97. What happens to the mass of each electrode as the cell operates? **(1 mark)**

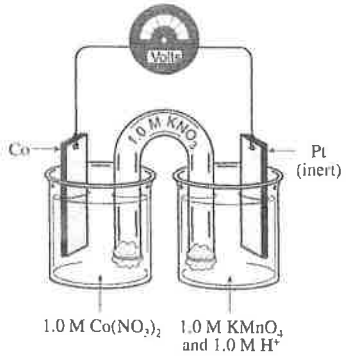
A. $Ag_{(s)}$ increases, $Zn_{(s)}$ increases
B. $Ag_{(s)}$ decreases, $Zn_{(s)}$ decreases
C. $Ag_{(s)}$ decreases, $Zn_{(s)}$ increases
D. $Ag_{(s)}$ increases, $Zn_{(s)}$ decreases

98. Which of the following is correct? **(1 mark)**

	Electrons Flow Towards	Anions Move Towards
A.	Zn	Zn
B.	Zn	Ag
C.	Ag	Zn
D.	Ag	Ag

99. Consider the following diagram:

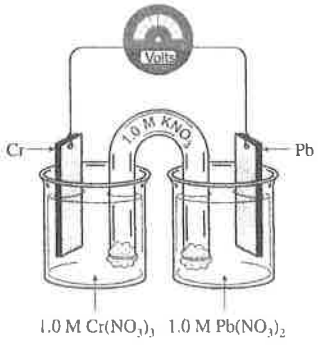
Identify the anode reaction for the cell shown in the diagram.



A. $H_2 \rightarrow 2H^+ + 2e^-$
B. $Co \rightarrow Co^{2+} + 2e^-$
C. $Co^{2+} + 2e^- \rightarrow Co$
D. $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

100. Consider the following cell:

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



A. +0.87 V
B. +0.61 V
C. +0.54 V
D. +0.28 V

101. Which of the following are produced at the anode and the cathode in the electrolysis of molten lithium chloride using platinum inert electrodes? **(1 mark)**

	Anode	Cathode
A.	oxygen	hydrogen
B.	hydrogen	oxygen
C.	chlorine	lithium
D.	lithium	chlorine

ELECTROCHEMISTRY WRITTEN

1 a) Indicate in the blank spaces on the following chart whether or not a reaction will occur when the metals are added to aqueous ions. **(1 mark)**

ion \ metal	Pd	Rh	Pt
Pd^{2+}			
Rh^{2+}	no reaction		no reaction
Pt^{2+}	reaction	reaction	

b) List the oxidizing agents in order of strongest to weakest. **(1 mark)**

2. Balance the following redox reaction in **basic** solution: **(4 marks)**

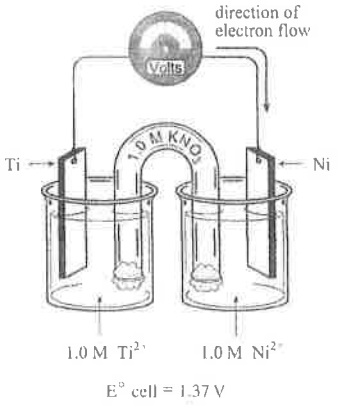
$$Au + Cl^- + O_2 \rightarrow AuCl_4^- + OH^- \qquad \text{(basic)}$$

3. Draw and label a simple electrolytic cell capable of electroplating an inert electrode with silver. **(2 marks)**

4. Balance the following redox reaction in a basic solution. **(4 marks)**

$$As \rightarrow AsH_3 + H_2AsO_4^- \qquad \text{(basic)}$$

5. Consider the following electrochemical cell:



a) Write the equation for the half-reaction that occurs at the anode.

b) Calculate the reduction potential of Ti^{2+}.

6. Consider the following reaction for the formation of rust:

$$Fe_{(s)} + \tfrac{1}{2}O_{2(g)} + H_2O_{(\ell)} \rightarrow Fe(OH)_{2(s)}$$

Describe and explain two methods, using different chemical principles, to prevent the formation of rust. **(2 marks)**

7. During the production of magnesium metal from sea water, magnesium ions are first precipitated from sea water as magnesium hydroxide.

a) The magnesium hydroxide is then neutralized by hydrochloric acid, producing magnesium chloride. Write the neutralization reaction. **(1 mark)**

b) The salt produced, magnesium chloride, is dried, melted and undergoes electrolysis. Write the reaction occurring at each electrode. **(2 marks)**

c) It is **not** possible to use electrolysis to remove Mg from a 1.0 M $MgCl_2$ solution. Why? **(1 mark)**

