# Chemistry 12

June 1997 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 | D | 1 | I-A-2 | 25. | U | 4 | D | 1 | IV-B-3 |
| 2. | K | 1 | D | 1 | I-B-2 | 26. | U | 4 | A | 1 | IV-F-3 |
| 3. | U | 1 | B | 1 | I-D-5 | 27. | U | 4 | A | 1 | IV-F-7 |
| 4. | K | 1 | D | 1 | I-E-2 | 28. | H | 4 | C | 1 | IV-F-4, 6, H-9 |
| 5. | K | 1 | D | 1 | I-E-3 | 29. | H | 4 | A | 1 | IV-F-11 |
| 6. | K | 2 | C | 1 | II-A-3 | 30. | U | 4 | A | 1 | IV-G-3, F-9 |
| 7. | U | 2 | D | 1 | II-E-2 | 31. | U | 4 | B | 1 | IV-I-2 |
| 8. | H | 2 | D | 1 | II-C-4 | 32. | U | 4 | D | 1 | IV-J-1 |
| 9. | U | 2 | B | 1 | II-E-2 | 33. | U | 4 | C | 1 | IV-J-4 |
| 10. | K | 2 | C | 1 | II-G-2 | 34. | K | 4 | D | 1 | IV-J-5 |
| 11. | U | 2 | B | 1 | II-I-2 | 35. | U | 4 | B | 1 | IV-J-1, 2, K-1 |
| 12. | U | 2 | A | 1 | II-J-2 | 36. | K | 4 | C | 1 | IV-L-2 |
| 13. | U | 2 | C | 1 | II-J-4 | 37. | K | 5 | C | 1 | V-A-6 |
| 14. | K | 3 | C | 1 | III-A-1 | 38. | U | 5 | D | 1 | V-A-3 |
| 15. | U | 3 | C | 1 | III-B-3 | 39. | U | 5 | A | 1 | V-A-4 |
| 16. | H | 3 | B | 1 | III-B-7 | 40. | U | 5 | B | 1 | V-C-3 |
| 17. | U | 3 | C | 1 | III-A-8 | 41. | U | 5 | A | 1 | V-D-1 |
| 18. | U | 3 | B | 1 | III-D-2 | 42. | U | 5 | A | 1 | V-B-4 |
| 19. | U | 3 | C | 1 | III-D-3 | 43. | U | 5 | D | 1 | V-E-1 |
| 20. | U | 3 | D | 1 | III-D-4 | 44. | U | 5 | C | 1 | V-F-2 |
| 21. | K | 4 | A | 1 | IV-B-1 | 45. | U | 5 | C | 1 | V-G-4, 6 |
| 22. | U | 4 | B | 1 | IV-D-2 | 46. | U | 5 | C | 1 | V-G-13 |
| 23. | U | 4 | C | 1 | IV-B-2 | 47. | K | 5 | D | 1 | V-I-3 |
| 24. | U | 4 | D | 1 | IV-D-7 | 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 | 4 | I-D-7 | 6. | a | 6 | U | 4 | 2 | IV-E-14 |
| | | | | | | I-B-2, C-1, D-3 | | b | 6 | K | 4 | 1 | IV-D-7, 8 |
| 2. | a | 2 | K | 2 | 1 | II-E-2 | 7. | | 7 | U | 4 | 2 | IV-H-9 |
| | b | 2 | U | 2 | 1 | II-E-2 | 8. | | 8 | U | 4 | 4 | IV-F-10 |
| 3. | | 3 | U | 2 | 3 | II-J-3 | 9. | | 9 | U | 5 | 3 | V-E-2 |
| 4. | a | 4 | K | 3 | 1 | III-B-5 | 10. | | 10 | H | 5 | 3 | V-F-1 |
| | b | 4 | U | 3 | 3 | III-D-5 | 11. | a | 11 | U | 5 | 1 | V-H-1 |
| 5. | | 5 | H | 4 | 2 | IV-D-7, 8 | | b | 11 | K | 5 | 1 | V-H-1 |

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. The combustion of coal, C, produces carbon dioxide gas according to the following equation:

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} + 394 \text{ kJ}$$

a) What is the value of $\Delta H$ for this reaction? **(1 mark)**

**Response:**

$\Delta H = -394$ kJ/mol $CO_2$ ← **1 mark**

b) Using collision theory, explain why a lump of coal does not react with oxygen at room temperature and pressure. **(1 mark)**

