Year 12 Chemistry **Topic Test #5 (Electrochemistry) - 2012**

Name: _____ Mark = _____ / 43

Part 1: Multiple Choice Section **10 marks**

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1. Which one of the following is not an oxidation-reduction reaction?

   A. $Mg(s) + 2\,H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$

   B. $2\,Ag^+(aq) + Zn(s) \rightarrow 2\,Ag(s) + Zn^{2+}(aq)$

   C. $Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$

   D. $C\ell_2(g) + 2\,I^-(aq) \rightarrow 2\,C\ell^-(aq) + I_2(s)$

2. Which one of the following is unlikely to be prodcued by the reduction of nitrous acid, HNO_2?

   A. Ammonium ions

   B. Nitrogen monoxide

   C. Nitrogen dioxide

   D. Nitrogen gas

3. Consider the following unbalanced equation.

$$I^-(aq) + IO_3^-(aq) + H^+(aq) \rightarrow I_2(s) + H_2O(\ell)$$

   Which one of the following statements is true?

   A. H^+ is reduced.

   B. $IO_3^-$is not the oxidising agent.

   C. The oxidising agent is I_2.

   D. $I^-$is the reducing agent.

4. Considering reduction potentials, which of the following equations would not occur spontaneously?

A.	$Ni_{(s)}$	+	$Zn^{2+}_{(aq)}$	→	$Ni^{2+}_{(aq)}$	+	$Zn_{(s)}$
B	$2\,Cr^{3+}_{(aq)}$	+	$3\,Mn_{(s)}$	→	$2\,Cr_{(s)}$	+	$3\,Mn^{2+}_{(aq)}$
C.	$2\,H^+_{(aq)}$	+	$Sn_{(s)}$	→	$H_{2(g)}$	+	$Sn^{2+}_{(aq)}$
D.	$C\ell_{2(g)}$	+	$2\,Br^-_{(aq)}$	→	$2\,C\ell^-_{(aq)}$	+	$Br_{2(l)}$

5. A student made the following observations relating to the reactions of three metals X, Y and Z and their corresponding nitrate solutions, $X(NO_3)_2$, $Y(NO_3)_2$, and $Z(NO_3)_2$.

I Metal X did not react with 1.0 mol L^{-1} $Y(NO_3)_2$ solution.
II Metal Y displaced metallic Z from 1.0 mol L^{-1} $Z(NO_3)_2$ solution.
III Metal Z metal did not react with 1.0 mol L^{-1} $X(NO_3)_2$solution.

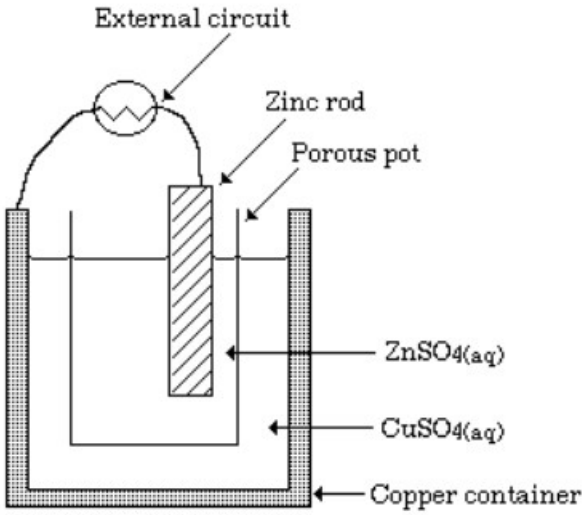
The decreasing order of strength as a reducing agent of the three metals is:

A. X > Y > Z.
B. X > Z > Y.
C. Y > Z > X.
D. Y > X > Z.

6. A salt bridge in an electrochemical cell allows:

A. passage of electrons through the salt bridge to the cathode.
B. free mixing of the reactants in each half cell.
C. migration of ions towards different half cells.
D. the formation of oppositely charged solutions in the half cells.

7. The diagram below represents a Daniell Cell, a battery from the mid 1800's.



When the zinc rod and the copper container are connected as part of a completed electrical circuit, a current flows in this circuit. When the cell is operating, which one of the following statements is true?

A. The copper container gradually dissolves.
B. Electrons flows from the copper to the zinc through the external circuit.
C. Zinc is deposited around the zinc rod.
D. Sulfate ions migrate through the porous pot from the copper compartment to the zinc compartment.

