# Chemistry 12

## August 2008 — Form A

Provincial Examination — Answer Key

| Cognitive Processes | Weightings | Question Types |
|---|---|---|
| **K** = Knowledge | 11% | **50** = Multiple Choice (MC) |
| **U** = Understanding | 78% | **8** = Written Response (WR) |
| **H** = Higher Mental Processes | 11% | |

| Topics | Prescribed Learning Outcomes (PLOs) | Weightings |
|---|---|---|
| 1. Reaction Kinetics | A1–8 | 12% |
| 2. Dynamic Equilibrium | B1–6 | 16% |
| 3. Solubility Equilibria | C1–8 | 16% |
| 4. Acids, Bases, and Salts | D1–6, E, F1–8 | 33% |
| 5. Oxidation – Reduction | G1–4, H1–5 | 23% |

| Question Number | Keyed Response | Cognitive Process | Mark | Topic | PLO | Question Type |
|---|---|---|---|---|---|---|
| 1. | C | U | 1 | 1 | A2 | MC |
| 2. | B | U | 1 | 1 | A3 | MC |
| 3. | B | U | 1 | 1 | A4 | MC |
| 4. | D | U | 1 | 1 | A7 | MC |
| 5. | D | U | 1 | 1 | A6 | MC |
| 6. | C | U | 1 | 2 | B1 | MC |
| 7. | A | K | 1 | 2 | B2 | MC |
| 8. | B | U | 1 | 2 | B3 | MC |
| 9. | C | U | 1 | 2 | B3 | MC |
| 10. | A | H | 1 | 2 | B3 | MC |
| 11. | D | U | 1 | 2 | B5 | MC |
| 12. | B | U | 1 | 2 | B6 | MC |
| 13. | C | U | 1 | 2 | B6 | MC |
| 14. | A | H | 1 | 2 | B6,3 | MC |
| 15. | B | H | 1 | 3 | C1/D4 | MC |
| 16. | A | U | 1 | 3 | C3 | MC |
| 17. | B | U | 1 | 3 | C4 | MC |
| 18. | A | H | 1 | 3 | C5/F1 | MC |
| 19. | B | U | 1 | 3 | C6 | MC |
| 20. | A | U | 1 | 3 | C7 | MC |
| 21. | C | U | 1 | 3 | C7 | MC |
| 22. | A | U | 1 | 4 | D1/F3 | MC |
| 23. | D | K | 1 | 4 | D3 | MC |
| 24. | A | K | 1 | 4 | D4 | MC |
| 25. | B | U | 1 | 4 | D5 | MC |
| 26. | C | U | 1 | 4 | D6,5 | MC |

| Question Number | Keyed Response | Cognitive Process | Mark | Topic | PLO | Question Type |
|---|---|---|---|---|---|---|
| 27. | B | K | 1 | 4 | E1 | MC |
| 28. | C | H | 1 | 4 | E1, 2 | MC |
| 29. | D | U | 1 | 4 | E2 | MC |
| 30. | A | H | 1 | 4 | E3/F5 | MC |
| 31. | C | U | 1 | 4 | E3, 2 | MC |
| 32. | D | U | 1 | 4 | F4 | MC |
| 33. | D | U | 1 | 4 | F5 | MC |
| 34. | A | K | 1 | 4 | F2 | MC |
| 35. | B | U | 1 | 4 | F3 | MC |
| 36. | A | U | 1 | 4 | F1 | MC |
| 37. | A | U | 1 | 4 | F6 | MC |
| 38. | D | U | 1 | 4 | F8 | MC |
| 39. | A | K | 1 | 5 | G1 | MC |
| 40. | D | U | 1 | 5 | G1 | MC |
| 41. | C | U | 1 | 5 | G1 | MC |
| 42. | C | H | 1 | 5 | G2 | MC |
| 43. | C | U | 1 | 5 | G3 | MC |
| 44. | A | U | 1 | 5 | G4 | MC |
| 45. | A | K | 1 | 5 | H1 | MC |
| 46. | A | U | 1 | 5 | H1 | MC |
| 47. | B | U | 1 | 5 | H1 | MC |
| 48. | C | H | 1 | 5 | H1/C4 | MC |
| 49. | C | U | 1 | 5 | H3 | MC |
| 50. | B | U | 1 | 5 | H4 | MC |

| Question Number | Keyed Response | Cognitive Process | Mark | Topic | PLO | Question Type |
|---|---|---|---|---|---|---|
| 1. | – | U | 4 | 1 | A2 | WR |
| 2. | – | U | 4 | 2 | B6 | WR |
| 3. | – | U | 4 | 3 | C7 | WR |
| 4. | – | U | 3 | 4 | D5 | WR |
| 5. | – | U | 5 | 4 | F5 | WR |
| 6. | – | U | 3 | 4 | F1 | WR |
| 7. | – | U | 4 | 5 | G3 | WR |
| 8. | – | U | 3 | 5 | H4 | WR |

