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CHEMISTRY

PHYSICAL CHEMISTRY II

Level & Board	AQA (A-LEVEL)
TOPIC:	ELECTRODE POTENTIALS AND CELLS
PAPER TYPE:	QUESTION PAPER - 1
TOTAL QUESTIONS	10
TOTAL MARKS	34

Electrode Potentials and Cells - 1

1. Large blocks of magnesium are bolted onto the hulls of iron ships in an attempt to prevent the iron being converted into iron(II), one of the steps in the rusting process.

Use the data below, where appropriate, to answer the questions which follow.

$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	E^o / V= –2.37
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	E^o / V =–0.44
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	E^o / V =+0.40

(a) Calculate the e.m.f. of the cell represented by $Mg(s)|Mg^{2+}(aq)||Fe^{2+}(aq)|Fe(s)$ under standard conditions.

Write a half-equation for the reaction occurring at the negative electrode of this cell when a current is drawn.

(2)

(b) Deduce how the e.m.f. of the cell $Mg(s)|Mg^{2+}(aq)||Fe^{2+}(aq)|Fe(s)$ changes when the concentration of Mg^{2+} is decreased.

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(3)

(c) Calculate a value for the e.m.f. of the cell represented by Pt(s)|OH–(aq)|O_2(g)||Fe^{2+}(aq)|Fe(s) and use it to explain why iron corrodes when in contact with water which contains dissolved oxygen.

(2)

2. The following cell has an EMF of +0.46 V.

Cu | Cu^{2+} || Ag^+ | Ag

Which statement is correct about the operation of the cell?

A. Metallic copper is oxidised by Ag^+ ions.
B. The silver electrode has a negative polarity.
C. The silver electrode gradually dissolves to form Ag^+ ions.
D. Electrons flow from the silver electrode to the copper electrode via an external circuit.

(1)

3. This question is about a glucose–oxygen fuel cell.

When the cell operates, the glucose ($C_6H_{12}O_6$) molecules react with water at the negative electrode to form carbon dioxide and hydrogen ions.

Oxygen gas reacts with hydrogen ions to form water at the positive electrode.

(a) Deduce the half-equation for the reaction at the negative electrode.

(1)

(b) Deduce the half-equation for the reaction at the positive electrode.

(1)

(c) Give the equation for the overall reaction that occurs in the Glucose–oxygen fuel cell.

(1)

(d) The negative electrode is made of carbon and the positive electrode is made of platinum.

Give the conventional representation for the glucose–oxygen fuel cell.

(2)

(e) State what must be done to maintain the EMF of this fuel cell when in use.

(1)

4. In this question consider the data below.

	E^o / V
$Ag^+ (aq) + e^- \rightarrow Ag(s)$	+0.80
$2H^+ (aq) + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	−0.13

The e.m.f. of the cell $Ag(s) \mid Ag^+ (aq) \parallel Pb^{2+}(aq) \mid Pb(s)$ is

A. 0.93 V
B. 0.67 V
C. −0.67 V
D. −0.93 V

(1)

5. The term oxidation was used originally to describe a reaction in which a substance gained oxygen.

The oxygen was provided by the oxidising agent.

Later the definition of oxidation was revised when the importance of electron transfer was recognised.

An aqueous solution of sulfur dioxide was reacted in separate experiments as follows.

Reaction 1 with HgO

$H_2O + SO_2 + HgO \rightarrow H_2SO_4 + Hg$

Reaction 2 with chlorine

$2H_2O + SO_2 + Cl_2 \rightarrow H_2SO_4 + 2HCl$

(a) In Reaction 1, identify the substance that donates oxygen and therefore is the oxidising agent.

(1)

(b) Show, by writing a half-equation, that this oxidising agent in reaction 1 is an electron acceptor.

(1)

(c) Write a half-equation for the oxidation process occurring in reaction 2.

(1)

(d) Write a half-equation for the reduction process occurring in reaction 2.

(1)

6. In this question consider the data below

	E^o / V
$Ag^+ (aq) + e^- \rightarrow Ag(s)$	+0.80
$2H^+ (aq) + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	−0.13

The e.m.f. of the cell $Pt(s) \mid H_2(g) \mid H^+ (aq) \parallel Ag^+ (aq) \mid Ag(s)$

Would be increased by

A. Increasing the concentration of H^+ (aq).
B. Increasing the surface area of the Pt electrode.
C. Increasing the concentration of Ag^+ (aq).
D. Decreasing the pressure of $H_2(g)$.

(1)

7. Nickel–cadmium cells are used to power electrical equipment such as drills and shavers.

The electrode reactions are shown below.

