3.94)^2}{(0.022)^2(0.0500)}$$ ← **1 ½ marks**

$$= 6.4 \times 10^5$$ ← **½ mark**

5. A 25.00 mL sample of a saturated ZnF_2 solution was evaporated to dryness. The mass of the residue was 0.508 g. Calculate the solubility product constant of ZnF_2. **(4 marks)**

Response:

$$\text{mol } ZnF_2 = \frac{0.508 \text{ g}}{103.4 \text{ g/mol}} = 4.91\times10^{-3}$$

$$\text{solubility } ZnF_2 = \frac{4.91\times10^{-3} \text{ mol}}{0.02500 \text{ L}} = 1.97\times10^{-1} \text{ M}$$

} ← **1 ½ marks**

$$ZnF_{2(s)} \rightleftarrows Zn^{2+}_{(aq)} + 2F^-_{(aq)}$$

$$x \qquad 2x$$

$$\left[Zn^{2+}\right] = x = 1.97\times10^{-1} \text{ M}$$

$$\left[F^-\right] = 2x = 2\left(1.97\times10^{-1}\right) = 3.93\times10^{-1} \text{ M}$$

} ← **1 mark**

$$K_{sp} = \left[Zn^{2+}\right]\left[F^-\right]^2$$

$$= \left(1.97\times10^{-1}\right)\left(3.93\times10^{-1}\right)^2$$

$$= 3.04\times10^{-2}$$

} ← **1 ½ marks**

Deduct ½ mark for incorrect significant figures.

6. The following data were collected when a 25.00 mL sample of water containing chloride ion was titrated using 0.100 M $AgNO_3$ to completely precipitate the chloride ion.

Initial volume of $AgNO_3$	18.20 mL
Final volume of $AgNO_3$	27.22 mL

a) Write the net ionic equation for the precipitation reaction. **(1 mark)**

Response:

$$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$$

b) Calculate the $\left[Cl^-\right]$. **(3 marks)**

Response:

$$\text{Volume of } AgNO_3 \text{ used } = 27.22 - 18.20 = 9.02 \text{ mL} \quad \leftarrow 1 \text{ mark}$$

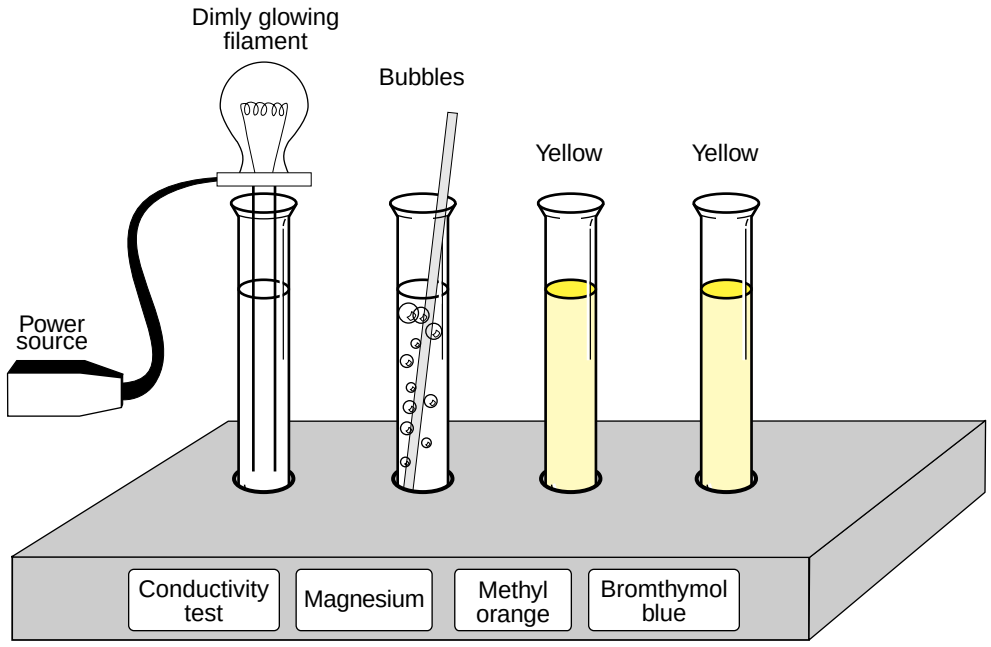
$$\text{mol } AgNO_3 = 0.100 \text{ M} \times 0.00902 \text{ L} = 9.02 \times 10^{-4} \quad \leftarrow \tfrac{1}{2} \text{ mark}$$