# Chemistry 12

**2007/08 Released Exam**

**August 2008**

Provincial Examination — Scoring Guide

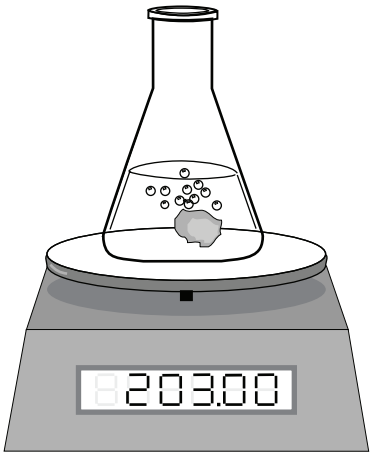
1. **(4 marks)**

Solid sodium bicarbonate and acetic acid were reacted in an open flask as follows:

$$NaHCO_3(s) + CH_3COOH(aq) \rightarrow NaCH_3COO(aq) + H_2O(\ell) + CO_2(g)$$

The following data was recorded:

| Time (s) | Mass of Flask and Contents (g) |
|---|---|
| 0.00 | 203.00 g |
| 30.0 | 202.95 g |
| 60.0 | 202.93 g |
| 90.0 | 202.92 g |




Calculate the overall rate of reaction in grams of $NaHCO_3$ per minute.

**Solution:**

***For Example:***

$$\text{rate} = \frac{0.08\,\text{g } CO_2}{90\,\text{s}} \times \frac{60\,\text{s}}{\text{min}} = 0.053\,\text{g } CO_2/\text{min} \qquad \leftarrow \textbf{2 marks}$$

$$\text{rate} = \frac{0.053\,\text{g } CO_2}{\text{min}} \times \frac{1\,\text{mol } CO_2}{44\,\text{g } CO_2} \times \frac{1\,\text{mol } NaHCO_3}{1\,\text{mol } CO_2} \times \frac{84\,\text{g } NaHCO_3}{\text{mol}}$$

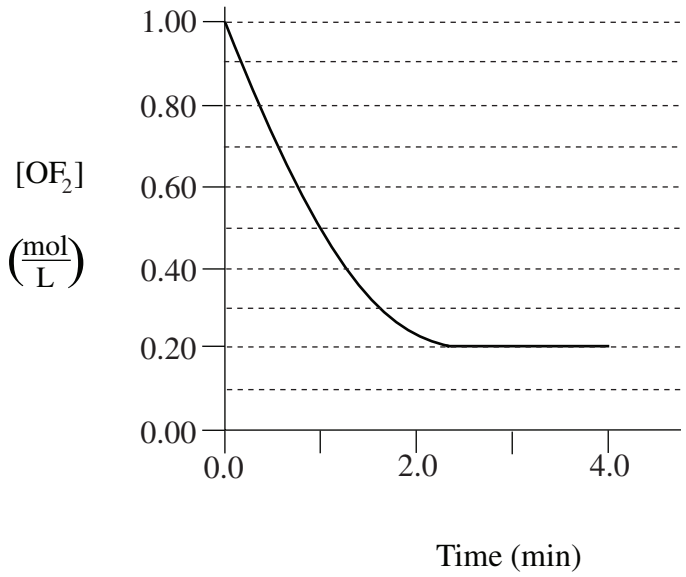
$$= 0.1\,\text{g } NaHCO_3/\text{min} \qquad \leftarrow \textbf{2 marks}$$

2. **(4 marks)**

Consider the following equilibrium:

$$O_2(g) + 2F_2(g) \rightleftarrows 2OF_2(g)$$

Initially, $OF_2$ was placed in a $1.00\,L$ container and allowed to react. The amount of $OF_2$ was monitored over 4.0 minutes and the following graph was produced:




Calculate the value of $K_{eq}$.

**Solution:**

***For Example:***

| | $O_2(g)$ | + | $2F_2(g)$ | $\rightleftarrows$ | $2OF_2(g)$ |
|---|---|---|---|---|---|
| [I] | 0 | | 0 | | 1.00 M |
| [C] | +0.40 | | +0.80 M | | −0.80 M |
| [E] | 0.40 | | 0.80 | | 0.20 |

← **2 marks**

$$K_{eq} = \frac{[OF_2]^2}{[O_2][F_2]^2}$$

$$= \frac{(0.20)^2}{(0.40)(0.80)^2}$$ ← **1 mark**

$$= 0.16$$ ← **1 mark**

3. **(4 marks)**

Consider the equilibrium for a saturated solution of $PbI_2$:

$$PbI_2(s) \rightleftarrows Pb^{2+}(aq) + 2I^-(aq)$$

What is the maximum $[Ag^+]$ that can exist in a saturated solution of $PbI_2$ without causing a precipitate to form?

