ALL SAINTS' COLLEGE

Science Department

Year 12 Chemistry 2018

Oxidation and Reduction Test

Name: **ANSWER KEY**

Instructions to Students:

Attempt all questions
Write in the spaces provided
Show all working when required
All answers to be in blue or black pen, diagrams in pencil.

Multiple Choice	Short Answer	TOTAL	Final Percentage
/15	/40	/55	

Section 1: Multiple Choice **15 marks**

1. In which of the following reactions is hydrogen peroxide the oxidant (oxidising agent)?

(a) $H_2O_{2(aq)} + 2\ Fe^{3+}_{(aq)} \rightarrow O_{2(g)} + 2\ H^+_{(aq)} + 2\ Fe^{2+}_{(aq)}$

(b) $H_2O_{2(aq)} + Cl_{2(g)} \rightarrow O_{2(g)} + 2\ H^+_{(aq)} + 2\ Cl^-_{(aq)}$

(c) $3\ H_2O_{2(aq)} + 6\ H^+_{(aq)} + 2\ Au_{(s)} \rightarrow 6\ H_2O_{(l)} + 2\ Au^{3+}_{(aq)}$

(d) $3\ H_2O_{2(aq)} + Cr_2O_7^{2-}{}_{(aq)} + 8\ H^+_{(aq)} \rightarrow 3\ O_{2(g)} + 2\ Cr^{3+}_{(aq)} + 7\ H_2O_{(l)}$

2. Consider the following reaction between cobalt metal and hydrochloric acid.

$$Co_{(s)} + 2\ H^+_{(aq)} \rightarrow Co^{2+}_{(aq)} + H_{2(g)}$$

Which of the following statements is **correct**?

(a) Electrons are transferred from $Co_{(s)}$ to $H^+_{(aq)}$.

(b) Electrons are transferred from $H^+_{(aq)}$ to $Co_{(s)}$.

(c) Both $Co_{(s)}$ and $H^+_{(aq)}$ will each gain and lose some electrons.

(d) Electrons are not transferred, as this is not a redox reaction.

3. In which of the following species is the oxidation state of sulfur the lowest?

(a) SO_3

(b) SO_3^{2-}

(c) $S_2O_4^{2-}$

(d) $S_2O_6^{2-}$

4. The equation for the addition of liquid bromine to a hot, concentrated solution of sodium hydroxide is:

$$3Br_{2(l)} + 6OH^-_{(aq)} \rightarrow 5Br^-_{(aq)} + BrO_3^-{}_{(aq)} + 3H_2O_{(l)}$$

For this process consider the following statements

i the hydrogen is reduced

ii the bromine is oxidised

iii the oxygen is the reducing agent

iv the bromine is the oxidising agent

Which of the following is correct?

(a) i only

(b) ii and iv only

(c) ii and iii only

(d) i, ii and iii only

5. Which of the following halogen displacements would **NOT** occur.

(a) $F_{2(aq)} + 2Cl^-_{(aq)} \rightarrow Cl_{2(aq)} + 2F^-_{(aq)}$

(b) $I_{2(aq)} + 2Cl^-_{(aq)} \rightarrow Cl_{2(aq)} + 2F^-_{(aq)}$

(c) $F_{2(aq)} + 2Br^-_{(aq)} \rightarrow Cl_{2(aq)} + 2Br^-_{(aq)}$

(d) $Cl_{2(aq)} + 2Br^-_{(aq)} \rightarrow Br_{2(aq)} + 2Cl^-_{(aq)}$

6. In a lead-acid car battery:

(a) The cathode is made of solid lead

(b) The electrolyte is dilute sulfuric acid

(c) The anode is made of lead sulfate

(d) The cathode is made of lead oxide

7. In a traditional Leclanche dry cell the anode is:

(a) A carbon rod running down the centre of the cell.