**Response:**

**For example:**

This reaction has a very high activation energy and therefore collisions will be unsuccessful. } ← **1 mark**

c) Many coal mine disasters have resulted when a spark ignites coal dust in the air. Explain, using collision theory. **(2 marks)**

**Response:**

**For example:**

The spark provides activation energy, therefore more effective collisions occur. ← **1 mark**

The large surface area provides for more collisions to occur. ← **1 mark**

2. Consider the following equilibrium:

$$CO_{(g)} + 2H_{2(g)} \rightleftarrows CH_3OH_{(g)} \qquad \Delta H = -18 \text{ kJ}$$

Explain, using Le Chatelier's principle, how the following changes will affect the number of moles of $CH_3OH$ present at equilibrium.

a) Adding a catalyst. **(1 mark)**

**Response:**

**For example:**

The moles of $CH_3OH$ will not change because the equilibrium does not shift. ← **1 mark**

b) Decreasing the volume of the system. **(1 mark)**

**Response:**

**For example:**

The moles of $CH_3OH$ will increase because the equilibrium shifts right. ← **1 mark**

3. Consider the following equilibrium:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)} \qquad K_{eq} = 64$$

Equal moles of $H_2$ and $I_2$ are placed in a 1.00 L container. At equilibrium, the $[HI] = 0.160$ mol/L . Calculate the initial $[H_2]$. **(3 marks)**

**Response:**

| | $H_{2(g)}$ | + | $I_{2(g)}$ | $\rightleftarrows$ | $2HI_{(g)}$ | |
|---|---|---|---|---|---|---|
| [**I**] | $x$ | | $x$ | | 0 | |
| [**C**] | $-0.080$ | | $-0.080$ | | $+0.160$ | ← **1 ½ marks** |
| [**E**] | $x - 0.080$ | | $x - 0.080$ | | 0.160 | |

$$K_{eq} = \frac{[HI]^2}{[H_2][I_2]}$$

$$64 = \frac{(0.160)^2}{(x - 0.080)^2}$$ ← **1 ½ marks**

$$[H_2] = x = 0.10 \text{ mol/L}$$

4. a) Write the net ionic equation for the precipitation reaction that occurs when solutions of $NaIO_3$ and $AgNO_3$ are mixed. **(1 mark)**

**Response:**

$$Ag^+_{(aq)} + IO_3^-{}_{(aq)} \rightarrow AgIO_{3(s)} \quad \leftarrow \textbf{1 mark}$$

b) Using appropriate calculations, explain why a precipitate forms when 15.0 mL of 0.50 M $NaIO_3$ are added to 35.0 mL of 0.50 M $AgNO_3$. **(3 marks)**

**Response:**

$$\left[IO_3^-\right] = 0.50\ \text{M} \times \frac{15.0\ \text{mL}}{50.0\ \text{mL}} = 0.15\ \text{M} \quad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\left[Ag^+\right] = 0.50\ \text{M} \times \frac{35.0\ \text{mL}}{50.0\ \text{mL}} = 0.35\ \text{M} \quad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\left.\begin{aligned} \text{Trial } K_{sp} &= \left[Ag^+\right]\left[IO_3^-\right] \\ &= 0.35\ \text{M} \times 0.15\ \text{M} \\ &= 0.052 \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

Since Trial $K_{sp}(0.052) > K_{sp}\left(3.2 \times 10^{-8}\right)$, a precipitate forms. $\leftarrow$ **1 mark**

5. What is the maximum $\left[CO_3^{2-}\right]$ that can exist in a $1.3 \times 10^{-4}$ M $AgNO_3$ solution? **(2 marks)**

**Response:**

$$2Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow Ag_2CO_{3(s)}$$

$$K_{sp} = \left[Ag^+\right]^2\left[CO_3^{2-}\right] \quad \left.\begin{array}{l}\\ \\ \end{array}\right\} \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$8.5 \times 10^{-12} = \left(1.3 \times 10^{-4}\right)^2\left[CO_3^{2-}\right] \quad \leftarrow \textbf{1 mark}$$

$$\left[CO_3^{2-}\right] = 5.0 \times 10^{-4}\ \text{M} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$\frac{1}{2}$ **mark was deducted for incorrect significant figures**

6. a) Write the net ionic equation for the predominant reaction between $NaHSO_3$ and $NaHC_2O_4$. **(2 marks)**

