Year 12 Chemistry **Topic Test #5 (Electrochemistry) - 2013**

Name: _____ Mark = _____ / 42

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

Answer by placing a cross through, or a circle around, the letter of the most correct answer.

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1. In which of the following species does platinum have the lowest oxidation number?

   A. $H_2PtC\ell_6$

   B. $NaPtC\ell_4$

   C. Pt_2O_3

   D. $PtCr_2O_7$

2. Which of the following are redox reactions?

   I. $O^{2-} + H_2O \rightarrow 2\ OH^-$

   II. $H^- + H_2O \rightarrow OH^- + H_2$

   III. $2\ H_2O_2 \rightarrow 2\ H_2O + O_2$

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

   A. II and IV

   B. III and IV

   C. II, III and IV

   D. all of them

3. Which of the following metals can be produced by bubbling hydrogen gas through a solution of its chloride?

   A. Copper

   B. Iron

   C. Sodium

   D. Zinc

4. Iodide ion (I^-) can be oxidized by X but not by Y. The identities of X and Y, respectively, could be:

	X		Y
A.	bromine	and	chlorine
B.	gold(III) ions	and	silver ions
C.	acidified MnO_4^-	and	hydrogen peroxide
D.	iron(III) ions	and	nickel(II) ions

5. A solution of sulfur dioxide in water is a strong bleach, decolourising substances by the reducing effect of the SO_2 species in solution. Which one of the following lists of species will ALL be reduced by the sulfur dioxide solution, given the standard reduction potential for the reduction reaction:

$$SO_4^{2-} + 4\,H^+ + 2\,e^- \rightarrow SO_2 + 2\,H_2O \qquad E°_{red} = +\,0.17\ V$$

A. Br^-, $C\ell^-$, I^-

B. Cu^{2+}, Sn^{2+}, Co^{2+}

C. Mn^{2+}, Fe^{3+}, K^+

D. Br_2, $C\ell_2$, I_2

6. Which of the following salts cannot be prepared by the reaction of a metal and a dilute acid?

A. Copper(II) sulfate

B. Iron(II) chloride

C. Nickel(II) chloride

D. Magnesium sulfate

7. Which of the following statements would you expect to find in the procedure for standardising a potassium permanganate solution using oxalic acid?

A. Before pipetting 20.00 mL of standard oxalic acid solution into a conical flask, rinse it with the oxalic acid.

B. Acidify the oxalic acid solution by adding about 15 mL of dilute hydrochloric acid.

C. Rinse the burette with water immediately prior to filling it with potassium permanganate solution

D. Warm the conical flask and its contents to about 80°C before titrating with permanganate solution.

8. An electrochemical cell is based on the following reaction:

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

Which of the following changes would increase the cell voltage?

A. Adding more solid $Cu(NO_3)_2$.

B. Adding more solid $Zn(NO_3)_2$.

C. Adding water to the aqueous $Cu(NO_3)_2$ solution.

D. Increasing the size of the copper electrode.

9. A cell with an EMF of 0.74 V has the cell reaction:

$$Cu^{2+}(aq) + 2\,X^{2+}(aq) \rightarrow 2\,X^{3+}(aq) + Cu(s)$$

Under standard conditions the reduction potential ($E°_{red}$) for the half reaction

$X^{3+}(aq) + e^{-} \rightarrow X^{2+}(aq)$ would be:

A. – 0.40 V

B. – 0.80 V

C. + 0.40V

D. + 0.80 V

10. Which one of the following reactions is most likely to occur spontaneously?

A. Hydrogen gas is bubbled through a solution containing a suspension of lead (II) sulphate.

B. A piece of iron is placed in a zinc sulfate solution.

C. A piece of copper is placed in a nickel(II) sulfate solution.

D. Hydrogen peroxide is added to a solution of iron(III) nitrate producing oxygen gas.

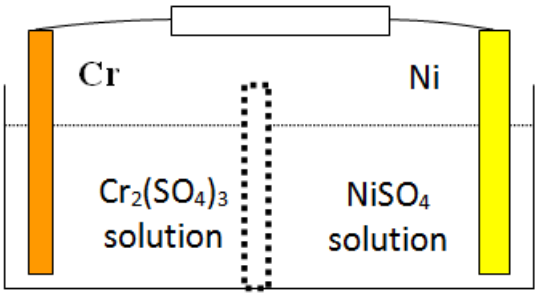
End of Part One

Part Two: Short Answer Section **32 marks**

Answer questions in the spaces provided. For calculations, show full working and give numerical answers to three significant figures.