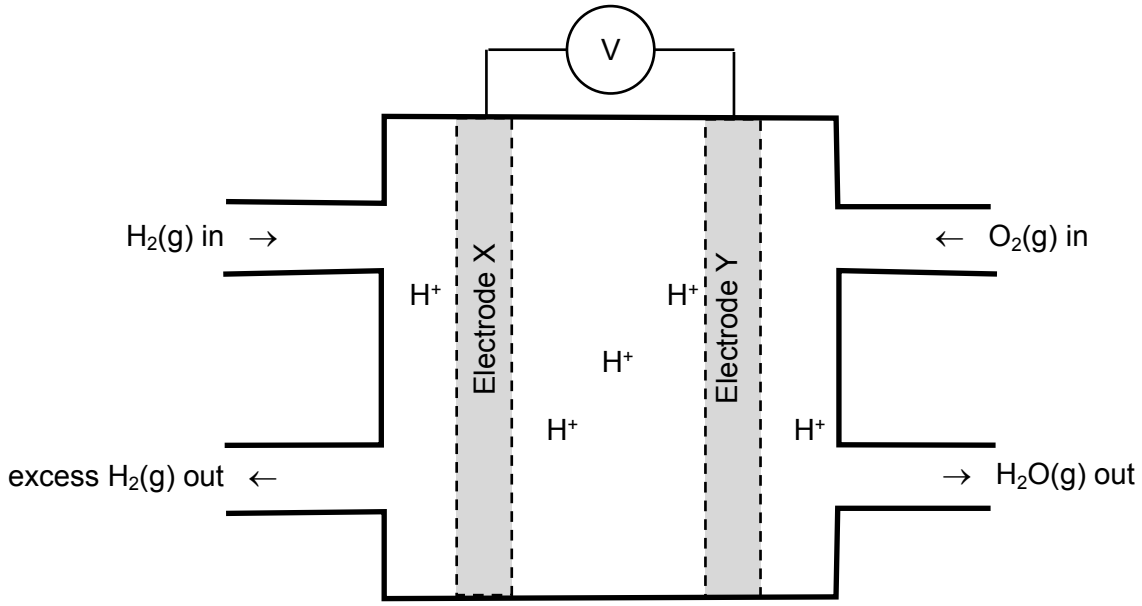
(b) A copper cap at the base of the cell

(c) The outer metal casing made of plastic or aluminium

(d) A zinc cup in which the electrolyte sits.

Questions 8 and 9 refer to the information below.

There are several different types of fuel cells, which mostly differ in terms of the fuel being utilised. One of the most common fuel cells is the hydrogen / oxygen fuel cell. A partially completed sketch of a hydrogen/oxygen fuel cell operating with an acid electrolyte is shown in the diagram below. The only overall chemical product of the hydrogen / oxygen fuel cell is water.



8. Which of the following statements are **correct**, regarding **fuel cells in general**?

i. Fuel cells involve a redox reaction.
ii. Fuel cells require continuous input of reactants to operate.
iii. Fuel cells are a type of galvanic cell.
iv. Fuel cells are a type of secondary cell.
v. Fuel cells do not produce any sources of toxic pollution.

(a) i, ii and iii only
(b) i, ii and v only
(c) ii, iii and iv only
(d) ii, iii and v only

9. Which of the following statements is **correct,** regarding the **hydrogen/oxygen fuel cell** shown in the diagram above?

(a) Reduction occurs at X.
(b) Electrons move from Y to X.
(c) Cations move towards Y.
(d) The EMF of this cell under standard conditions is 1.15 volts.

10. When comparing electrochemical cells with electrolytic cells, it is true to say that

(a) the anode is positive, and the cathode is negative in each case.

(b) reduction occurs at the negative electrode in a galvanic cell.

(c) reduction occurs at the cathode in both cases.

(d) oxidation occurs at the cathode in an electrolysis cell.

