Christ Church
Grammar School

Year 12 Chemistry

Redox test
2021

Time allowed: **45 minutes**

Name:_____

Mark = **……/49**

Teacher:

DGM **JPT** **NMO**

Section 1 Multiple Choice **10 marks**

1. In which of the following is phosphorus in the lowest oxidation state (oxidation number)?

   A. HPO_3^{2-}
   B. $P_3O_9^{3-}$
   C. H_3PO_4
   D. P_4O_{10}

2. Which of the following does **not** contain a nitrogen atom with an oxidation number of +5?

   A. $Mg(NO_3)_2$
   B. NH_4NO_3
   C. N_2O_5
   D. $Cr(NO_2)_3$

3. Which of the following are redox reactions?

   I. $2Li + 2HCl \rightarrow 2LiCl + H_2$
   II. $Li_2O + 2HCl \rightarrow 2LiCl + H_2O$
   III. $LiOH + HCl \rightarrow LiCl + H_2O$
   IV. $Li_2CO_3 + 2HCl \rightarrow 2LiCl + CO_2 + H_2O$

   A. I only
   B II, III and IV only
   C. I and IV only
   D. all of them

4. Which of the following best describes the transfer of electrons when 4 moles of Br_2 molecules are converted into bromate, BrO_3^-, ions

   A. 10 electrons are gained
   B. 20 electrons are gained
   C. 40 electrons are gained
   D. 40 electrons are lost

5. Which of the following combinations of substances would result in an observable reaction?

   A. hydrogen peroxide solution is added to chromium (III) nitrate solution
   B. hydrogen peroxide solution is added to potassium fluoride solution
   C. hydrogen peroxide solution is added to silver nitrate solution
   D. hydrogen peroxide solution is added to sodium nitrate solution

The following 3 questions refer to a galvanic cell comprising a $Fe^{2+}(aq)$ /$Fe^{3+}(aq)$ half-cell and a $Pb(s)/Pb^{2+}(aq)$ half-cell under standard conditions

6. What will be the voltage of the galvanic cell?

   A. 0.13V
   B. 0.64V
   C. 0.77V
   D. 0.90V

7. Which of the following best describes the changes in the masses of the two electrodes that would be observed during operation of the cell?

	Mass of cathode	Mass of anode
A	increased	decreased
B	decreased	increased
C	unchanged	unchanged
D	unchanged	changed

8. During the operation of the cell, which of the following will occur?

   A. Electrons will flow towards the Pb/Pb^{2+} half cell.
   B. Negative ions in the salt bridge will flow towards Pb/Pb^{2+} half cell.
   C. The enthalpy of the system will increase.
   D. The voltage of the cell will gradually increase.

9. Which of the following is true for all electrolytic cells?

   A. Anions in the electrolyte flow towards the cathode.
   B. Reduction occurs at the positive electrode.
   C. Electrons flow from the anode to the cathode through the external circuit.
   D. A salt bridge is not used because of the high temperatures.

10. In the electrolysis of sodium chloride, which of the following is true?

    A. The products are of lower enthalpy than the reactants.
    B. It is an exothermic process.
    C. Sodium is produced at the anode.
    D. Electrical energy is converted into chemical energy.

Section 2 Short Answers **39 marks**

Question 11 **(9 marks)**

Write balanced half-equations and a full equation for the following processes.

(a) The electrolysis of molten aluminium oxide

Oxidation half equation	
Reduction half equation	
Full redox equation	

(4 marks)

(b) When nitrate ions are added to copper metal, nitrogen monoxide (NO) is formed and the solution turns blue.

Oxidation half equation	
Reduction half equation	
Full redox equation	

(5 marks)

Question 12 **(7 marks)**

Consider the following standard reduction reactions and their potentials ;

