CHEMISTRY 3.3

An assessment for AS90696

Describe oxidation-reduction processes

Credits: Three

INSTRUCTIONS

Answer **ALL** questions

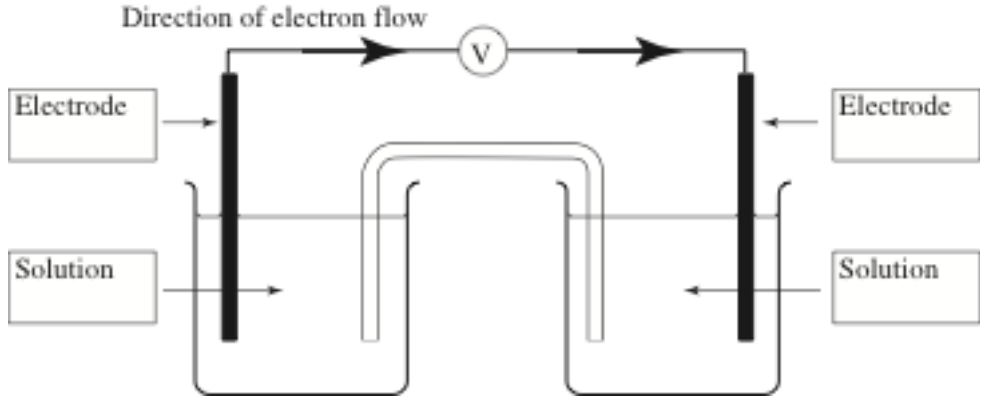
You are advised to spend 35 minutes answering these questions

QUESTION ONE

An electrochemical cell is set up based on the reaction between bromine solution and silver ions.

$E°(Br_2/Br^-) = +1.08$ V $\qquad$ $E°(Ag^+/Ag) = +0.80$ V

(a) (i) Identify the solutions and the electrode substances in the apparatus shown. The direction of electron flow is shown.



(ii) Calculate the cell potential.

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(b) The salt used in the salt bridge is potassium nitrate, KNO_3. Explain the flow of charge through the salt bridge in this cell, both in terms of the species involved and their direction of movement.

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(c) A new electrochemical cell is set up in which the voltmeter is replaced by a wire and the Br_2/Br^- half cell is replaced by a Fe^{2+}/Fe half cell.

$$E^\circ (Fe^{2+}/Fe) = -0.44 \text{ V}$$

This new cell is allowed to run for some time. Discuss the changes that would be observed in each half cell. Your answer should include:

- an explanation of the electron movement in the cell
- observations of changes occurring in each half cell linked to the appropriate species
- balanced half-equations
- the cell potential

QUESTION TWO

(a) Sulfur dioxide is bubbled through a solution of acidified potassium permanganate.

(i) Write balanced half-equations for the oxidation and reduction reactions, and then write a balanced equation for the overall reaction.

Oxidation:
Reduction:
Balanced overall equation:

(ii) When sulfur dioxide is bubbled through potassium permanganate solution in strongly basic conditions, the $E°_{cell}$ is +0.11 V.

Determine $E°$ (SO_4^{2-}/SO_2) using the data in the table below.

Redox couple	***E*° / V**
MnO_4^- / MnO_2	+1.69
MnO_4^- / Mn^{2+}	+1.51
MnO_4^- / MnO_4^{2-}	+0.56

(b) (ii) Arrange the standard reduction potentials $E°$ (Fe^{3+}/Fe^{2+}), $E°(NO_3^-/NO_2)$, and $E°$ (Cu^{2+}/Cu) from highest to lowest using the information from the unbalanced equations below. Discuss your answer.

$Fe^{2+} + NO_3^- \longrightarrow Fe^{3+} + NO_2$ (1)

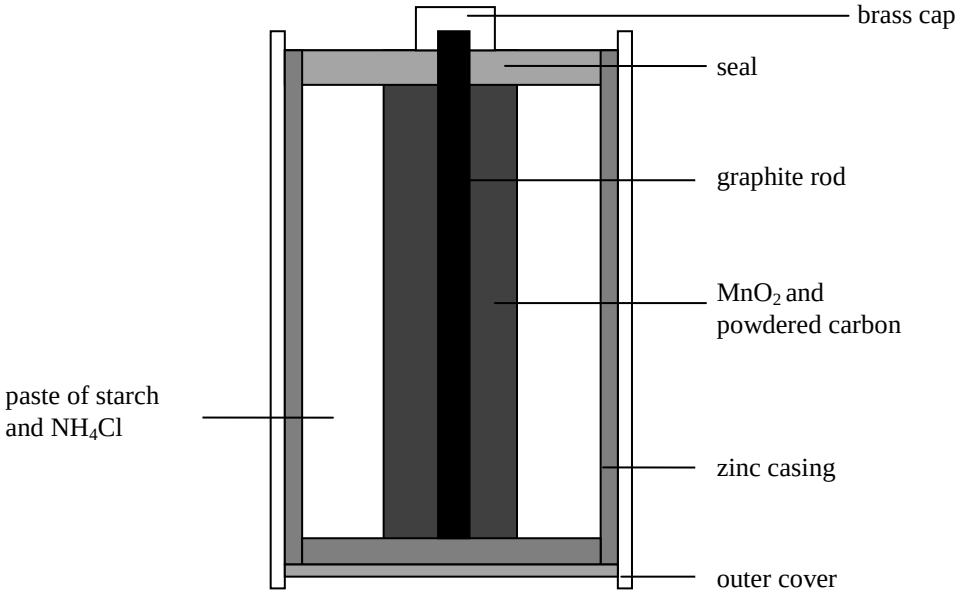
$Cu^{2+} + Fe^{2+} \longrightarrow$ no reaction (2)

$Cu + NO_3^- \longrightarrow Cu^{2+} + NO_2$ (3)

(ii) Identify the species that is the strongest oxidant. Justify your answer.

QUESTION THREE

The dry cell was first developed in 1866 by Georges Leclanche. Used for low energy drain appliances such as torches, it has the advantage of being portable and cheap.



The following equations can be assumed to represent the reactions taking place when a dry cell is operating:

$2MnO_2 + H_2O + 2e^- \longrightarrow Mn_2O_3 + 2OH^-$ **Reaction 1**

$Zn \longrightarrow Zn^{2+} + 2e^-$ **Reaction 2**

(a) (i) Circle the reaction which occurs at the cathode. Give a reason for your answer.

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(ii) Give the standard cell diagram for the dry cell.

(b) Disproportionation involves the simultaneous oxidation and reduction of a species. In the reaction between copper(I) oxide and sulfuric acid, copper(I) undergoes disproportionation:

$$Cu_2O + H_2SO_4 \longrightarrow Cu + CuSO_4 + H_2O$$

(i) Use oxidation numbers to show that this is a disproportionation reaction.

(ii) Discuss, using the relevant reduction potentials from the list below, why solutions of copper(I) ions do not exist. Include balanced equations to support your answer.

Redox couple	***E*° / V**
Cu^{2+} / Cu	+0.34
Cu^{2+} / Cu^{+}	+0.16
Cu^{+} / Cu	+0.52