8. In the process of extracting tin from a sample of ore, the tin is removed as Sn^{2+} ions. A titration requires 21.43 mL of 0.0170 M $K_2Cr_2O_7$ to reach the equivalence point with the Sn^{2+} in a 0.750 g sample of the ore.

$$3Sn^{2+}_{(aq)} + Cr_2O_7{}^{2-}_{(aq)} + 14H^+_{(aq)} \rightarrow 3Sn^{4+}_{(aq)} + 2Cr^{3+}_{(aq)} + 7H_2O_{(\ell)}$$

Using the reaction, calculate the percent mass of tin in the ore sample. **(4 marks)**

9. Balance the following redox reaction in basic solution. **(5 marks)**

$$MnO_4{}^- + C_2O_4{}^{2-} \rightarrow MnO_2 + CO_3{}^{2-} \qquad \text{(basic)}$$

10. a) Draw and label the parts of an operating electrolytic cell during the electrolysis of molten potassium chloride $KCl_{(\ell)}$. **(3 marks)**

b) Define the term *oxidizing agent.* **(1 mark)**

11. Consider the following redox reaction in acidic solution:

$$MnO_4{}^- + H_2O_2 \rightarrow Mn^{2+} + O_2 \qquad \text{(acidic)}$$

a) Write a balanced equation for the above reaction. **(4 marks)**

b) The above reaction was used for a redox titration. At the equivalence point 5.684×10^{-4} mol $KMnO_4$ was required to titrate 5.00 mL of H_2O_2 solution. Calculate the $[H_2O_2]$. **(2 marks)**

12. Cathodic protection is one method used to inhibit the corrosion of iron.

a) Explain the principle of *cathodic protection.* **(2 marks)**

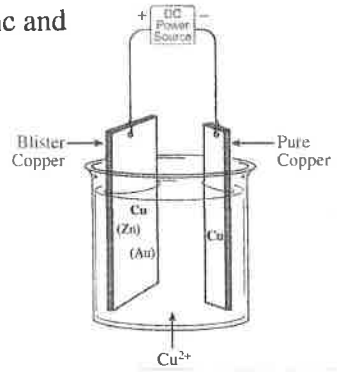
b) Identify **two** methods, other than cathodic protection, that could be used to inhibit the corrosion of iron. **(2 marks)**

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

$$Ag_2O + Si \rightarrow Ag + SiO_3^{2-} \quad \text{(acidic)}$$

14. Sodium metal is produced commercially by the electrolysis of molten $NaCl_{(\ell)}$. Explain why sodium metal, $Na_{(s)}$, cannot be produced by electrolysis of aqueous $NaCl_{(aq)}$. **(2 marks)**

15. Blister copper is an impure sample of copper containing small amounts of zinc and gold. Blister copper is purified using electrolysis.



Sufficient voltage is supplied to oxidize copper at the anode.

a) What happens to the zinc at the anode? Explain.

b) Write the equation for the half-reaction that occurs at the cathode.

16. Balance the following redox equation: **(4 marks)**

$$ClO_3^- + S_2O_3^{2-} \rightarrow S_4O_6^{2-} + Cl^- \quad \text{(acidic)}$$

17. State two characteristics of the overall reaction in an electrochemical cell. **(2 marks)**

18. Describe two chemically different methods of preventing the corrosion of iron. Explain how each method works. **(3 marks)**

19. Consider the following experimental results:

$$Ce^{4+} + Pd \rightarrow Pd^{2+} + Ce^{3+}$$

$$In^{3+} + Cd \rightarrow \text{no reaction}$$

$$Pd^{2+} + In^{2+} \rightarrow In^{3+} + Pd$$

$$Cd^{2+} + Pd \rightarrow \text{no reaction}$$

Use these results to complete the table of reduction half-reactions below. **(3 marks)**

STRONGEST ↑ WEAKEST

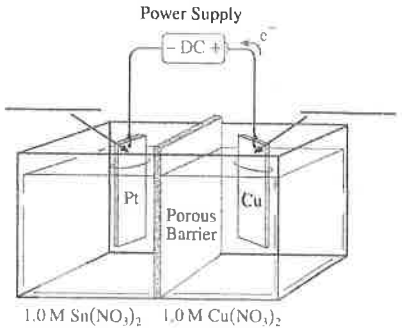
Oxidizing Agents		Reducing Agents
	⇄	
	⇄	
	⇄	
	⇄	