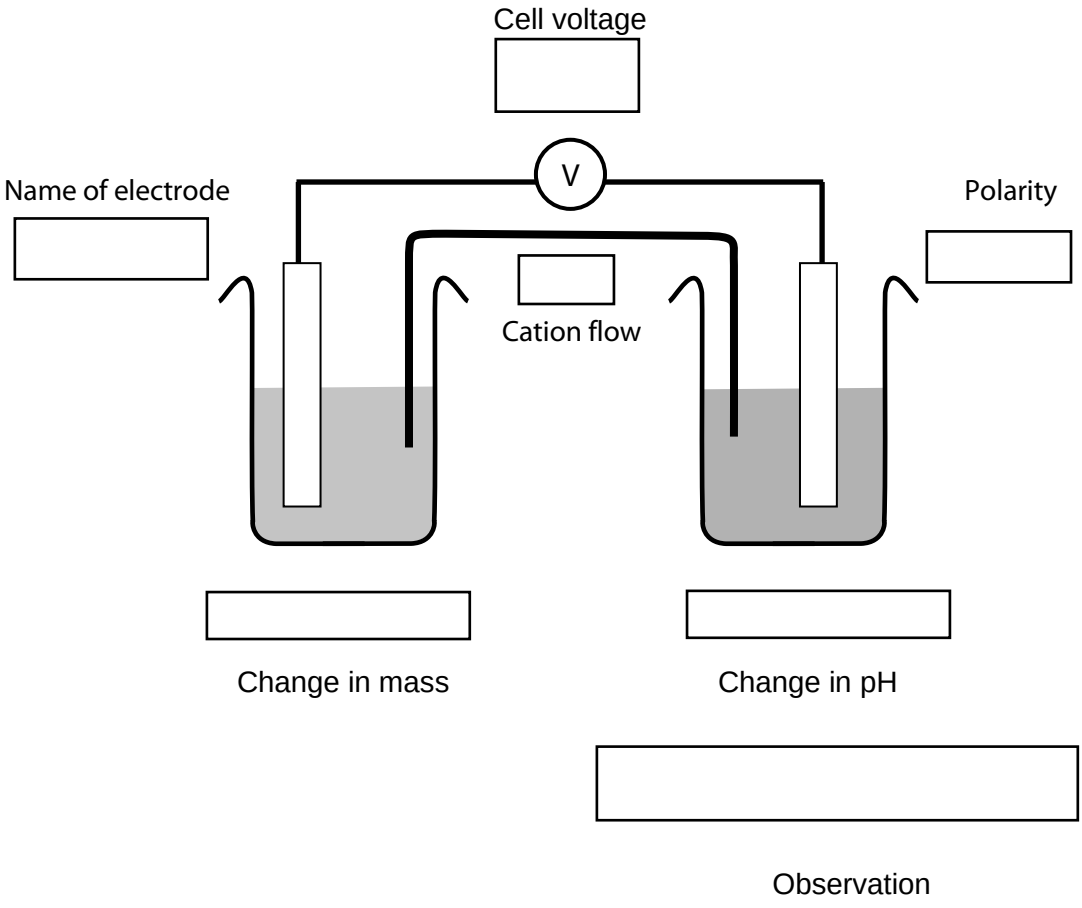
$$FeO_4^{2-}(aq) + 8H^+(aq) + 3e^- \rightleftharpoons Fe^{3+}(aq) + 4H_2O(l) \quad +2.20V$$

$$S_2O_8^{2-}(aq) + 2e^- \rightleftharpoons 2SO_4^{2-}(aq) \quad +2.01V$$

An galvanic cell is constructed as follows. In the half-cell on the left, a platinum electrode is placed into a solution that contains both 1.00 $molL^{-1}$ $S_2O_8^{2-}(aq)$ and 1.00 $molL^{-1}$ SO_4^{2-} (aq). In the half-cell on the right, another platinum electrode is placed into a solution that contains both 1.00 $molL^{-1}$ $FeO_4^{2-}(aq)$ and 1.00 $molL^{-1}$ $Fe^{3+}(aq)$.

Complete the diagram below, indicating the following in the relevant spaces provided.

- Name of the left-hand electrode (anode or cathode).
- Polarity of the right-hand electrode (+ or -).
- Direction of flow of cations in the salt bridge.
- Observation at the right-hand electrode
- Change in mass of the left-hand electrode (increase, decrease, no change)
- Change in pH of the right-hand electrode (increase, decrease, no change)
- Cell voltage



Question 13 **(6 marks)**

Use your data sheet and knowledge of the lead acid battery to complete the following tables

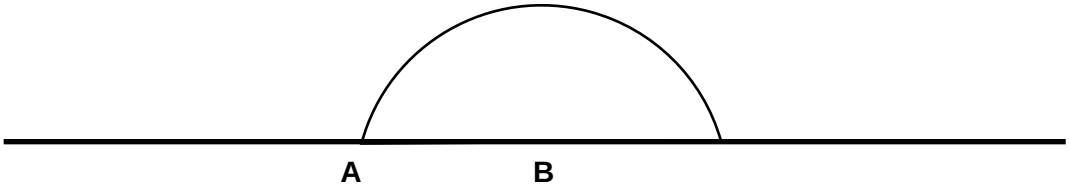
The overall reversible reaction is shown below

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

DURING DISCHARGE	
The half-equation for the anode reaction	
The reductant (reducing agent)	
The change in pH of the electrolyte (increase, decrease or no change)	
DURING RECHARGE	
The half-equation for the cathode reaction	
The change in mass of lead (II) sulfate, $PbSO_4$ (increase, decrease or no change)	
The minimum voltage that needs to be applied for recharge to take place.	