8. The EMF of a cell composed of a Sn^{4+}/Sn^{2+} half cell and a $C\ell_2/C\ell^-$ standard half cell is 1.25 V. A cell composed of an I_2/I^- half cell and a $C\ell_2/C\ell^-$ standard half cell has an EMF of 0.82 V. In each cell the $C\ell_2$ acts as the oxidising agent.

If a cell was formed from a I_2/I^- standard half cell and a Sn^{4+}/Sn^{2+} standard half cell, then its EMF would be:

A. 0.16 V.

B. 0.31 V.

C. 0.43 V.

D. 2.07 V.

9. Car batteries are known as lead-acid accumulators. The overall reaction which occurs as the battery discharges is:

$$Pb(s) + PbO_2(s) + 4\,H^+(aq) + 2\,SO_4^{2-}(aq) \rightarrow 2\,PbSO_4(s) + 2\,H_2O(l)$$

As the lead acid accumulator discharges the pH of the electrolyte solution in the battery:

A. decreases steadily

B. increases steadily

C. remains constant

D. initially decreases then remains constant

10. An electrochemical cell was constructed, which used the following pair of redox half-reactions

$CO_2 + 8\,H^+ + 8\,e^- \rightarrow CH_4 + 2\,H_2O$ $\quad E^0 = +0.17$ V

$O_2 + 4\,H^+ + 4\,e^- \rightarrow 2\,H_2O$ $\quad E^0 = +1.23$ V

Which of the following processes would occur at the positive electrode of the cell?

A. Production of methane.

B. Production of oxygen gas.

C. Oxidation of methane.

D. Consumption of oxygen.

End of Part 1

Part 2: Short Answer Section **33 marks**

11. Assign oxidation numbers to the element in bold type in each of following:

(a) $Na_3\mathbf{P}O_4$ _____ (b) $H_2\mathbf{C}_2O_4$ _____ (c) $\mathbf{Fe}(CN)_6^{3-}$ _____

(3 marks)

12. Consider the following equation:

$$2\ NaC\ell O_3 + SO_2 + H_2SO_4 \rightarrow 2\ C\ell O_2 + 2\ NaHSO_4$$

(a) Identify the oxidant. _____

(1 mark)

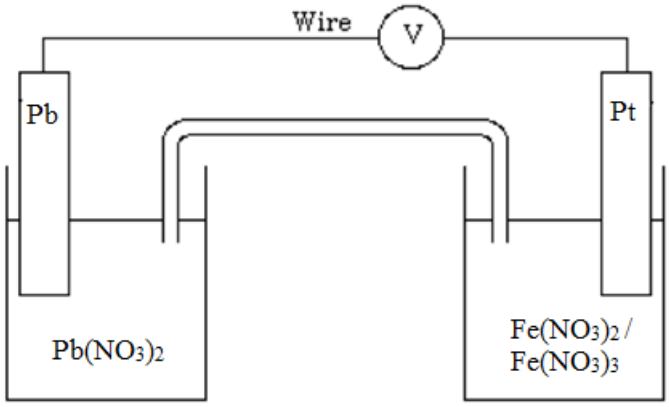
(b) Give a reason for your answer.

_____

_____

(1 mark)

13. Consider the following electrochemical cell:



(a) Identify the anode and cathode. (1 mark)

(b) Indicate the direction of flow of electrons in the wire and of cations within the salt-bridge.

(2 marks)

(c) Write equations for the reactions occuring at the anode and cathode.

anode: _____

cathode: _____

(2 marks)

(d) Assuming standard conidtions, what will be the reading on the voltmeter? _____

(1 mark)

(e) Suggest a suitable solution for use in the salt bridge. _____

(1 mark)

14. (a) Construct half-equations and write a balanced redox equation for the reaction with the following observation:

An acidified purple solution reacts with a colourless solution to give a colourless gas.

(3 marks)

(b) Is it wise to store copper(II) sulfate solution in an aluminium container? Explain, with the aid of equations.

(3 marks)

(c) Consider the following description:

A greenish-yellow gas is bubbled through waste water to remove hydrogen sulfide.

(i) Write a balanced equation for the reaction.

(3 marks)

(ii) Give an observation for the reaction.

(1 mark)

15. Tellurite, TeO_2, is used in the manufacture of optical fibres. The amount of tellurite in a sample of ore can be determined by reaction with a strong oxidising agent such as acidified dichromate solution, forming the tellurate ion, TeO_4^{2-}.

