MEGA LECTURE

A LEVEL CHEMISTRY

TOPIC 13 – ELECTROCHEMISTRY

TEST

Answer all questions

Max 50 marks

Name	…………………………………………………………………..		
Mark	……../50	………%	Grade ………

1. The table contains some standard electrode potential data.

Electrode half-equation	$E^⦵$ / V
$F_2 + 2e^- \rightarrow 2F^-$	+2.87
$Au^+ + e^- \rightarrow Au$	+1.68
$2HOCl + 2H^+ + 2e^- \rightarrow Cl_2 + 2H_2O$	+1.64
$Cl_2 + 2e^- \rightarrow 2Cl^-$	+1.36
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+1.23
$Ag^+ + e^- \rightarrow Ag$	+0.80
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77
$2H^+ + 2e^- \rightarrow H_2$	0.00
$Fe^{2+} + 2e^- \rightarrow Fe$	0.44

(a) In terms of electrons, explain the meaning of the term **oxidising agent**.

....

....

(1)

(b) Identify the weakest oxidising agent in the table.
Explain your choice.

Weakest oxidising agent ....

Explanation ....

....

....

(2)

(c) Write the conventional representation of the cell used to measure the standard electrode potential for the Ag^{+} / Ag electrode.

State the conditions necessary when measuring this value.

Conventional
representation ....

....
....

Conditions ....
....

....
....

....
....

(4)

(d) Use data from the table to explain, in terms of redox, what happens when a soluble gold(I) compound containing Au^{+} ions is added to water.

State what you would observe.

Write an equation for the reaction that occurs.

Explanation ....
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....

Observation ....
....

....
....

Equation ....
....

(4)

(e) A cell is made by connecting Fe^{2+} / Fe and Ag^{+} / Ag electrodes with a salt bridge.

(i) Calculate the e.m.f. of this cell.

....

....

Answer .... **(1)**

(ii) Suggest why potassium chloride would **not** be suitable for use in the salt bridge of this cell.

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(1)

(f) Use data from the table to explain what happens when a solution of iron(II) chloride is exposed to the air.

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....

(2)

(Total 15 marks)

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

Standard electrode potentials	$E^{\ominus}$ /V
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Br_2(aq) + 2e^- \rightarrow 2Br^-(aq)$	+1.09
$2BrO_3^-(aq) + 12H^+(aq) + 10e^- \rightarrow Br_2(aq) + 6H_2O(l)$	+1.52

Each of the above can be reversed under suitable conditions.

(a) State the hydrogen ion concentration and the hydrogen gas pressure when, at 298 K, the potential of the hydrogen electrode is 0.00 V.

Hydrogen ion concentration ....

Hydrogen gas pressure ....

(2)

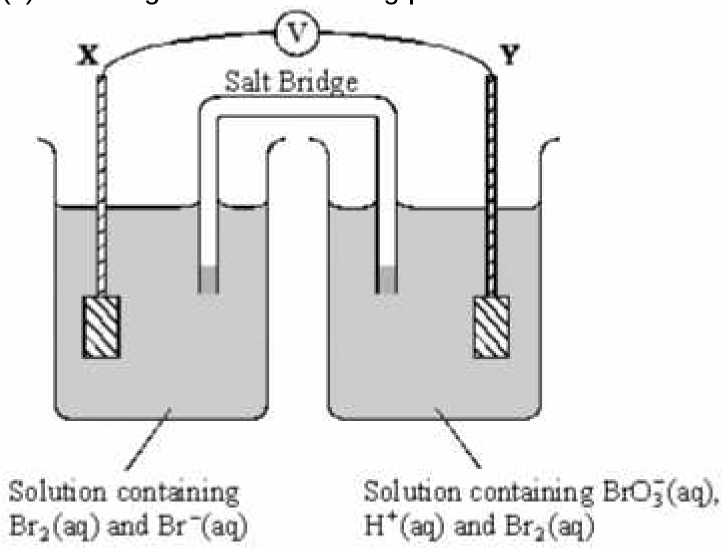
(b) The electrode potential of a hydrogen electrode changes when the hydrogen ion concentration is reduced. Explain, using Le Chatelier's principle, why this change occurs and state how the electrode potential of the hydrogen electrode changes.

Explanation of change ....

Change in electrode potential ....

(3)

(c) A diagram of a cell using platinum electrodes **X** and **Y** is shown below.



(i) Use the data above to calculate the e.m.f. of the above cell under standard conditions.

....

(ii) Write a half-equation for the reaction occurring at electrode **X** and an overall equation for the cell reaction which occurs when electrodes **X** and **Y** are connected.

Half-equation ....

Overall equation ....

....