WEAKEST ↓ STRONGEST

20. Balance the following equation. **(3 marks)**

$$Cr_2O_7^{2-} + C_2O_4^{2-} \rightarrow Cr^{3+} + CO_2 \qquad \text{(acidic)}$$

21. Consider the following **electrolytic cell** which contains a porous barrier to prevent general mixing of solutions.



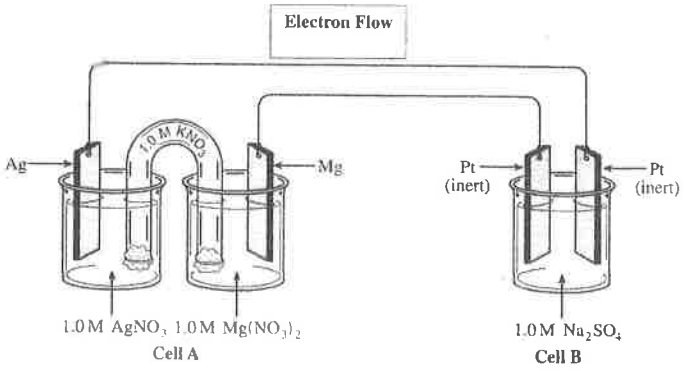
a) Label the anode and cathode in the space provided on the diagram above. **(1 mark)**

b) Write an equation for the overall cell reaction. **(2 marks)**

c) Calculate the minimum theoretical voltage required for this reaction under standard conditions. **(1 mark)**

22. When setting up the apparatus to electroplate a zinc object with copper, the object is suspended in a Cu^{2+} solution. Explain why it is a good idea to turn on the power supply before immersing the electrodes in the solution. **(1 mark)**

23. Consider the following apparatus consisting of an electrochemical cell joined to an electrolytic cell:



a) On the diagram above, indicate the direction of electron flow in the top wire. **(1 mark)**

b) Which metal in cell A is the cathode? **(1 mark)**

c) Write the anode and cathode half-reactions for cell B. **(3 marks)**

Electrochemistry Monster Review Key

1. B
2. B
3. D
4. B
5. C
6. C
7. C
8. A
9. C
10. A
11. D
12. B
13. D
14. D
15. A
16. D
17. C
18. D
19. D
20. B
21. D
22. D
23. A
24. B
25. A
26. C
27. A
28. D
29. D
30. D
31. B
32. C
33. D
34. D
35. A
36. C
37. B
38. D
39. C
40. D
41. B
42. A
43. D
44. A
45. D
46. B
47. D
48. B
49. A
50. A
51. A
52. A
53. C
54. C
55. D
56. A
57. C
58. B
59. C
60. A
61. D
62. D
63. D
64. C
65. C
66. D
67. A
68. B
69. B
70. D
71. B
72. B
73. D
74. D
75. D
76. C
77. C
78. B
79. B
80. A
81. C
82. C
83. A
84. B
85. B
86. A
87. C
88. A
89. D
90. B
91. A
92. D
93. B
94. B
95. C
96. B
97. D
98. C
99. B
100. B
101. C

ELECTROCHEMISTRY WRITTEN KEY

1. a) Indicate in the blank spaces on the following chart whether or not a reaction will occur when the metals are added to aqueous ions. **(1 mark)**

ion \ metal	Pd	Rh	Pt
Pd^{2+}		***reaction***	***no reaction***
Rh^{2+}	no reaction		no reaction
Pt^{2+}	reaction	reaction	

b) List the oxidizing agents in order of strongest to weakest. **(1 mark)**

Solution:

$$Pt^{2+} > Pd^{2+} > Rh^{2+}$$

2. Balance the following redox reaction in **basic** solution: **(4 marks)**

$$Au + Cl^- + O_2 \rightarrow AuCl_4^- + OH^- \qquad \text{(basic)}$$

Solution:

For Example:

$$4 \times \left(Au + 4Cl^- \rightarrow AuCl_4^- + 3e^-\right)$$
$$3 \times \left(4e^- + 3H^+ + O_2 \rightarrow OH^- + H_2O\right)$$
$$4Au + 16Cl^- + 9H^+ + 3O_2 \rightarrow 4AuCl_4^- + 3OH^- + 3H_2O$$
$$+9OH^- \qquad +9OH^-$$
$$4Au + 16Cl^- + 6H_2O + 3O_2 \rightarrow 4AuCl_4^- + 12OH^-$$