(a) Write a half equation for the oxidation of TeO_2 to TeO_4^{2-}.

(2 marks)

(b) Write the full redox equation for the oxidation of TeO_2 by reaction with acidified potassium dichromate solution.

(2 marks)

A sample of ore contaiing tellurite was analysed in the following manner:

I A 1.054 g sample of ore was crushed and added to 50.00 mL of 0.03052 mol L^{-1} potassium dichromate solution.

II Excess dichromate was determined through titration with 0.0525 mol L^{-1} $Fe(NO_3)_2$ solution, according to the following equation:

$$Cr_2O_7^{2-}(aq) + 6\ Fe^{2+}(aq) + 14\ H^+(aq) \rightarrow 2\ Cr^{3+}(aq) + 6\ Fe^{3+}(aq) + 7\ H_2O(l)$$

A titre of 19.71 mL was required to reach equivalence.

(c) Calculate the percentage, by mass, of tellurite in the sample.

(7 marks)

End of Test

Year 12 Chemistry

Topic Test #5 (Electrochemistry) - 2012

Name: **ANSWERS** Mark = _____ / 43

Part 1: Multiple Choice Section **10 marks**

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1. **C** 2. **C** 3. **D** 4. **A** 5. **D** 6. **C** 7. **D** 8. **C** 9. **B** 10. **D**

Part 2: Short Answer Section **33 marks**

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11. Assign oxidation numbers to the element in bold type in each of following:

(a) $Na_3\mathbf{P}O_4$ **+5** (b) $H_2\mathbf{C}_2O_4$ **+3** (c) $\mathbf{Fe}(CN)_6^{3-}$ **+3**

✓ **each** (3 marks)

12. Consider the following equation:

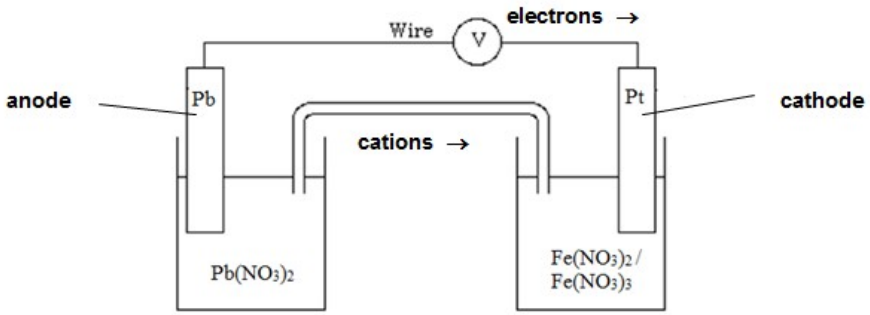
$$2\ NaC\ell O_3 + SO_2 + H_2SO_4 \rightarrow 2\ C\ell O_2 + 2\ NaHSO_4$$

(a) Identify the oxidant. **$NaC\ell O_3$** ✓ (1 mark)

(b) Give a reason for your answer.

The oxidant is reduced in a redox reaction. ✓
$NaC\ell O_3$ contains chlorine, which is reduced from +5 to +4 (1 mark)

13. Consider the following electrochemical cell:



(a) Identify the anode and cathode. ✓ (1 mark)

(b) Indicate the direction of flow of electrons in the wire and of cations within the salt-bridge.

✓✓ (2 marks)

(c) Write equations for the reactions occuring at the anode and cathode.

anode: **$Pb(s) \rightarrow Pb^{2+}(aq) + 2\ e^-$** ✓

cathode: **$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$** ✓ (2 marks)

(d) Assuming standard conidtions, what will be the reading on the voltmeter? **+ 0.90 V** ✓

(1 mark)

(e) Suggest a suitable solution for use in the salt bridge. **saturated $KNO_3(aq)$**
saturated $NH_4NO_3(aq)$
✓ (1 mark)

14. (a) Construct half-equations and write a balanced redox equation for the reaction with the following observation:

An acidified purple solution reacts with a colourless solution to give a colourless gas.