(4)
(Total 9 marks)

3. Nickel–cadmium cells are used to power electrical equipment such as drills and shavers.
The electrode reactions are shown below.

$NiO(OH) + H_2O + e^- \rightarrow Ni(OH)_2 + OH^-$ $E^\ominus = +0.52$ V

$Cd(OH)_2 + 2e^- \rightarrow Cd + 2OH^-$ $E^\ominus = -0.88$ 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.

Oxidising agent ....

Oxidation state ....

(2)

(Total 5 marks)

4. Redox reactions occur in the discharge of all electrochemical cells. Some of these cells are of commercial value.
The table below shows some redox half-equations and standard electrode potentials.

Half-equation	$E^\ominus$/ V
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$Ag_2O(s) + 2H^+(aq) + 2e^- \rightarrow 2Ag(s) + H_2O(l)$	+0.34
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	+1.23

$F_2(g) + 2e^- \quad 2F^-(aq)$	+2.87

(a) In terms of electrons, state what happens to a reducing agent in a redox reaction.

....

(1)

(b) Use the table above to identify the strongest reducing agent from the species in the table.

Explain how you deduced your answer.

Strongest reducing agent ....

Explanation ....

....

(2)

(c) Use data from the table to explain why fluorine reacts with water.

Write an equation for the reaction that occurs.

Explanation ....

....

....

Equation ....

....

(3)

(d) An electrochemical cell can be constructed using a zinc electrode and an electrode in which silver is in contact with silver oxide. This cell can be used to power electronic devices.

(i) Give the conventional representation for this cell.

....

(2)

(ii) Calculate the e.m.f. of the cell.

....

(1)

(iii) Suggest **one** reason why the cell cannot be electrically recharged.

....

....

(1)

(e) The electrode half-equations in a lead–acid cell are shown in the table below.

Half-equation	$E^\ominus$/ V
$PbO_2(s) + 3H^+(aq) + HSO_4^-(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$	+1.69
$PbSO_4(s) + H^+(aq) + 2e^- \rightarrow Pb(s) + HSO_4^-(aq)$	to be calculated

(i) The PbO_2/$PbSO_4$ electrode is the positive terminal of the cell and the e.m.f. of the cell is 2.15 V.

Use this information to calculate the missing electrode potential for the half-equation shown in the table.

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....

(1)

(ii) A lead–acid cell can be recharged.
Write an equation for the overall reaction that occurs when the cell is being recharged.

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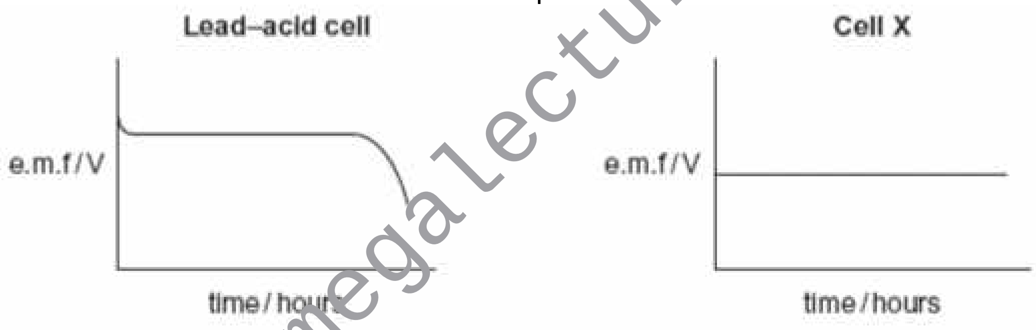
(2)

(f) The diagrams below show how the e.m.f. of each of two cells changes with time when each cell is used to provide an electric current.



(i) Give **one** reason why the e.m.f. of the **lead–acid cell** changes after several hours.

....

....

(1)

(ii) Identify the type of cell that behaves like **cell X**.

....

(1)

(iii) Explain why the voltage remains constant in **cell X**.

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(2)
(Total 17 marks)

5. 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 $E^{\ominus}$ data for copper and mercury species.

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

(Total 1 mark)

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

	$E^{\ominus}$ / 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

The most powerful oxidising agent in the table is

A $Mn^{2+}(aq)$

B Zn(s)

C $MnO_4^{-}(aq)$

D $Zn^{2+}(aq)$

(Total 1 mark)

7. In this question consider the data below.

	$E^\ominus$ / 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) | $H_2(g)$ | $H^+(aq)$ || $Ag^+(aq)$ | 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 $H_2(g)$.

(Total 1 mark)

8. In this question consider the data below.

	$E^\ominus$ / 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) | $Ag^+(aq)$ || $Pb^{2+}(aq)$ | Pb(s) is

A 0.93 V

B 0.67 V

C 0.67 V

D 0.93 V

(Total 1 mark)