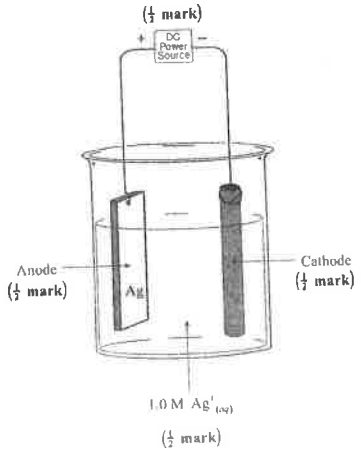
1 mark for half-reactions

1 mark for balancing charges

1 mark for addition

1 mark for basic

3. Draw and label a simple electrolytic cell capable of electroplating an inert electrode with silver. **(2 marks)**



4. Balance the following redox reaction in a basic solution. **(4 marks)**

$$As \rightarrow AsH_3 + H_2AsO_4^- \quad \text{(basic)}$$

Solution:

For Example:

$5 \times \left(3e^- + 3H^+ + As \rightarrow AsH_3\right)$ ← **1 mark for half-reactions**

$3 \times \left(4H_2O + As \rightarrow H_2AsO_4^- + 6H^+ + 5e^-\right)$ ← **1 mark for balancing electrons**

$12H_2O + 8As \rightarrow 5AsH_3 + 3H_2AsO_4^- + 3H^+$ ← **1 mark for addition, cancellation**

BASIC Add $3OH^-$ to each side.

$9H_2O + 3OH^- + 8As \rightarrow 5AsH_3 + 3H_2AsO_4^-$ ← **1 mark for basic**

For Example:

$3H_2O + 3e^- + As \rightarrow AsH_3 + 3OH^-$ ← **1 mark for basic half-reaction**

$6OH^- + As \rightarrow H_2AsO_4^- + 5e^- + 2H_2O$ ← **1 mark for basic half-reaction**

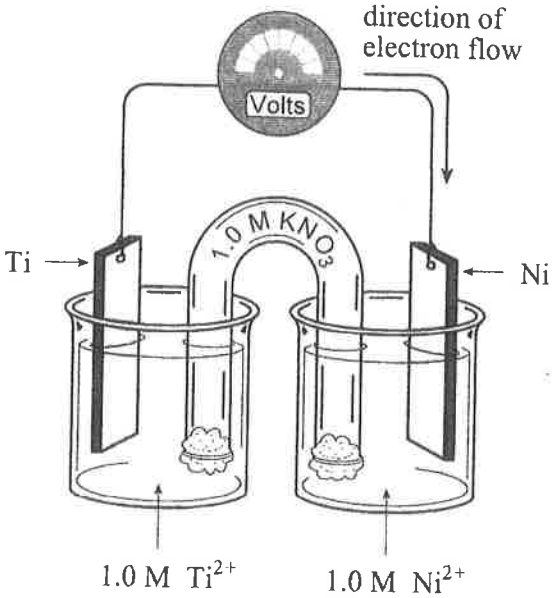
9 $\cancel{15}H_2O + \cancel{15e^-} + 5As \rightarrow 5AsH_3 + \cancel{15OH^-}$

3 $\cancel{18}OH^- + 3As \rightarrow 3H_2AsO_4^- + \cancel{15e^-} + \cancel{6H_2O}$

$9H_2O + 3OH^- + 8As \rightarrow 5AsH_3 + 3H_2AsO_4^-$

← **2 marks for balancing electrons, addition and cancellation**

5. Consider the following electrochemical cell:



E° cell = 1.37 V

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

Solution:

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

b) Calculate the reduction potential of Ti^{2+}. **(1 mark)**

Solution:

For Example:

$$E^\circ_{(for\ cell)} = E^\circ_{(for\ reduction)} + E^\circ_{(for\ oxidation)}$$

$$Ni^{2+} + 2e^- \rightarrow Ni$$

$$E^\circ_{(for\ reduction)} = -0.26\,V$$

$$1.37\,V = (-0.26\,V) + E^\circ_{(for\ oxidation)}$$

$$E^\circ_{(for\ oxidation)} = 1.63\,V$$

Therefore, the reduction potential of Ti^{2+} is $-1.63\,V$

← **1 mark**

6. Consider the following reaction for the formation of rust:

$$Fe_{(s)} + \tfrac{1}{2}O_{2(g)} + H_2O_{(\ell)} \rightarrow Fe(OH)_{2(s)}$$

Describe and explain two methods, using different chemical principles, to prevent the formation of rust. **(2 marks)**

Solution:

For Example:

Coating with zinc $\left(\frac{1}{2}\right.$ **mark**$\left.\right)$. Zinc acts as a sacrificial anode $\left(\frac{1}{2}\right.$ **mark**$\left.\right)$.
Painting $\left(\frac{1}{2}\right.$ **mark**$\left.\right)$ prevents contact between Fe and O_2 $\left(\frac{1}{2}\right.$ **mark**$\left.\right)$.