$MnO_4^-(aq) + 8\ H^+(aq) + 5\ e^- \rightarrow Mn^{2+}(aq) + 4\ H_2O(l)$ ✓

$H_2C_2O_4(aq) \rightarrow 2\ CO_2(g) + 2\ H^+(aq) + 2\ e^-$ ✓

$5\ H_2C_2O_4(aq) + 2\ MnO_4^-(aq) + 6\ H^+(aq) \rightarrow 10\ CO_2(g) + 2\ Mn^{2+}(aq) + 8\ H_2O(l)$ ✓

**** $H_2O_2(aq) \rightarrow O_2(g) + 2\ H^+(aq) + 2\ e^-$ is an alternative oxidation reaction***

(3 marks)

(b) Is it wise to store copper(II) sulfate solution in an aluminium container? Explain, with the aid of equations.

No, there would be a spontaneous metal displacement reaction. ✓

Assuming standard conditions:

$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$	**$E°_{red} = +0.34$ V**
$A\ell(s) \rightarrow A\ell^{3+}(aq) + 3\ e^-$	**$\underline{E°_{ox} = +1.68\ V}$**
	$E°_{cell} = +2.02$ V ✓✓

(3 marks)

(c) Consider the following description:

A greenish-yellow gas is bubbled through waste water to remove hydrogen sulfide.

(i) Write a balanced equation for the reaction.

$C\ell_2(g) + 2\ e^- \rightarrow 2\ C\ell^-(aq)$ ✓

$H_2S(aq) \rightarrow S(s) + 2\ H^+(aq) + 2\ e^-$ ✓

$C\ell_2(g) + H_2S(aq) \rightarrow 2\ C\ell^-(aq) + S(s) + 2\ H^+(aq)$ ✓

(3 marks)

(ii) Give an observation for the reaction.

A green-yellow gas bubbles through a colourless solution forming a pale yellow precipitate ✓

(1 mark)

15. Tellurite, TeO_2, is used in the manufacture of optical fibres. The amount of tellurite in a sample of ore can be determined by reaction with a strong oxidising agent such as acidified dichromate solution, forming the tellurate ion, TeO_4^{2-}.

(a) Write a half equation for the oxidation of TeO_2 to TeO_4^{2-}.

$TeO_2(s) + 2\ H_2O(l) \rightarrow TeO_4^{2-}(aq) + 4\ H^+(aq) + 2\ e^-$ ✓✓

(2 marks)

(b) Write the full redox equation for the oxidation of TeO_2 by reaction with acidified potassium dichromate solution.

$Cr_2O_7^{2-}(aq) + 14\ H+(aq) + 6\ e^- \rightarrow 2\ Cr^{3+}(aq) + 7\ H_2O(l)$

$TeO_2(s) + 2\ H_2O(l) \rightarrow TeO_4^{2-}(aq) + 4\ H^+(aq) + 2\ e^-$ **(x3)**

$Cr_2O_7^{2-}(aq) + 3\ TeO_2(s) + 2\ H^+(aq) \rightarrow 2\ Cr^{3+}(aq) + 3\ TeO_4^{2-}(aq) + H_2O(l)$ ✓✓

(2 marks)

A sample of ore contaiing tellurite was analysed in the following manner:

I A 1.054 g sample of ore was crushed and added to 50.00 mL of 0.03052 mol L^{-1} potassium dichromate solution.

II Excess dichromate was determined through titration with 0.0525 mol L^{-1} $Fe(NO_3)_2$ solution, according to the following equation:

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A titre of 19.71 mL was required to reach equivalence.

(c) Calculate the percentage, by mass, of tellurite in the sample.

(7 marks)

$n(Cr_2O_7^{2-})_{total} = n(K_2Cr_2O_7) = c.V = 0.03052 \times 0.05000 = 0.001526$ mol ✓

$n(Fe^{2+}) = n(Fe(NO_3)_2) = c.V = 0.0525 \times 0.01971 = 0.001035$ mol ✓

$n(Cr_2O_7^{2-})_{excess} = 1/6\ n(Fe^{2+}) = 0.0001725$ mol ✓

$n(Cr_2O_7^{2-})_{reacted} = 0.001526 - 0.0001725 = 0.001354$ mol ✓

$n(TeO_2) = 3.n(Cr_2O_7^{2-})_{reacted} = 0.004061$ mol ✓

$m(TeO_2) = n.M = 0.004061 \times 159.6 = 0.6481$ g ✓

$\%(TeO_2) = 0.6481 / 1.054 \times 100 =$ <u>61.5%</u> ✓

End of Test