Electrode Potentials & Redox
A Level only
Question Paper 3

Leveli	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	Electrode Potentials & Redox
Paper	A Level only
Booklet	Question Paper 3

Time allowed: **50 minutes**

Score: **/37**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

Question 1

Which redox reaction contains the largest change in oxidation state for sulfur?

A $H_2SO_4 + 8HI \rightarrow H_2S + 4I_2 + 4H_2O$

B $S + O_2 \rightarrow SO_2$

C $S_2O_3^{2-} + 2H^+ \rightarrow SO_2 + S + H_2O$

D $S + 6HNO_3 \rightarrow H_2SO_4 + 6NO_2 + 2H_2O$

[1]

Redox reactions are used to generate electrical energy from electrochemical cells.

(a) **Table 4.1** shows three redox systems, and their standard redox potentials.

redox system	$E^{\ominus}$/V
$Cu^{+}(aq) + e^{-} \rightleftharpoons Cu(s)$	+0.52
$Cr^{3+}(aq) + 3e^{-} \rightleftharpoons Cr(s)$	–0.74
$Sn^{4+}(aq) + 2e^{-} \rightleftharpoons Sn^{2+}(aq)$	+0.15

Table 4.1

(i) Draw a labelled diagram to show how the standard electrode potential of a Sn^{4+}/Sn^{2+} redox system could be measured. [3]

(ii) Using the information in **Table 4.1**, write equations for the reactions that are feasible.

Suggest **two** reasons why these reactions may **not** actually take place. [5]

(b) Modern fuel cells are being developed as an alternative to the direct use of fossil fuels. The 'fuel' can be hydrogen but many other substances are being considered.
In a methanol fuel cell, the overall reaction is the combustion of methanol.

As with all fuel cells, the fuel (methanol) is supplied at one electrode and the oxidant (oxygen) at the other electrode.

Oxygen reacts at the negative electrode of a methanol fuel cell:

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

(i) Write an equation for the complete combustion of methanol. [1]

(ii) Deduce the half-equation for the reaction that takes place at the positive electrode in a methanol fuel cell. [1]

(iii) State **two** advantages of vehicles using fuel cells compared with the combustion of conventional fossil fuels. [2]

(iv) Suggest **one** advantage of using methanol, rather than hydrogen, in a fuel cell for vehicles. Justify your answer.

[1]

[Total: 13 Marks]

This question is about redox, electrode potentials and feasibility.

Table 22.1 shows standard electrode potentials for four redox systems.
You need to use this information to answer the questions below.

Redox system	Equation	$E^{\ominus}$/V
1	$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	–0.76
2	$SO_4^{2-}(aq) + 2H^+(aq) + 2e^- \rightleftharpoons SO_3^{2-}(aq) + H_2O(l)$	+0.17
3	$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
4	$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+1.51

Table 22.1

(a) A standard cell is set up in the laboratory based on redox systems **1** and **3** and the standard cell potential is measured.

(i) Draw a labelled diagram to show how this cell could be set up to measure its standard cell potential.

Include details of the apparatus, solutions and the standard conditions required to measure this standard cell potential.

[4]

(ii) Predict the standard cell potential of this cell. **[1]**

(b) In **Table 22.1**, what is the strongest reducing agent and the strongest oxidising agent?

[2]

(c) Electrode potentials can be used to predict the feasibility of reactions.

Construct an overall equation for the predicted reaction between the species in redox systems **2** and **4**.

[2]

(Total 9 marks)

Storage cells and fuel cells are types of electrochemical cell used as sources of energy.

Information about five redox systems that could be used in electrochemical cells is shown below. You may need to use this information throughout this question.

redox system					$E^{\ominus}$ / V
1	$Fe^{2+}(aq) + 2e^-$	$\rightleftharpoons$	$Fe(s)$		–0.44
2	$2H_2O(l) + 2e^-$	$\rightleftharpoons$	$2OH^-(aq) + H_2(g)$		–0.83
3	$2H^+(aq) + 2e^-$	$\rightleftharpoons$	$H_2(g)$		0.00
4	$O_2(g) + 2H_2O(l) + 4e^-$	$\rightleftharpoons$	$4OH^-(aq)$		+0.40
5	$O_2(g) + 4H^+(aq) + 4e^-$	$\rightleftharpoons$	$2H_2O(l)$		+1.23

(a) The standard electrode potential of redox system **1** can be measured by constructing an electrochemical cell.

- Draw a diagram below to show how the standard electrode potential could be measured for redox system **1**.
- State the conditions needed to measure this standard electrode potential. [4]

(b) When an **alkaline** hydrogen–oxygen fuel cell is being used to produce electrical energy, chemical changes take place within the cell.

(i) Write half-equations for the changes that take place at each electrode. [2]

(ii) Write the overall equation for the cell reaction. [1]

(iii) What is the standard cell potential of this fuel cell? [1]

(c) State **one** important difference between a fuel cell and a conventional storage cell. [1]

(d) People often assume that hydrogen–oxygen fuel cells are a source of energy that is carbon neutral, *i.e.* there is no net increase in carbon dioxide from using the fuel cell.

Suggest **one** reason why this assumption may **not** be correct. [1]

(e) A student constructs a cell as follows.

- A half-cell is made from a strip of chromium metal and a solution of aqueous chromium(III) sulfate.
- A second half-cell is made from a strip of a metal **X** and a solution of **X**SO_4(aq).
- The two half-cells are connected together and a current is allowed to pass for a length of time.

The chromium electrode gains 1.456 g in mass.
The electrode made of metal **X** loses 1.021 g in mass.

Determine the identity of metal **X**.
Show all your working. [4]

[Total 14 Marks]