7. During the production of magnesium metal from sea water, magnesium ions are first precipitated from sea water as magnesium hydroxide.

a) The magnesium hydroxide is then neutralized by hydrochloric acid, producing magnesium chloride. Write the neutralization reaction. **(1 mark)**

Solution:

$$Mg(OH)_{2(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + 2H_2O_{(\ell)}$$ ← **1 mark**

b) The salt produced, magnesium chloride, is dried, melted and undergoes electrolysis. Write the reaction occurring at each electrode. **(2 marks)**

Solution:

Anode: $2Cl^- \rightarrow Cl_2 + 2e^-$ ← **1 mark**

Cathode: $Mg^{2+} + 2e^- \rightarrow Mg$ ← **1 mark**

c) It is **not** possible to use electrolysis to remove Mg from a 1.0 M $MgCl_2$ solution. Why?

Solution: Water is a stronger oxidizing agent than Mg^{2+}. ← **1 mark**

8. In the process of extracting tin from a sample of ore, the tin is removed as Sn^{2+} ions. A titration requires 21.43 mL of 0.0170 M $K_2Cr_2O_7$ to reach the equivalence point with the Sn^{2+} in a 0.750 g sample of the ore.

$$3Sn^{2+}_{(aq)} + Cr_2O_7{}^{2-}_{(aq)} + 14H^+_{(aq)} \rightarrow 3Sn^{4+}_{(aq)} + 2Cr^{3+}_{(aq)} + 7H_2O_{(l)}$$

Using the reaction, calculate the percent mass of tin in the ore sample. **(4 marks)**

Solution:

$$\text{mol } Cr_2O_7{}^{2-} = \left(0.0170 \text{ mol/L } Cr_2O_7{}^{2-}\right)\left(0.02143 \text{ L}\right) = 3.643 \times 10^{-4} \text{ mol } Cr_2O_7{}^{2-} \quad \leftarrow \textbf{1 mark}$$

$$\text{mol } Sn^{2+} = 3.643 \times 10^{-4} \text{ mol } Cr_2O_7{}^{2-}\left(\frac{3 \text{ mol } Sn^{2+}}{1 \text{ mol } Cr_2O_7{}^{2-}}\right) = 1.093 \times 10^{-3} \text{ mol } Sn^{2+} \quad \leftarrow \textbf{1 mark}$$

$$\text{mol Sn} = \text{mol } Sn^{2+} = 1.093 \times 10^{-3} \text{ mol Sn}$$

$$\text{g Sn} = 1.093 \times 10^{-3} \text{ mol Sn}\left(\frac{118.7 \text{ g Sn}}{1 \text{ mol Sn}}\right) = 1.297 \times 10^{-1} \text{ g Sn} \quad \leftarrow \textbf{1 mark}$$

$$\% \text{ Sn} = \frac{1.297 \times 10^{-1} \text{ g Sn}}{0.750 \text{ g Sn ore}} \times 100\% = 17.3\% \quad \leftarrow \textbf{1 mark}$$

9. Balance the following redox reaction in basic solution. **(5 marks)**

$$MnO_4{}^- + C_2O_4{}^{2-} \rightarrow MnO_2 + CO_3{}^{2-} \qquad \text{(basic)}$$

Solution:

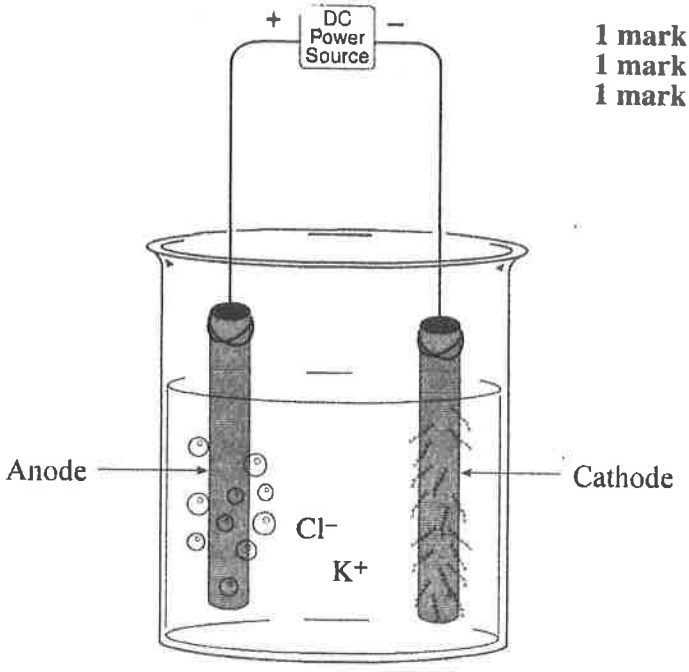
For Example:

$$2 \times \left(3e^- + 4H^+ + MnO_4{}^- \rightarrow MnO_2 + 2H_2O\right)$$
$$3 \times \left(2H_2O + C_2O_4{}^{2-} \rightarrow 2CO_3{}^{2-} + 4H^+ + 2e^-\right)$$
$$2H_2O + 2MnO_4{}^- + 3C_2O_4{}^{2-} \rightarrow 2MnO_2 + 6CO_3{}^{2-} + 4H^+$$

2 marks (1 mark for each half cell)
1 mark for multiplication
1 mark for addition
1 mark for basic

$$4OH^- + 2MnO_4{}^- + 3C_2O_4{}^{2-} \rightarrow 2MnO_2 + 6CO_3{}^{2-} + 2H_2O$$

10. a) Draw and label the parts of an operating electrolytic cell during the electrolysis of molten potassium chloride $KCl_{(\ell)}$. **(3 marks)**



1 mark for single container
1 mark for power supply
1 mark for electrodes

b) Define the term *oxidizing agent*. **(1 mark)**

Solution:

For Example:

An oxidizing agent is a species which causes another to lose electrons. ← **1 mark**

11. Consider the following redox reaction in acidic solution:

$$MnO_4^- + H_2O_2 \rightarrow Mn^{2+} + O_2 \qquad \text{(acidic)}$$

a) Write a balanced equation for the above reaction. **(4 marks)**

Solution:

For Example:

$$\begin{array}{r} 2 \times \left(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O\right) \\ 5 \times \left(H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-\right) \\ \hline 2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2 \end{array}$$

← **4 marks**

b) The above reaction was used for a redox titration. At the equivalence point 5.684×10^{-4} mol $KMnO_4$ was required to titrate 5.00 mL of H_2O_2 solution. Calculate the $[H_2O_2]$. **(2 marks)**

$$\text{mol } H_2O_2 = 5.684 \times 10^{-4} \text{ mol } MnO_4^- \times \frac{5 \text{ mol } H_2O_2}{2 \text{ mol } MnO_4^-} = 1.421 \times 10^{-3} \text{ mol}$$

$$[H_2O_2] = \frac{1.421 \times 10^{-3} \text{ mol}}{0.00500 \text{ L}} = 0.284 \text{ M}$$

← **2 marks**

12. Cathodic protection is one method used to inhibit the corrosion of iron.

a) Explain the principle of *cathodic protection*. **(2 marks)**

Solution:

For Example:

The process of protecting a metal from oxidation by placing it in electrical contact with another metal that is a stronger reducing agent. The protected metal becomes a cathode and the other becomes a sacrificial anode.

← **2 marks**

b) Identify **two** methods, other than cathodic protection, that could be used to inhibit the corrosion of iron. **(2 marks)**

Solution:

For Example:

Coating with paint or grease. ← **1 mark**

Keep in totally dry atmosphere. ← **1 mark**

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

$$Ag_2O + Si \rightarrow Ag + SiO_3^{2-} \quad \text{(acidic)}$$

Solution:

For Example:

