Q1. Where appropriate, use the standard electrode potential data in the table below to answer the questions which follow.

							$E^{\ominus}$/V
$Zn^{2+}(aq)$	+	$2e^-$	→	$Zn(s)$			–0.76
$V^{3+}(aq)$	+	e^-	→	$V^{2+}(aq)$			–0.26
$SO_4^{2-}(aq) + 2H^+(aq)$	+	$2e^-$	→	$SO_3^{2-}(aq)$	+	$H_2O(l)$	+0.17
$VO^{2+}(aq) + 2H^+(aq)$	+	e^-	→	$V^{3+}(aq)$	+	$H_2O(l)$	+0.34
$Fe^{3+}(aq)$	+	e^-	→	$Fe^{2+}(aq)$			+0.77
$VO_2^+(aq) + 2H^+(aq)$	+	e^-	→	$VO^{2+}(aq)$	+	$H_2O(l)$	+1.00
$Cl_2(aq)$	+	$2e^-$	→	$2Cl^-(aq)$			+1.36

(a) From the table above select the species which is the most powerful reducing agent.

....

(1)

(b) From the table above select

(i) a species which, in acidic solution, will reduce $VO_2^+(aq)$ to $VO^{2+}(aq)$ but will **not** reduce $VO^{2+}(aq)$ to $V^{3+}(aq)$,

....

(ii) a species which, in acidic solution, will oxidise $VO^{2+}(aq)$ to $VO_2^+(aq)$.

....

(2)

(c) The cell represented below was set up under standard conditions.

$Pt|Fe^{2+}(aq), Fe^{3+}(aq)||Tl^{3+}(aq), Tl^+(aq)|Pt$ Cell e.m.f. = + 0.48 V

(i) Deduce the standard electrode potential for the following half-reaction.

$Tl^{3+}(aq) + 2e^- \rightarrow Tl^+(aq)$

....

....

(ii) Write an equation for the spontaneous cell reaction.

....

(3)

(d) After acidification, 25.0 cm^3 of a solution of hydrogen peroxide reacted exactly with 16.2 cm^3 of a 0.0200 mol dm^{-3} solution of potassium manganate(VII). The overall equation for the reaction is given below.

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

(i) Use the equation for this reaction to determine the concentration, in g dm^{-3}, of the hydrogen peroxide solution.

....

....

....

....

....

....

(ii) Calculate the maximum volume of oxygen, measured at a pressure of 98 kPa and a temperature of 298 K, which would be evolved in this reaction.

....

....

....

....

....

(8)
(Total 14 marks)

Q2. 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.

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

Cell e.m.f. ....

Half-equation ....

....

(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. Explain your answer.

Change in e.m.f. ....

Explanation ....

....

(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.

Cell e.m.f. ....

Explanation ....

....

(2)
(Total 7 marks)

Q3. Use the standard electrode potential data in the table below to answer the questions which follow.

			$E^{\ominus}$ / V
$Ce^{4+}(aq) + e^-$	$\rightleftharpoons$	$Ce^{3+}(aq)$	+1.70
$MnO^-(aq) + 8H^+(aq) + 5e^-$	$\rightleftharpoons$	$Mn^{2+}(aq) + 4H_2O(l)$	+1.51
$Cl_2(g) + 2e^-$	$\rightleftharpoons$	$2Cl^-(aq)$	+1.36
$VO_2^+(aq) + 2H^+(aq) + e^-$	$\rightleftharpoons$	$VO^{2+}(aq) + H_2O(l)$	+1.00
$Fe^{3+}(aq) + e^-$	$\rightleftharpoons$	$Fe^{2+}(aq)$	+0.77
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$	$\rightleftharpoons$	$H_2SO_3(aq) + H_2O(l)$	+0.17

(a) Name the standard reference electrode against which all other electrode potentials are measured.

....

(1)

(b) When the standard electrode potential for $Fe^{3+}(aq)$ / $Fe^{2+}(aq)$ is measured, a platinum electrode is required.

(i) What is the function of the platinum electrode?

....