11. An electrolysis cell is set up with two platinum electrodes dipping into a 1 M solution of $Cu(NO_3)_{2\ (aq)}$.

The substance which would be generated at the positive electrode is

(a) copper.

(b) nitrogen dioxide.

(c) oxygen.

(d) hydrogen.

12. In an electrolytic cell

(a) electrons pass through the electrolyte.

(b) positive ions move through the electrolyte towards the electrode at which oxidation occurs.

(c) negative ions move through the electrolyte towards the electrode at which oxidation occurs.

(d) electrons pass through the salt bridge.

13. Which of the following reactions depicts the process occurring at the **cathode** during the **charging cycle** of a lead-acid battery?

(a) $PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$

(b) $PbSO_4 + 2H_2O \rightarrow PbO_2 + SO_4^{2-} + 4H^+ + 2e^-$

(c) $PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$

(d) $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$

14. The device in the picture shown is correctly known as a

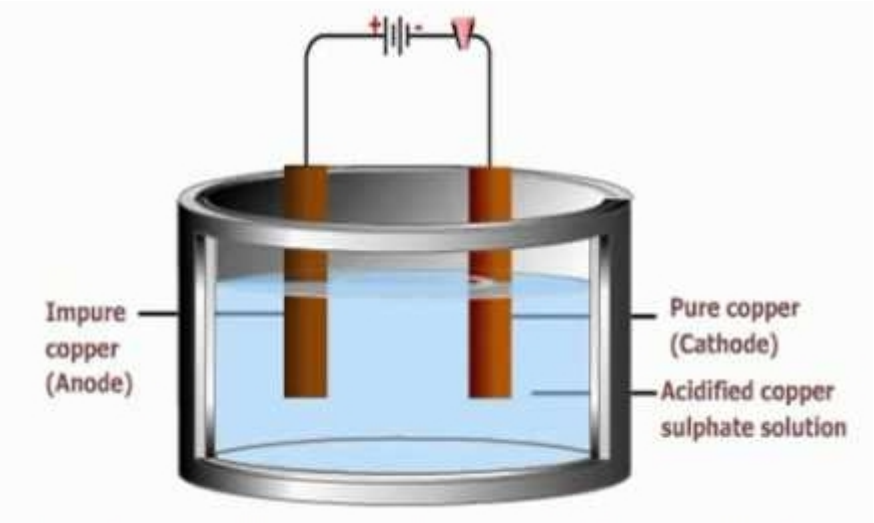
(a) Primary cell

(b) Secondary cell

(c) Tertiary cell

(d) Rechargeable battery

15. The electrolytic refining of copper is shown in the diagram below:



Impurities such as gold or silver fall to the bottom of the electrolytic cell container because:

(a) They have a greater tendency to be oxidized
(b) They have a greater tendency to be reduced
(c) They have a lower tendency to be oxidised
(d) They have a lower tendency to be reduced

Short Answer Section (40 marks)

Question 1 (6 marks)

Tin is a metallic element located in Group 14 of the periodic table. It is used to make many different alloys such as bronze and solder, as well as finding application in the plating of steel to produce 'tin cans' for storage.

A chemistry student had 1.0 mol L^{-1} solutions of the following four substances;

$Ni(NO_3)_2$ $Zn(NO_3)_2$ $Pb(NO_3)_2$ $Mg(NO_3)_2$

(a) Which of these solutions could **not** be stored in a tin container? Explain your answer using a relevant chemical equation.

(3 marks)

Lead nitrate could not be stored in a tin container. (1)

The lead (II) ion and tin metal would react spontaneously as the combined E° for the couple is 0.01V.

The tin has a greater tendency to be oxidized than the lead ions.

When tin metal is placed in an acidified solution containing the weak acid hydrogen chromate ($HCrO_4^-$) a deep green solution containing chromium(III) ions is formed, and the tin metal dissolves producing tin(II) ions.

(b) Write the oxidation and reduction half-equations and the overall redox equation for this reaction.

