Electrode Potentials & Redox
A Level only

Question Paper 2

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	Electrode Potentials & Redox
Paper	A Level only
Booklet	Question Paper 2

Time allowed: **41 minutes**

Score: **/30**

Percentage: **/100**

Grade Boundaries:

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

A cell is constructed from the two redox systems below.

$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$ $E^\ominus = +0.34\ V$
$Ag^{+}(aq) + e^- \rightleftharpoons Ag(s)$ $E^\ominus = +0.80\ V$

Which statement(s) is/are correct for the cell?

1 The cell potential is 1.14 V.

1 The reaction at the copper electrode is $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$.

1 The silver electrode increases in mass.

A. 1, 2 and 3

B. Only 1 and 2

C. Only 2 and 3

D. Only 1 **[1]**

Electrochemical cells have been developed as a convenient and portable source of energy.

The essential components of any electrochemical cell are two redox systems, one providing electrons and the other accepting electrons. The tendency to lose or gain electrons can be quantified using values called standard electrode potentials.

Standard electrode potentials for seven redox systems are shown in **Table 4.1**. You may need to use this information throughout this question.

Table 4.1

redox system	equation	$E^\ominus$/V
1	$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0
2	$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
3	$SO_4^{2-}(aq) + 2H^+(aq) + 2e^- \rightleftharpoons SO_3^{2-}(aq) + H_2O(l)$	+0.17
4	$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.34
5	$Cl_2(aq) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
6	$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	+1.23
7	$I_2(aq) + 2e^- \rightleftharpoons 2I^-(aq)$	+0.54

(a) An electrochemical cell can be made based on redox systems 2 and 4.

(i) Draw a labelled diagram to show how this cell can be set up in the laboratory. [3]

(ii) State the charge carriers that transfer current

through the wire,

hrough the solution. [1]

(iii) Write down the overall cell reaction. [1]

(iv) Write down the cell potential.

cell potential [1]

(b) Select from **Table 4.1**,

(i) a species which oxidises Fe^{2+}(aq) to Fe^{3+}(aq), [1]

(i) a species which reduces Fe^{3+}(aq) to Fe^{2+}(aq) but does **not** reduce Ag^{+}(aq) to Ag(s). [1]

(b) Fuel cells are a type of electrochemical cell being developed as a potential source of energy in the future.

- State **one** important difference between a fuel cell and a conventional electrochemical cell.
- Write the equation for the overall reaction that takes place in a hydrogen fuel cell.
- State **two** ways that hydrogen might be stored as a fuel for cars.
- Suggest why some people consider that the use of hydrogen as a fuel for cars consumes more energy than using fossil fuels such as petrol and diesel. [5]

[Total: 13 Marks]

Redox titrations using $KMnO_4$ in acidic conditions can be used to analyse reducing agents. Acidified $KMnO_4$ is a strong oxidising agent, readily removing electrons:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

A student analysed a solution of hydrogen peroxide, H_2O_2(aq), using a redox titration with $KMnO_4$ under acidic conditions. Under these conditions, H_2O_2 is a reducing agent.

The overall equation for the reaction is given below.

$$2MnO_4^- + 6H^+ + 5H_2O_2 \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$$

(a) Deduce the simplest whole number half-equation for the oxidation of H_2O_2 under these conditions. [2]

(b) The student diluted 25.0 cm^3 of a solution of hydrogen peroxide with water and made the solution up to 250.0 cm^3. The student titrated 25.0 cm^3 of this solution with 0.0200 mol dm^{-3} $KMnO_4$ under acidic conditions. The volume of $KMnO_4$(aq) required to reach the end-point was
23.45 cm^3.

- Calculate the concentration, in g dm^{-3}, of the **undiluted** hydrogen peroxide solution.
- What volume of oxygen gas, measured at RTP, would be produced during this titration?

[6]

[Total: 8 Marks]

The Dissolved Oxygen Concentration (DOC) in rivers and lakes is important for aquatic life. If the DOC falls below 5 mg dm^{-3}, most species of fish cannot survive.

Environmental chemists can determine the DOC in water using the procedure below.

- A sample of river water is shaken with aqueous Mn^{2+} and aqueous alkali.
  The dissolved oxygen oxidises the Mn^{2+} to Mn^{3+}, forming a pale brown precipitate of $Mn(OH)_3$.

  $$O_2(aq) + 4Mn^{2+}(aq) + 8OH^-(aq) + 2H_2O(l) \rightarrow 4Mn(OH)_3(s)$$

- The $Mn(OH)_3$ precipitate is then reacted with an excess of aqueous potassium iodide, which is oxidised to iodine, I_2.

  $$2Mn(OH)_3(s) + 2I^-(aq) \rightarrow I_2(aq) + 2Mn(OH)_2(s) + 2OH^-(aq)$$

- The iodine formed is then determined by titration with aqueous sodium thiosulfate, $Na_2S_2O_3(aq)$.

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

A 25.0 cm^3 sample of river water was analysed using the procedure above.

The titration required 24.6 cm^3 of 0.00100 mol dm^{-3} $Na_2S_2O_3(aq)$.

(a) (i) Calculate the DOC of the sample of river water, in mg dm^{-3}. [4]

(ii) Comment on whether there is enough dissolved oxygen in the river water for fish to survive. [1]

(b) The presence of nitrate(III) ions, NO_2^-, interferes with this method because NO_2^- ions can also oxidise iodide ions to iodine.

During the reaction, a colourless gas is produced with a molar mass of 30 $g mol^{-1}$.

(i) Predict the formula of the colourless gas. [1]

(ii) Write an equation for the oxidation of aqueous iodide ions by aqueous nitrate(III) ions. Hydroxide ions are produced in this reaction. [2]

[Total: 8 Marks]