(ii) What are the standard conditions which apply to $Fe^{3+}(aq)/Fe^{2+}(aq)$ when measuring this potential?

....

....

....

(3)

(c) The cell represented below was set up under standard conditions.

$Pt|H_2SO_3(aq), SO_4^{2-}(aq)||MnO_4^-(aq), Mn^{2+}(aq)|Pt$

Calculate the e.m.f. of this cell and write an equation for the spontaneous cell reaction.

Cell e.m.f. ....

Equation ....

....

(3)

(d) (i) Which one of the species given in the table is the strongest oxidising agent?

....

(ii) Which of the species in the table could convert $Fe^{2+}(aq)$ into $Fe^{3+}(aq)$ but could not convert $Mn^{2+}(aq)$ into $MnO_4^-(aq)$?

....

(3)

(e) Use data from the table of standard electrode potentials to deduce the cell which would have a standard e.m.f. of 0.93 V. Represent this cell using the convention shown in part (c).

....

(2)
(Total 12 marks)

Q4. 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

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 $Cr^{2+}(aq)$

(Total 1 mark)

Q5. 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)

Q6. 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 $Pt(s) \mid H_2(g) \mid H^+(aq) \parallel Ag^+(aq) \mid Ag(s)$ 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 $H_2(g)$.

(Total 1 mark)

Q7. 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)

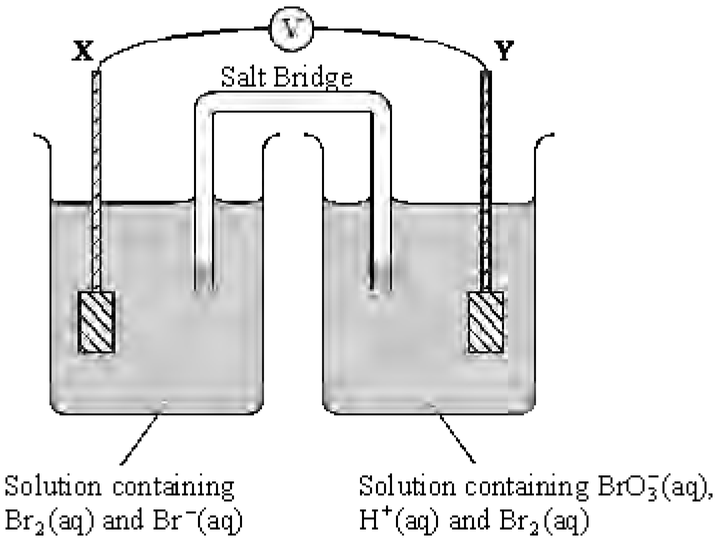
(b) The electrode potential of a hydrogen electrode changes when the hydrogen ion concentration is reduced. Explain, using Le Chatelier's principle, why this change occurs and state how the electrode potential of the hydrogen electrode changes.

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)

Q8.

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^-$	→	$2Cr^{3+}(aq) + 7H_2O(l)$	$E^\ominus = +1.33$ V
$Br_2(aq) + 2e^-$	→	$2Br^-(aq)$	$E^\ominus = +1.09$ V
$Fe^{3+}(aq) + e^-$	→	$Fe^{2+}(aq)$	$E^\ominus = +0.77$ V
$VO^{2+}(aq) + 2H^+(aq) + e^-$	→	$V^{3+}(aq) + H_2O(l)$	$E^\ominus = +0.34$ V
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$	→	$H_2SO_3(aq) + H_2O(l)$	$E^\ominus = +0.17$ V

Based on the above data, which one of the following could reduce 0.012 mol of bromine to bromide ions?

A 40 cm^3 of a 0.10 mol dm^{-3} solution of $Cr_2O_7^{2-}(aq)$

B 80 cm^3 of a 0.30 mol dm^{-3} solution of $Fe^{3+}(aq)$

C 50 cm^3 of a 0.24 mol dm^{-3} solution of $V^{3+}(aq)$

C 50 cm^3 of a 0.24 mol dm^{-3} solution of $H_2SO_3(aq)$

(Total 1 mark)

Q9. 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)