$$\text{mol } Cl^- = 9.02 \times 10^{-4} \text{ mol } Ag^+ \times \frac{1 \text{ mol } Cl^-}{1 \text{ mol } Ag^+} = 9.02 \times 10^{-4} \quad \leftarrow \tfrac{1}{2} \text{ mark}$$

$$\left[Cl^-\right] = \frac{9.02 \times 10^{-4} \text{ mol}}{0.02500 \text{L}} = 3.61 \times 10^{-2} \text{ M} \quad \leftarrow 1 \text{ mark}$$

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

7. A 1.0 M unknown solution was analyzed and the following was observed:



Classify the unknown as an acid or base indicating whether it is weak or strong.
Justify your answer using the data provided. **(2 marks)**

Response:

For example:

Unknown is an **acid**
because it reacts with magnesium.
or
bromthymol blue is yellow $\therefore$ pH < 6.0

← **1 mark**

Unknown is a **weak** acid
because it has poor electrical conductivity.
or
indicators are both yellow which indicates
a pH between 4.4 and 6.0

← **1 mark**

8. Calculate the pH of 2.0 M nitrous acid. **(4 marks)**

Response:

	$\mathbf{HNO_2} + \mathbf{H_2O} \rightleftharpoons$	$\mathbf{H_3O^+}$ +	$\mathbf{NO_2^-}$
[**I**]	**2.0**	0	0
[**C**]	$-x$	$+x$	$+x$
[**E**]	$2.0 - x$	x	x

← **1 $\frac{1}{2}$ marks**

$\approx$ **2.0** ← $\frac{1}{2}$ **mark** assumption

$$K_a\ HNO_2 = 4.6 \times 10^{-4} = \frac{[H_3O^+][NO_2^-]}{[HNO_2]}$$

$$4.6 \times 10^{-4} = \frac{x^2}{2.0}$$

$$3.0 \times 10^{-2} = x$$

$$[H_3O^+] = 3.0 \times 10^{-2}\ M$$

$$pH = -\log 3.0 \times 10^{-2} = 1.52$$

← **2 marks**

9. A 2.0 L solution contains one mole of the weak acid, H_3PO_4, in equilibrium with one mole of the salt, NaH_2PO_4.

a) Write an equation that represents this equilibrium. **(2 marks)**

Response:

For example:

$$H_3PO_4 + H_2O \rightleftarrows H_3O^+ + H_2PO_4^-$$

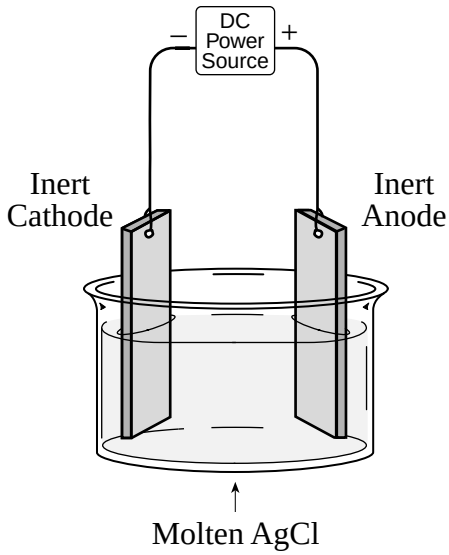
b) Explain why the pH of this solution does not change significantly when 10.0 mL of 1.0 M KOH is added. **(1 mark)**

Response:

For example:

A buffer solution forms and resists a change in pH.

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



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

Response:

Electron flow is from the anode to the cathode on the diagram.

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

Response:

$2Cl^- \rightarrow Cl_2 + 2e^-$

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

Response:

$Ag^+ + e^- \rightarrow Ag$

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

Response:

$2Ag^+ + 2Cl^- \rightarrow 2Ag + Cl_2$

11. Write the balanced equation for the half-reaction:

$$Cu(OH)_2 \rightarrow Cu_2O \qquad \text{(basic)}$$ **(3 marks)**

Response:

$$2Cu(OH)_2 + 2e^- \rightarrow Cu_2O + H_2O + 2OH^-$$

Balanced in acid ← **2 marks**
Convert to base ← **1 mark**

END OF KEY