(3 marks)

Oxidation half-equation	$\mathbf{Sn \rightarrow Sn^{2+} + 2e^-}$
Reduction half-equation	$\mathbf{HCrO_4^- + 7H^+ + 3e^- \rightarrow Cr^{3+} + 4H_2O}$
Overall redox equation	$\mathbf{2HCrO_4^- + 14H^+ + 3Sn \rightarrow 2Cr^{3+} + 3Sn^{2+} + 8H_2O}$

Question 2 **(14 marks)**

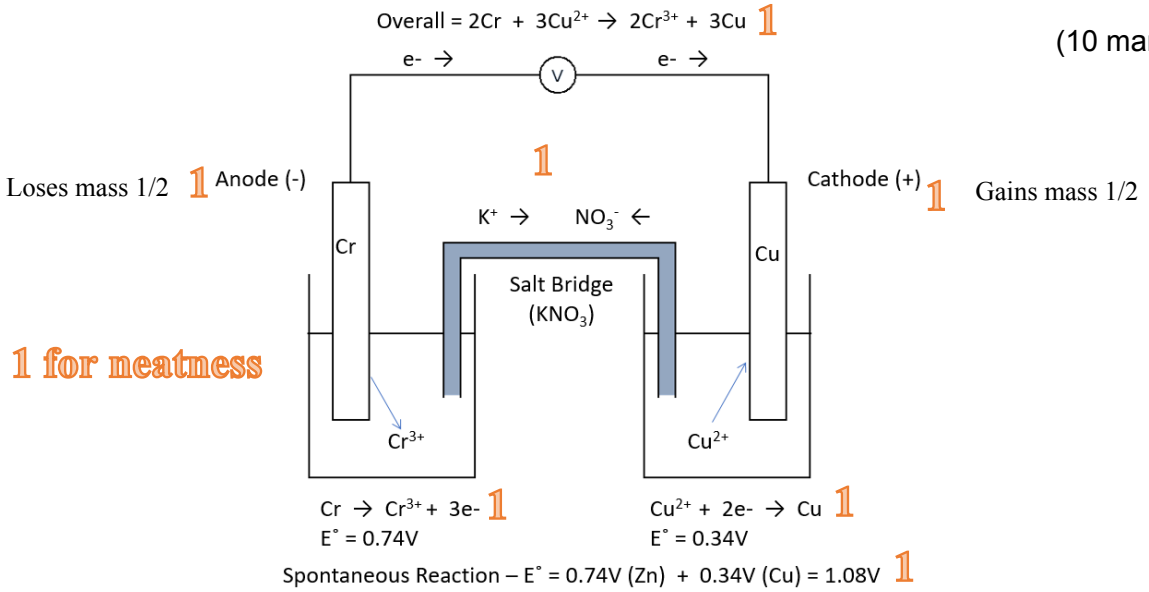
A chromium rod is dipping into a 1M $Cr(NO_3)_3$ solution and a copper rod dipping into 1M $CuSO_4$ solution are connected to a voltmeter (a salt bridge containing a suitable electrolyte is included).

(a) Draw a large diagram of the circuit indicating:

- the flow of electrons
- the anode and the cathode
- the sign on each electrode
- the overall E° of the cell
- the movement of ions in each cell
- the flow of ions across the salt bridge
- the electrode that loses mass and the electrode gaining mass (if any).
- the half equation for the reaction occurring in each cell,
- and the overall equation for the cell.

Note - The appearance of your diagram is also worth one mark.

(10 marks)



(b) Describe the appearance of the chromium half-cell before **and** after complete reaction occurs. (2 marks)

The cell initially starts off with a silver electrode in a deep green solution. (1) After reaction, the silver coloured electrode has lost mass and the solution is a deeper green. (1)

(c) Describe the appearance of the copper half-cell before **and** after complete reaction occurs. (2 marks)

The cell initially starts off with a salmon pink electrode in a blue solution. (1) After reaction, the salmon pink electrode has gained mass and the solution has become less blue. (1)

Question 3 **(9 marks)**

The "Downs cell" is used to produced sodium metal electrolytically.

