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CHEMISTRY

PHYSICAL CHEMISTRY II

Level & Board	AQA (A-LEVEL)
TOPIC:	ELECTRODE POTENTIALS AND CELLS
PAPER TYPE:	QUESTION PAPER - 3
TOTAL QUESTIONS	10
TOTAL MARKS	32

Electrode Potentials and Cells - 3

1. An experiment was carried out to measure the e.m.f. of this cell.

$Al(s) \mid Al^{3+}(aq) \parallel H^{+}(aq) \mid H_2(g) \mid Pt(s)$

(a) The aluminium used as the electrode is rubbed with sandpaper prior to use.

Suggest the reason for this.

(1)

(b) Draw a labelled diagram of a suitable apparatus for the right-hand electrode in this cell.

You do not need to include the salt bridge or the external electrical circuit.

(2)

(c) A simple salt bridge can be prepared by dipping a piece of filter paper into potassium carbonate solution.

Explain why such a salt bridge would not be suitable for use in this cell.

(2)

2. Use the data in the table below to answer this question.

	E^o/ V
MnO_4^- (aq) + $8H^+$ (aq) + $5e^- \rightarrow Mn^{2+}$(aq) + $4H_2O$(l)	+ 1.52
$Cr_2O_7^{-2}$ (aq) + $14H^+$ (aq) + $6e^- \rightarrow 2Cr^{3+}$(aq) + $7H_2O$(l)	+ 1.33
Fe^{3+}(aq) + $e^- \rightarrow Fe^{2+}$(aq)	+ 0.77
Cr^{3+}(aq) + $e^- \rightarrow Cr^{2+}$(aq)	− 0.41
Zn^{2+}(aq) + $2e^- \rightarrow$ Zn(s)	− 0.76

Which one of the following statements is not correct?

A. Fe^{2+}(aq) can reduce acidified MnO_4^- (aq) to Mn^{2+}(aq)
B. CrO_7^{-2} (aq) can oxidise acidified Fe^{2+}(aq) to Fe^{3+}(aq)
C. Zn(s) can reduce acidified $Cr_2O_7^{-2}$ (aq) to Cr^{2+}(aq)
D. Fe^{2+}(aq) can reduce acidified Cr^{3+}(aq) to Cr^{2+}(aq)

(1)

3. Fuel cells are an increasingly important energy source for vehicles.

Standard electrode potentials are used in understanding some familiar chemical reactions including those in fuel cells.

The following table contains some standard electrode potential data

Electrode half-equation	E^o/ V
F_2 + $2e^- \rightarrow 2F^-$	+2.87
Cl_2 + $2e^- \rightarrow 2Cl^-$	+1.36
O_2 + $4H^+$ + $4e^- \rightarrow 2H_2O$	+1.23
Br_2 + $2e^- \rightarrow 2Br^-$	+1.07
I_2 + $2e^- \rightarrow 2I^-$	+0.54
O_2 + $2H_2O$ + $4e^- \rightarrow 4OH^-$	+0.40
SO_4^{2-} + $4H^+$ + $2e^- \rightarrow SO_2$ + $2H_2O$	+0.17
$2H^+$ + $2e^- \rightarrow H_2$	0.00
$4H_2O$ + $4e^- \rightarrow 4OH^-$ + $2H_2$	−0.83

(a) A salt bridge was used in a cell to measure electrode potential.

Explain the function of the salt bridge.

(2)

(b) Use data from the table above to deduce the halide ion that is the weakest reducing agent.

(1)

(c) Use data from the table to justify why sulfate ions should not be capable of oxidising bromide ions.

(1)

(d) Use data from the table to calculate a value for the EMF of a hydrogen–oxygen fuel cell operating under alkaline conditions.

(1)

(e) There are two ways to use hydrogen as a fuel for cars.

One way is in a fuel cell to power an electric motor, the other is as a fuel in an internal combustion engine.

Suggest the major advantage of using the fuel cell.

(1)

4. Use the data in the table below to answer this question.

	E^o/ V
MnO_4^- (aq) + 8H^+ (aq) + 5e^- → Mn^{2+}(aq) + 4H_2O(l)	+ 1.52
$Cr_2O_7^{-2}$ (aq) + 14H^+ (aq) + 6e^- → 2Cr^{3+}(aq) + 7H_2O(l)	+ 1.33
Fe^{3+}(aq) + e^- → Fe^{2+}(aq)	+ 0.77
Cr^{3+}(aq) + e^- → Cr^{2+}(aq)	− 0.41
Zn^{2+}(aq) + 2e^- → Zn(s)	− 0.76

The most powerful oxidising agent in the table is

A. Mn^{2+}(aq)
B. Zn(s)
C. MnO_4^- (aq)
D. Zn^{2+}(aq)

(1)

5. Hydrogen–oxygen fuel cells are used to provide electrical energy for electric motors in vehicles.

(a) In a hydrogen–oxygen fuel cell, a current is generated that can be used to drive an electric motor.

Deduce half-equations for the electrode reactions in a hydrogen–oxygen fuel cell.

Use these half-equations to explain how an electric current can be generated.

(3)

(b) Explain why a fuel cell does not need to be recharged.