Question 11 **(10 marks)**

The following diagram represents an electrochemical cell based on chromium and nickel.
A porous barrier separates the two half cells but allows ions to migrate between them.



(a) Write the equation for the overall reaction that occurs.

(2 marks)

(b) On the diagram, label the electrode that is the anode.

(1 mark)

(c) Draw an arrow in the box provided to show the direction of the electron flow in the wire.

(1 mark)

(d) What emf (voltage) will be generated under standard conditions?

(1 mark)

(e) Which metal cations will migrate through the porous barrier?

(1 mark)

(f) List a change that would occur in each half-cell as the cell operates.

(2 marks)

(g) Apart from the colour change in the solution, what other changes would be expected in the cell if the porous barrier was removed and the solutions become mixed?

(2 marks)

Question 12 **(8 marks)**

A method for determining the manganese content in steel is to convert all the manganese to the deeply coloured permanganate ion and then to measure how much light is absorbed by the solution.

Step 1: A sample of steel is dissolved in sulfuric acid, producing the manganese(II) ion and sulfur dioxide gas.

Step 2: This solution is then reacted with an acidified solution of periodate (IO_4^-) ions, producing the permanganate and iodate (IO_3^-) ions.

Write the oxidation and reduction half equations and then the fully balanced chemical equations for each of these steps.

Step 1

Oxidation:

_____

Reduction:

_____

Full equation:

_____

(4 marks)

Step 2

Oxidation:

_____

Reduction:

_____

Full equation:

_____

(4 marks)

Question 13 **(3 marks)**

The owner of an aluminium trailer carelessly stored a leaking bag of herbicide in the trailer in the open air over winter. The herbicide contained a solid soluble copper(II) compound. When the owner returned much later, a hole had appeared in the trailer underneath the fertiliser bag. Using equations, explain what happened.

Question 14 **(5 marks)**

The inside surface of copper frying pans used for cooking foods such as eggs can develop a black coating due to the formation of copper(II) sulfide. These blackened pans can be restored by adding an electrolyte solution such as sodium chloride and placing aluminium foil in the pan. The copper(II) sulfide is reduced to copper metal and aqueous sulfide ions. The aluminium is oxidised. This method does not remove any of the copper from the pan. The equation for the reduction reaction is:

$$CuS(s) + 2\,e^- \rightarrow Cu(s) + S^{2-}(aq)$$

The by-product of this process is aluminium sulfide.

(a) Write the full equation for the reaction.

(2 marks)

(b) A frying pan has a 0.0525 g coating of copper(II) sulfide. What mass of aluminium sulfide will be formed as the copper is restored?

(3 marks)

Question 15 **(6 marks)**

A jar containing a pale pink powder is labelled *commercial grade manganese(II) sulfate* $MnSO_4$. A chemist needed to know its purity in term of percentage by mass. He decides to analyse it by utilising the reaction between hydrogen peroxide and manganese(II) ions. The manganese(II) ions are converted into a black precipitate of manganese(III) oxide. The black oxide quickly settles to the bottom of the conical flask. The equation for the reaction is:

$$H_2O_2(aq) + 2\ Mn^{2+}(aq) + H_2O(\ell) \rightarrow Mn_2O_3(s) + 4\ H^+(aq)$$

The end point is taken to be when the final drop of hydrogen peroxide no longer produced a black precipitate.

The chemist dissolved 2.00 g sample of the impure manganese(II) sulfate in water in a 100 mL volumetric flask. He then pipetted 25.00 mL of this solution and diluted it to 250 mL in another volumetric flask. Next, he titrated 20.0 mL aliquots of the diluted manganese(II) sulfate solution against 0.00221 mol L^{-1} hydrogen peroxide solution. The average titre required was 46.55 mL.

What was the percentage purity of the commercial manganese(II) sulfate?

End of Test