$NiO(OH) + H_2O + e^- \rightarrow Ni(OH)_2 + OH^-$ $\quad E^o = +0.52$ V
$Cd(OH)_2 + 2e^- \rightarrow Cd + 2OH^-$ $\quad E^o = -0.88$ V

(a) Calculate the e.m.f. of a nickel–cadmium cell.

(1)

(b) Deduce an overall equation for the reaction that occurs in the cell when it is used.

(2)

(c) Identify the oxidising agent in the overall cell reaction and give the oxidation state of the metal in this oxidising agent.

(2)

8. The E^o values for two electrodes are shown.

$Fe^{2+}(aq) + 2\ e^- \rightarrow Fe(s)$ $\quad E^o = -0.44$ V
$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$ $\quad E^o = +0.34$ V

What is the EMF of the cell

$Fe(s)|Fe^{2+}(aq)||Cu^{2+}(aq)|Cu(s)$?

A. +0.78 V
B. +0.10 V
C. −0.10 V
D. −0.78 V

(1)

9. Lithium ion cells are used to power cameras and mobile phones.

A simplified representation of a cell is shown below.

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$Li \mid Li^+ \parallel Li^+, CoO_2 \mid LiCoO_2 \mid Pt$

The reagents in the cell are absorbed onto powdered graphite that acts as a support medium.

The support medium allows the ions to react in the absence of a solvent such as water.

The half-equation for the reaction at the positive electrode can be represented as follows.

$Li^+ + CoO2 + e^- \rightarrow Li^+[CoO_2]^-$

(a) Identify the element that undergoes a change in oxidation state at the positive electrode and deduce these oxidation states of the element.

(3)

(b) Write a half-equation for the reaction at the negative electrode during operation of the lithium ion cell.

(1)

(c) Suggest two properties of platinum that make it suitable for use as an external electrical contact in the cell.

(2)

(d) Suggest one reason why water is not used as a solvent in this cell.

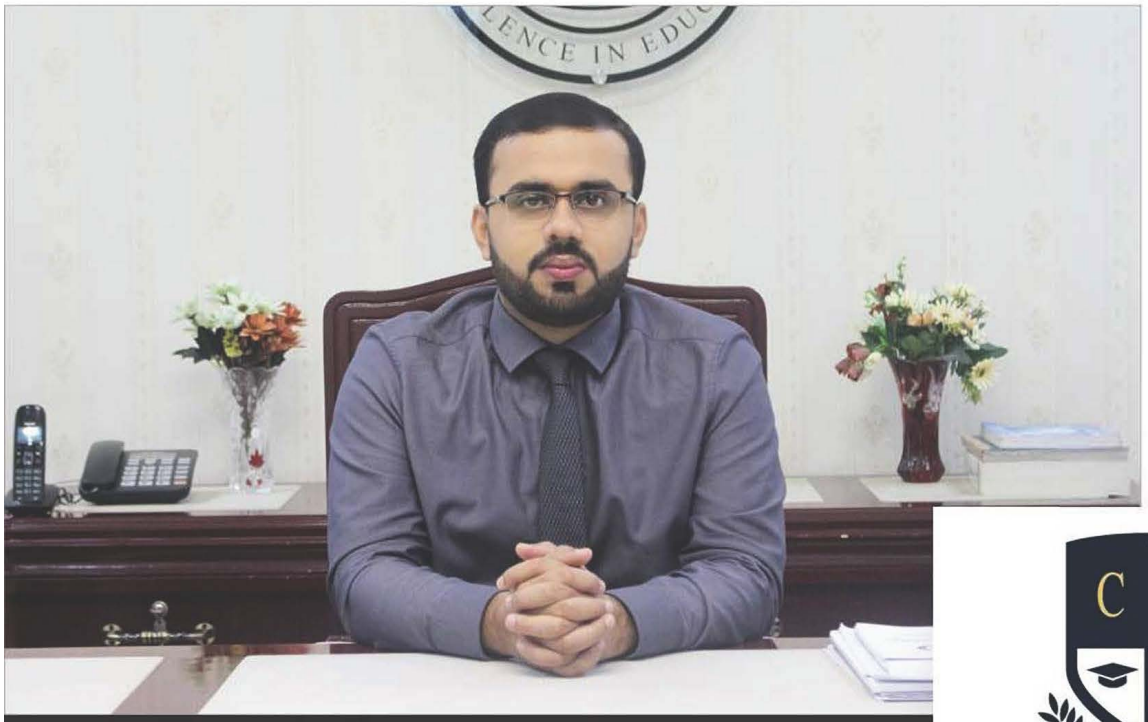
(1)

10. Which ion cannot catalyse the reaction between iodide (I^-) and peroxodisulfate ($S_2O_8^{2-}$)?

Use the data below to help you answer this question.

A. Co^{2+}
B. Cr^{2+}
C. Fe^{2+}
D. Fe^{3+}

(1)



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