$$2 \times \left(2e^- + 2H^+ + Ag_2O \rightarrow 2Ag + H_2O\right)$$

← **2 marks (1 mark for each half-reaction)**

$$1 \times \left(3H_2O + Si \rightarrow SiO_3^{2-} + 6H^+ + 4e^-\right)$$

← **1 mark for balancing electrons**

$$2Ag_2O + H_2O + Si \rightarrow 4\,Ag + SiO_3^{2-} + 2H^+$$

← **1 mark for addition**

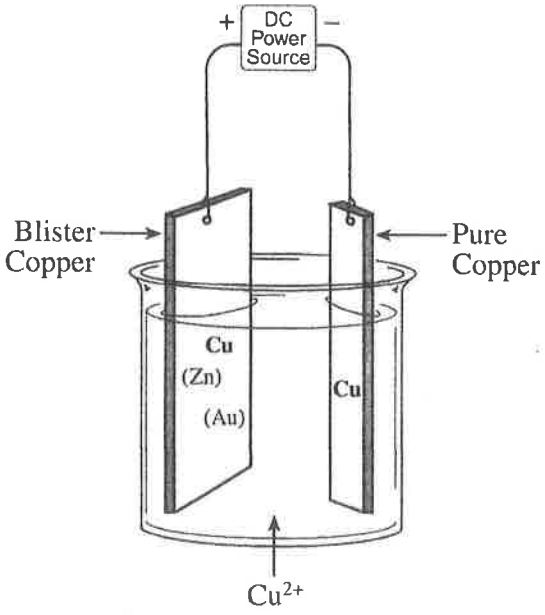
14. Sodium metal is produced commercially by the electrolysis of molten $NaCl_{(\ell)}$. Explain why sodium metal, $Na_{(s)}$, cannot be produced by electrolysis of aqueous $NaCl_{(aq)}$. **(2 marks)**

Solution:

For Example:

H_2O is more easily reduced than Na^+. ← **2 marks**

15. Blister copper is an impure sample of copper containing small amounts of zinc and gold. Blister copper is purified using electrolysis.



Sufficient voltage is supplied to oxidize copper at the anode.

a) What happens to the zinc at the anode? Explain. **(2 marks)**

Zn is oxidized. ← **1 mark**

It is an even stronger reducing agent than the copper. ← **1 mark**

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

$$Cu^{2+} + 2e^- \rightarrow Cu$$

16. Balance the following redox equation: **(4 marks)**

$$ClO_3^- + S_2O_3^{2-} \rightarrow S_4O_6^{2-} + Cl^- \quad \text{(acidic)}$$

$$6e^- + 6H^+ + ClO_3^- \rightarrow Cl^- + 3H_2O$$

$$3 \times \left(2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-\right)$$

$$6H^+ + ClO_3^- + 6S_2O_3^{2-} \rightarrow Cl^- + 3H_2O + 3S_4O_6^{2-}$$

2 marks (1 for each half-reaction)
1 mark for balancing electrons
1 mark for addition

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

17. State two characteristics of the overall reaction in an electrochemical cell. **(2 marks)**

*Any **two** of the following for 1 mark each:*

- redox reaction
- spontaneous
- +E° value
- exothermic

← **2 marks**

18. Describe two chemically different methods of preventing the corrosion of iron. Explain how each method works. **(3 marks)**

- Coating with paint or oil prevents contact between iron and oxygen. ← **1 $\frac{1}{2}$ marks**

- Attaching a more readily oxidized metal such as zinc—cathodic protection—turns the iron into a cathode, preventing oxidation. ← **1 $\frac{1}{2}$ marks**

19. Consider the following experimental results:

$$Ce^{4+} + Pd \rightarrow Pd^{2+} + Ce^{3+}$$

$$In^{3+} + Cd \rightarrow \text{no reaction}$$

$$Pd^{2+} + In^{2+} \rightarrow In^{3+} + Pd$$

$$Cd^{2+} + Pd \rightarrow \text{no reaction}$$

Use these results to complete the table of reduction half-reactions below. **(3 marks)**

Oxidizing Agents		Reducing Agents
$Ce^{4+} + e^-$	$\rightleftarrows$	Ce^{3+}
$Pd^{2+} + 2e^-$	$\rightleftarrows$	Pd
$Cd^{2+} + 2e^-$	$\rightleftarrows$	Cd
$In^{3+} + e^-$	$\rightleftarrows$	In^{2+}

STRONGEST ↑ WEAKEST ↓ WEAKEST ↑ STRONGEST ↓

← 3 marks

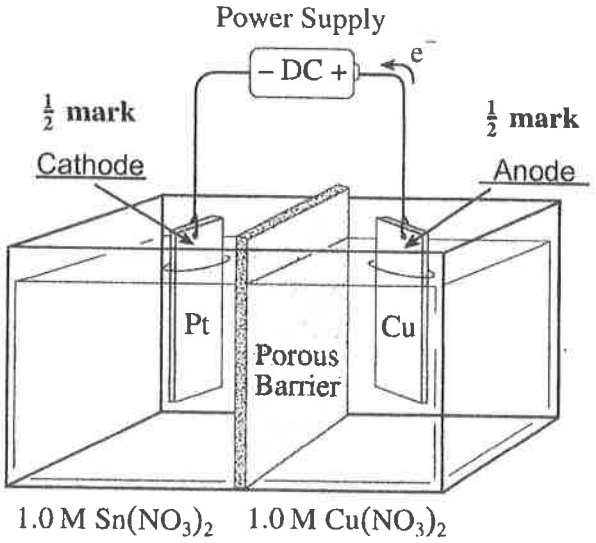
20. Balance the following equation. **(3 marks)**