**Solution:**

***For Example:***

For the $PbI_2$:

$$K_{sp} = [Pb^{2+}][I^-]^2 = 8.5 \times 10^{-9}$$

$s$ = solubility

$$4s^3 = 8.5 \times 10^{-9}$$

$$s = \sqrt[3]{\frac{8.5 \times 10^{-9}}{4}} = \sqrt[3]{2.1 \times 10^{-9}}$$

$$s = 1.286 \times 10^{-3}\ M$$

← **1 mark**

$$[I^-] = 2s = 2.57 \times 10^{-3}\ M$$

← **1 mark**

For $AgI$:

$$K_{sp} = [Ag^+][I^-] = 8.5 \times 10^{-17}$$

$$[Ag^+] = \frac{8.5 \times 10^{-17}}{2.57 \times 10^{-3}}$$

← **1 mark**

$$[Ag^+] = 3.3 \times 10^{-14}\ M$$

← **1 mark**

4. **(3 marks)**

Complete the following equilibrium, then predict whether the reactants or products will be favoured and explain why.

$$HSO_4^- + HSO_3^- \rightleftarrows \_\_\_\_\_$$

**Solution:**

***For Example:***

$HSO_4^- + HSO_3^- \rightleftarrows \underline{H_2SO_3 + SO_4^{2-}}$ ← **1 mark**

The equilibrium favours the reactants ← **1 mark**

since the $K_a\ H_2SO_3 > K_a\ HSO_4^-$ ← **1 mark**

5. **(5 marks)**

Calculate the initial concentration of a $KF$ salt solution that has a $pH = 8.65$.
Begin by writing the equation for the predominant equilibrium reaction.

**Solution:**

***For Example:***

| | $F^-(aq)$ | + $H_2O(\ell)$ $\rightleftarrows$ | $HF(aq)$ | + $OH^-(aq)$ | ← **1 mark** |
|---|---|---|---|---|---|
| [I] | $x$ | | 0 | 0 | |
| [C] | $-4.47 \times 10^{-6}$ | | $+4.47 \times 10^{-6}$ | $+4.47 \times 10^{-6}$ | |
| [E] | $x - 4.47 \times 10^{-6}$ | | $4.47 \times 10^{-6}$ | $4.47 \times 10^{-6}$ | ← **1 mark** |

↑

$pOH = 5.35$

$pH = 8.65$

(it may be assumed that $4.47 \times 10^{-6}$ is negligible)

← **1 mark**

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{3.5 \times 10^{-4}} = 2.86 \times 10^{-11}$$

$$K_b = \frac{[HF][OH^-]}{[F^-]}$$

← **1 mark**

$$2.86 \times 10^{-11} = \frac{(4.47 \times 10^{-6})(4.47 \times 10^{-6})}{x}$$

← **1 mark**

$$x = 0.70\,M = [F^-] = [KF]$$

6. **(3 marks)**

In three separate trials, $10.00\,\text{mL}$ samples of $H_2SO_4$ were titrated with $0.40\,\text{M}$ NaOH and the results are tabulated below.

| Trial | Volume of 0.40 M NaOH |
|---|---|
| 1 | 18.20 mL |
| 2 | 16.90 mL |
| 3 | 17.10 mL |

Calculate the concentration of the $H_2SO_4$.

**Solution:**

***For Example:***

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

average volume of NaOH = 17.00 mL ← **1 mark**

$$[H_2SO_4] = \frac{0.40\,\text{mol NaOH}}{\text{L}} \times 0.01700\,\text{L} \times \frac{1\,\text{mol } H_2SO_4}{2\,\text{mol NaOH}} \times \frac{1}{0.0100\,\text{L}}$$

← **2 marks**

$$= 0.34\,\text{M}$$

7. **(4 marks)**

Balance the following redox equation in basic solution:

$$O_2 + Co(NH_3)_6^{2+} \rightarrow Co(NH_3)_6^{3+} \qquad \text{(basic)}$$

**Solution:**

***For Example:***

$$\left(4e^- + 4H^+ + O_2 \rightarrow 2H_2O\right) \times 1$$

$$\left(Co(NH_3)_6^{2+} \rightarrow Co(NH_3)_6^{3+} + e^-\right) \times 4$$

$$4e^- + 4H^+ + O_2 + 4Co(NH_3)_6^{2+} \rightarrow 2H_2O + 4Co(NH_3)_6^{3+} + 4e^-$$

$$4\,OH^- \qquad\qquad 4\,OH^-$$

$$2H_2O + O_2 + 4Co(NH_3)_6^{2+} \rightarrow 4Co(NH_3)_6^{3+} + 4OH^-$$

8. **(3 marks)**

A solution of $MnSO_4$ is electrolyzed using inert electrodes. Write the anode and cathode half-reactions and describe any observations at the cathode.

Anode half-reaction: _____

Cathode half-reaction: _____

Cathode observation: _____

**Solution:**

***For Example:***

Anode half-reaction: $H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$ ← **1 mark**

Cathode half-reaction: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ ← **1 mark**

Cathode observation: gas bubbles form ← **1 mark**

**(Note: no mark for a conclusion such as "hydrogen is produced." Must be an observation.)**