Question 14 **(5 marks)**

Below is a simplified diagram of a drop of water on an iron surface.



Write 'true' or 'false' in the boxes below alongside the following statements;

Statement	True or False
Loss of iron metal will most likely be seen at location B	
A is a cathodic area	
Electrons will flow through the iron from A to B	
During the corrosion process, Fe(s) is oxidised to Fe^{2+}(aq) and O_2(g) is reduced to OH^-(aq)	
The red/brown colour of the rust is due $Fe(OH)_2$(s)	

Question 15 **(6 marks)**

A galvanic cell is set up with the following half-cells

Half-cell 1

$H_2(g)$ is bubbled over a platinum electrode in 50mL of 0.100molL^{-1} nitric acid.

Half-cell 2

A 5.00g chromium electrode in 50.0mL of 0.100molL^{-1} chromium (III) nitrate.

A pH meter was placed in half-cell 1 and, after the cell was operating for 20 minutes, the pH of the solution was found to be 1.3

Use this information to calculate the final mass of the chromium electrode in half-cell 2.

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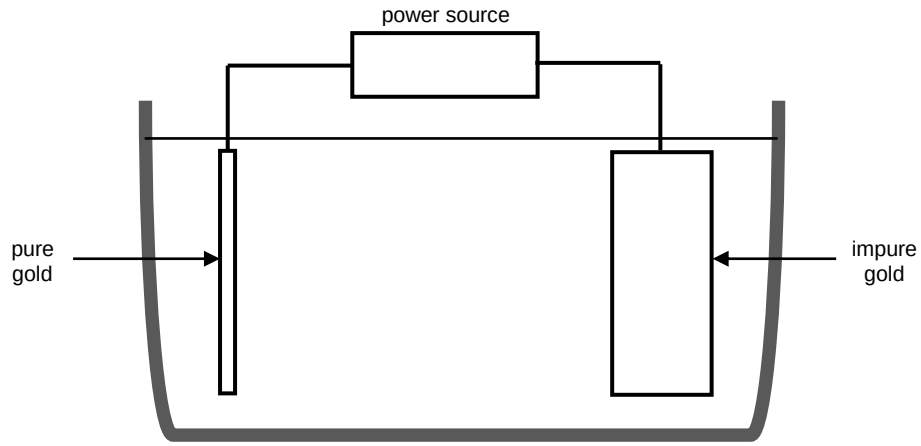
Question 16 **(6 marks)**

The Wohlwill process is an electrorefining technique used to purify gold, when very high purity gold metal is required. In this process, the electrolyte is composed of chloroauric acid, $HAuCl_4$. An electric potential of approximately 0.5 V is applied.

The basis of this electrorefining process is very similar to that used for copper metal, with some of the metal impurities entering the electrolyte solution, and some forming a sludge beneath the anode.

The diagram below is a simplified representation of the Wohlwill process.



(a) On the diagram above, label the

- the direction of electron flow through the power source
- the direction of ion flow of Au^{3+} ions in the electrolyte.

(2 marks)

(b) Write balanced half-equations representing the processes occurring at the cathode and the anode.

(2 marks)

cathode	
anode	

(c) State the overall EMF for the reaction occurring,

(1 mark)

EMF = ……. V

(d) If silver metal was an impurity in the gold, would this likely be found in the electrolyte (as Ag^+ ions) or the anode sludge (as Ag metal), once the electrorefining process was complete? Circle your answer. (1 mark)

Electrolyte Sludge

END OF TEST

The active ingredient in most commercial bleach is sodium hypochlorite, NaClO, which contains the hypochlorite (ClO^-) ion. A common method of establishing the chlorine content of a bottle of bleach from a supermarket is as follows.

Step 1 Add the bleach to an excess of acidified potassium iodide solution. This converts all of the iodide ions into aqueous iodine, turning the solution brown.

$$OCl^-(aq) + 2H+(aq) + 2I^-(aq) \rightarrow Cl^-(aq) + I_2(aq) + H_2O(l)$$

Step 2 Samples of the resultant solution are titrated against sodium thiosulfate, which converts the iodine back into iodide ions, the end-point being when the brown colour of the aqueous iodine disappears.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

In a particular investigation, the following procedure was followed.

- A 10.0mL sample of bleach was added to a beaker and found to have a mass of 10.13g.
- An excess of acidified potassium iodide solution was added.
- The resultant solution was made up to 100mL in a volumetric flask.
- 20.0mL samples were taken from the volumetric flask and titrated against $0.107 molL^{-1}$ sodium thiosulfate solution.
- An average titre of 17.26mL was obtained.

Calculate the percentage by mass of sodium hypochlorite in the bleach. You may assume that the hypochlorite ion is the only oxidant present in the bleach.