(1)

(c) To provide energy for a vehicle, hydrogen can be used either in a fuel cell or in an internal combustion engine.

Suggest the main advantage of using hydrogen in a fuel cell rather than in an internal combustion engine.

(1)

(d) Identify one major hazard associated with the use of a hydrogen–oxygen fuel cell in a vehicle.

(1)

6. A disproportionation reaction occurs when a species M^+ spontaneously undergoes simultaneous oxidation and reduction.

$2M^+(aq) \rightarrow M^{2+}(aq) + M(s)$

The table below contains E^o data for copper and mercury species.

	E^o/ V
$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$	+ 0.15
$Cu^+(aq) + e^- \rightarrow Cu(s)$	+ 0.52
$Hg_2^{2+}(aq) + e^- \rightarrow Hg_2^+(aq)$	+ 0.91
$Hg_2^+(aq) + e^- \rightarrow Hg(l)$	+ 0.80

Using these data, which one of the following can be predicted?

A. Both Cu(I) and Hg(I) undergo disproportionation.
B. Only Cu(I) undergoes disproportionation.
C. Only Hg(I) undergoes disproportionation.
D. Neither Cu(I) nor Hg(I) undergoes disproportionation.

(1)

7. Domestic bleaches contain sodium chlorate(I), NaOCl.

Write the ionic equation to show the disproportionation of the chlorate(I) ion.

Use oxidation numbers to explain the meaning of the term disproportionation in this reaction.

(3)

8. Copper, in the form of nanoparticles of copper(II) hexacyanoferrate(II), has recently been investigated as an efficient method of storing electrical energy in a rechargeable cell.

(a) Solar cells generate an electric current from sunlight.

These cells are often used to provide electrical energy for illuminated road signs.

Explain why rechargeable cells are connected to these solar cells.

(2)

(b) Suggest one reason why many waste disposal centres contain a separate section for cells and batteries.

(1)

9. An ethanol–oxygen fuel cell may be an alternative to a hydrogen–oxygen fuel cell.

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When the cell operates, all of the carbon atoms in the ethanol molecules are converted into carbon dioxide.

(a) Deduce the equation for the overall reaction that occurs in the ethanol–oxygen fuel cell.

(1)

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

In this half-equation, ethanol reacts with water to form carbon dioxide and hydrogen ions.

(1)

(c) Suggest why ethanol can be considered to be a carbon-neutral fuel.

(2)

10. Explain the meaning of disproportionation.

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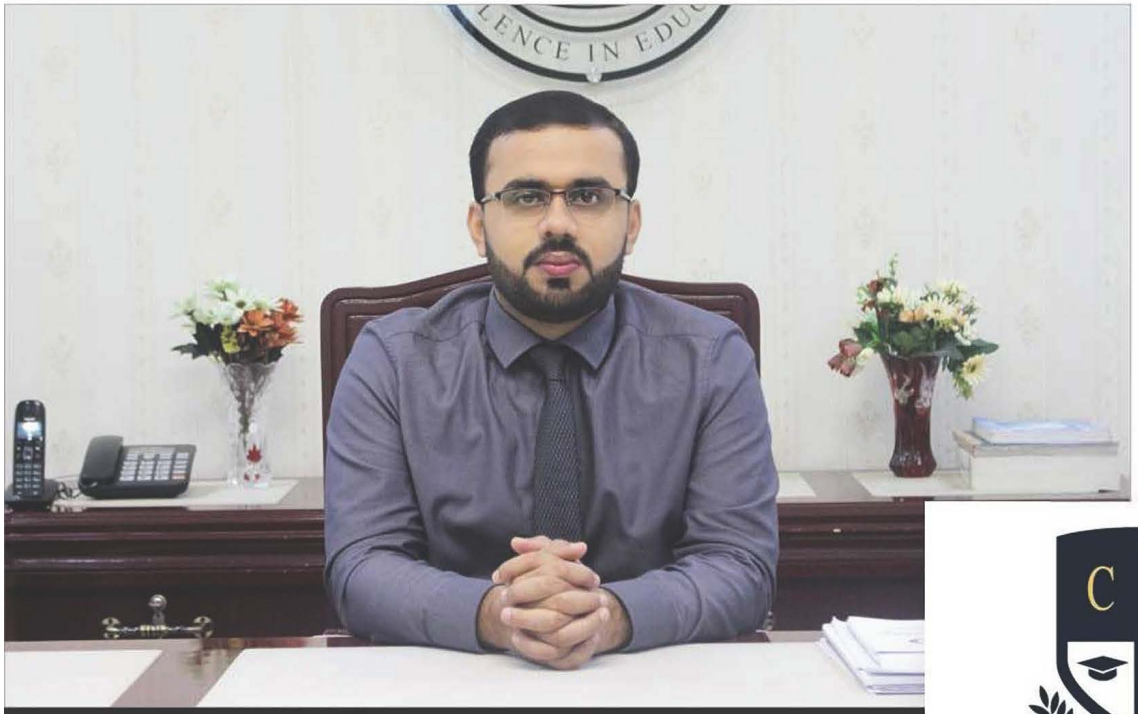
(2)



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