**Response:**

$$HSO_3^- + HC_2O_4^- \rightleftarrows C_2O_4^{2-} + H_2SO_3$$

b) Explain why the reactants are favoured in the above reaction. **(1 mark)**

**Response:**

**For example:**

$H_2SO_3$ is a stronger acid than $HC_2O_4^-$ ← **1 mark**

7. What is the $\left[H_3O^+\right]$ in a solution formed by adding 60.0 mL of water to 40.0 mL of 0.040 M KOH? **(2 marks)**

**Response:**

$$\textbf{After dilution } [\mathbf{KOH}] = \mathbf{0.040\ M} \times \frac{\mathbf{40.0\ mL}}{\mathbf{100.0\ mL}} \quad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\left[\mathbf{OH^-}\right] = 0.016\ \mathbf{M} \quad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\left[\mathbf{H_3O^+}\right] = \frac{1.0\times10^{-14}}{0.016} = 6.2\times10^{-13}\ \mathbf{M} \quad \leftarrow \textbf{1 mark}$$

8. Calculate the pH in 100.0 mL of 0.400 M $H_3BO_3$. **(4 marks)**

**Response:**

$$H_3BO_3 \ + \ H_2O \ \rightleftarrows \ H_3O^+ + H_2BO_3^-$$

| | | | |
|---|---|---|---|
| [**I**] | 0.400 | 0 | 0 |
| [**C**] | $-x$ | $+x$ | $+x$ |
| [**E**] | $0.400 - x \approx 0.400$ | $x$ | $x$ |

$\leftarrow$ **1 $\frac{1}{2}$ marks**

$$K_a = \frac{\left[H_3O^+\right]\left[H_2BO_3^-\right]}{\left[H_3BO_3\right]}$$

$$7.3\times10^{-10} = \frac{x^2}{0.400}$$

$$x = 1.7\times10^{-5}$$

$$\left[H_3O^+\right] = 1.7\times10^{-5}\ \mathrm{M}$$

$\leftarrow$ **1 $\frac{1}{2}$ marks**

$$\mathrm{pH} = -\log\left(1.7\times10^{-5}\right) = 4.77 \quad \leftarrow \textbf{1 mark}$$

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

$$ClO_4^- + Al \rightarrow Cl^- + Al^{3+} \qquad (\text{acidic})$$

**Response:**

**1 mark**

$3\left(ClO_4^- + 8H^+ + 8e^- \rightarrow Cl^- + 4H_2O\right)$ ← **½ mark**

$8\left(Al \rightarrow Al^{3+} + 3e^-\right)$ ← **½ mark**

$$3ClO_4^- + 8Al + 24H^+ \rightarrow 3Cl^- + 8Al^{3+} + 12H_2O$$ ← **1 mark**

10. An impure sample of iron was dissolved in acid. The $Fe^{2+}$ in this solution was titrated with 0.0210 M $KMnO_4$. Use the following data table and redox equation to determine the moles of $Fe^{2+}$ in the sample. **(3 marks)**

$$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

| TRIAL | VOLUME $KMnO_4$ |
|---|---|
| 1 | 37.26 mL |
| 2 | 35.18 mL |
| 3 | 35.22 mL |

**Response:**

Average volume $KMnO_4 = 35.20$ mL ← **1 mark**

$$\text{mol } KMnO_4 = (0.03520\ \text{L})(0.0210\ \text{M}) = 7.392 \times 10^{-4}\ \text{mol}$$ ← **1 mark**

$$\text{mol } Fe^{2+} = \left(\frac{5\ \text{mol } Fe^{2+}}{1\ \text{mol } MnO_4^-}\right)\left(7.39 \times 10^{-4}\ \text{mol}\right) = 3.70 \times 10^{-3}\ \text{mol}$$ ← **1 mark**

**½ mark was deducted for incorrect significant figures**

11. The overall reaction in a fuel cell is:

$$2H_2 + O_2 \rightarrow 2H_2O$$

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

**Response:**

**For example:**

$H_{2(g)} + 2OH^- \rightarrow 2H_2O + 2e^-$ ← **1 mark**

b) Is the overall reaction spontaneous? Explain. **(1 mark)**

**Response:**

Yes, the reaction is spontaneous.

**For example:**

- $0.82 - (-0.41) = 1.23\ V$
- Positive $E°$ value
- Electrochemical cell

**END OF KEY**