$$Cr_2O_7^{2-} + C_2O_4^{2-} \rightarrow Cr^{3+} + CO_2 \qquad \text{(acidic)}$$

$$\left(6e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O\right) \times 1$$
$$\left(C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-\right) \times 3$$
$$14H^+ + Cr_2O_7^{2-} + 3C_2O_4^{2-} \rightarrow 2Cr^{3+} + 7H_2O + 6CO_2$$

← 3 marks

21. Consider the following **electrolytic cell** which contains a porous barrier to prevent general mixing of solutions.



a) Label the anode and cathode in the space provided on the diagram above. **(1 mark)**

See diagram above.

b) Write an equation for the overall cell reaction. **(2 marks)**

$Sn^{2+} + Cu_{(s)} \rightarrow Cu^{2+} + Sn_{(s)}$ ← 2 marks

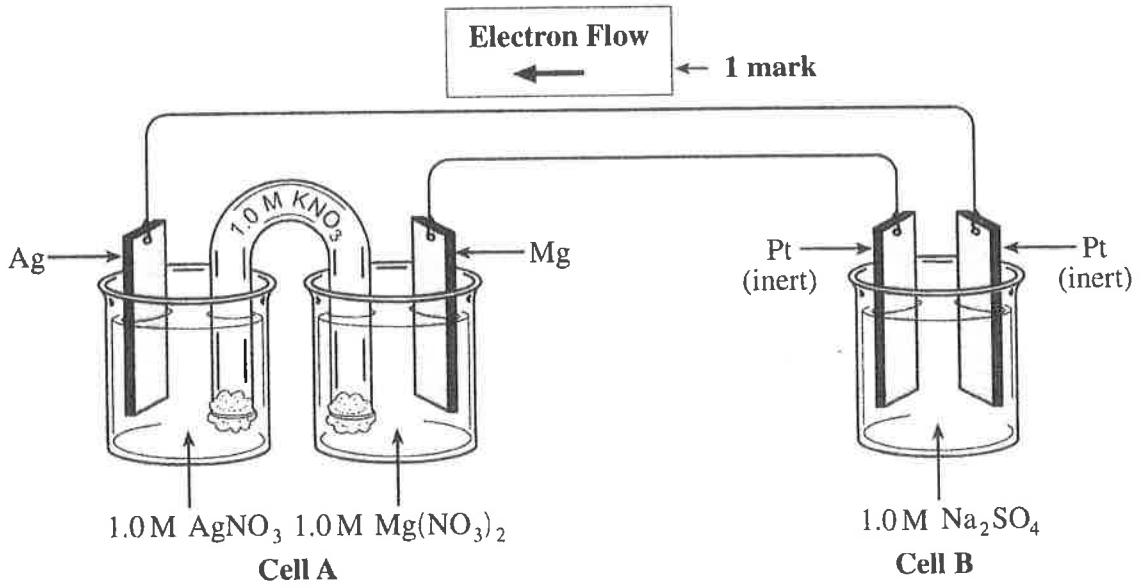
c) Calculate the minimum theoretical voltage required for this reaction under standard conditions. **(1 mark)**

0.48 V ← 1 mark

22. When setting up the apparatus to electroplate a zinc object with copper, the object is suspended in a Cu^{2+} solution. Explain why it is a good idea to turn on the power supply before immersing the electrodes in the solution. **(1 mark)**

If you did not turn on the power supply before immersing the electrodes in the solution, the Cu^{2+} would react spontaneously with the zinc to be plated, oxidizing the zinc. ← **1 mark**

23. Consider the following apparatus consisting of an electrochemical cell joined to an electrolytic cell:



a) On the diagram above, indicate the direction of electron flow in the top wire. **(1 mark)**

Solution:

For Example:

See diagram above. ← **1 mark**

b) Which metal in cell A is the cathode? **(1 mark)**

Solution:

Cathode: Ag ← **1 mark**

c) Write the anode and cathode half-reactions for cell B. **(3 marks)**

Solution:

For Example:

Anode: $H_2O \rightarrow 2H^+ + \frac{1}{2}O_2 + 2e^-$

Cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ ← **3 marks**