(a) What is the electrolyte in this case?

Molten sodium chloride (1 mark)

(b) Why is an aqueous solution not used for this process?

The water would have been preferentially reduced and oxidized. (1 mark)

(c) What is a suitable material for the anode and why?

Graphite would be suitable as it is inert (1) and would not react with the cell components (1)

(2 marks)

(d) White a half equation for the anode reaction.

$2Cl^- \rightarrow Cl_2 + 2e^-$

(1 mark)

(e) Write a half equation for the cathode reaction.

$Na^+ + e^- \rightarrow Na$

(1 mark)

(f) What is the other product of this cell besides sodium metal?

Chlorine gas

(1 mark)

(g) Write the overall cell equation.

$2Na^+ + 2Cl^- \rightarrow 2Na + Cl_2$

(1 mark)

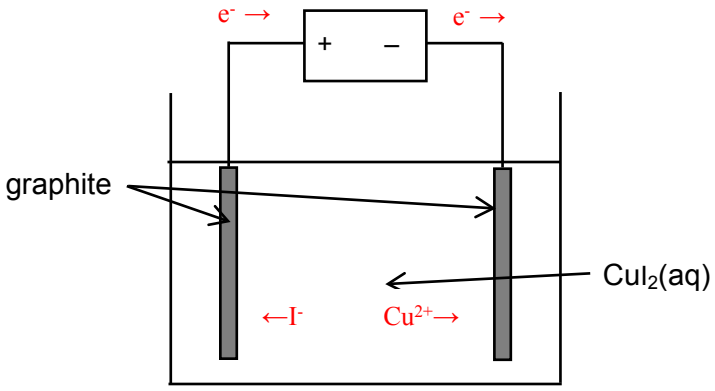
(h) What is the minimum voltage that needs to be supplied in order for this cell to operate?

+4.07V

(1 mark)

Question 4 **(11 marks)**

An electrolytic cell is set up as shown below. The electrolyte is aqueous copper(II) iodide and both electrodes are made from graphite. As the cell runs, copper metal and iodine are produced.



(a) Indicate the direction of electron flow and cation flow on the diagram above.

(2 marks)

(b) Write half-equations to illustrate the reactions occurring at each electrode.

(2 marks)

cathode	$Cu^{2+} + 2e^- \rightarrow Cu$
anode	$2I^- \rightarrow I_2 + 2e^-$

(c) Tick **all** of the **observations** that are **correct** for this cell as it continues to run.

(2 marks)

- ■ copper metal forms at the cathode
- ☐ a silver metal forms at the negative electrode
- ☐ a salmon pink metal forms at the anode
- ■ the electrolyte becomes paler blue
- ■ a brown solution forms around the positive electrode

(d) When aqueous copper(II) **chloride** is electrolysed, oxygen gas forms instead of chlorine gas. Explain why this occurs.

(2 marks)

When copper (II) chloride is used, the oxidation reaction of water to oxygen gas

$$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$$

Happens at a more positive potential (-1.23V) than chloride (-1.36V)

(e) If a concentrated copper (II) chloride solution is used, chlorine gas is produced. Why is this?

(1 mark)

This is due to the **concentration effect**. Redox potentials are only reliable for predictions when the concentration is 1M.

(f) One noticeable feature that differentiates most electrolytic cells from electrochemical cells is the lack of a salt bridge. Using relevant chemical theory explain why this may be the case.

(2 marks)

Electrochemical cells require the sites of oxidation and reduction to be separated to prevent spontaneous redox reaction. The salt bridge allows for ion movement in this situation to stop polarization of each half cell occurring.

Electrolytic cells do not rely on a spontaneous redox reaction, so do not need to be separated, so do not need a salt bridge.