19.1 Electrochemical Cells

Question Paper

Course	DP IB Chemistry
Section	19. Redox Processes (HL only)
Topic	19.1 Electrochemical Cells
Difficulty	Medium

Time allowed: 70

Score: /52

Percentage: /100

Question 1a

a)

Some standard electrode potential data are shown in **Table 1** which you will need to answer the following questions.

Table 1

Half-equation	E^{θ} / V
$Cu^{2+}(aq) + 2e^{-} \rightleftharpoons Cu(s)$	+0.34
$Ni^{2+}(aq) + 2e^{-} \rightleftharpoons Ni(s)$	-0.25
$Fe^{3+}(aq) + e^{-} \rightleftharpoons Fe^{2+}(aq)$	+0.77
$Sn^{2+}(aq) + 2e^{-} \rightleftharpoons Sn(s)$	−0.14
$Fe^{2+}(aq) + 2e^{-} \rightleftharpoons Fe(s)$	−0.44

Deduce the species from **Table 1** that is the weakest oxidising agent. Explain your choice.

[2 marks]

Question 1b

b)

Give the conventional representation of the cell that is used to measure the standard electrode potential of copper/copper(II) ions as shown in **Table 1** in part (a).

[2 marks]

Question 1c

c)

A voltaic cell is made from nickel in a solution of nickel(II) chloride and copper in a solution of copper(II) sulfate.

Calculate the EMF of this cell using the values given in **Table 1** in part (a).

[1 mark]

Question 1d

d)
Two half-cells, involving species in **Table 1**, are connected together to give a cell with an EMF = +0.30 V.

i)
Determine which two half equations produce this EMF using the data from **Table 1** and write the overall equation for the reaction

ii)
Suggest the half-equation for the reaction that occurs at the positive electrode(cathode).

[3 marks]

Question 2a

a)
Aqueous copper(II) sulfate can be electrolysed using passive or active electrodes. Passive electrodes can be made of platinum and active electrodes from copper.

Draw a labelled diagram of an electrolytic cell for this process using platinum electrodes and identify in which direction electrons flow.

[2 marks]

Question 2b

b)
Write the half equations taking place at each electrode in part a), including state symbols, and state what is seen at each electrode.

[4 marks]

Question 2c

c)
Write the half equations taking place at each electrode when using copper electrodes, including state symbols, and state what is seen at each electrode.

[4 marks]

Question 2d

d)
State what happens to the colour and acidity of the electrolyte when using platinum and copper electrodes in the electrolysis of aqueous copper(II) sulfate.

[4 marks]

Question 3a

a)
Iron(II) bromide can be electrolysed in the liquid state. Describe two ways in which the current is conducted in an electrolytic cell.

[2 marks]

Question 3b

b)
A current of 2.00 A flows for 20 minutes in a cell containing molten iron(II) bromide.

Write the half reaction equations at the electrodes and determine the mass of iron and bromine produced.

[4 marks]

Question 3c

c)
If iron(III) bromide was used in place of iron(II) bromide in part b) determine the differences in the mass of iron and bromine produced.

[2 marks]

Question 3d

d)
State and explain the products of electrolysing dilute iron(II) bromide.

[4 marks]

Question 4a

a)
State the conditions under which the EMF of a redox reaction will be spontaneous.

[1 mark]

Question 4b

b)
Using Sections 1 & 24 of the Data Booklet, calculate $\Delta G^{\ominus}$ for the following reaction and state whether the reaction is spontaneous under standard conditions.

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

[3 marks]

Question 4c

c)
Suggest, with a reason, how a non-spontaneous reaction could be made spontaneous.

[2 marks]

Question 4d

d)
Using **Table 2**, predict and write overall equations for all the spontaneous reactions.

Table 2

Half-equation	E^{θ} / V
$Ag^{+}(aq) + e^{-} \rightleftharpoons Ag(s)$	+0.80
$\frac{1}{2} I_2(aq) + e^{-} \rightleftharpoons I^{-}(aq)$	+0.54
$Sn^{2+}(aq) + 2e^{-} \rightleftharpoons Sn(s)$	−0.14

[3 marks]

Question 5a

a)
Metals coatings on other metals can be achieved using electroplating. Three beakers containing solutions of $Sn(NO_3)_4$, $Co_2(SO_4)_3$, $Pb(NO_3)_2$, were set up as electrolytic cells and used to electroplate the metals. The same amount of current was passed through the cells for the same length of time.

State and explain in which cell would the greatest amount of metal be produced and identify the electrode where the metals are deposited.

[4 marks]

Question 5b

b)
Apart from current and time, identify two factors that influence the amount of cobalt deposited in the $Co_2(SO_4)_3$ cell.

[2 marks]

Question 5c

c)
State **two** reasons why electroplating of metals is carried out.

[2 marks]

Question 5d

d)
A nickel teaspoon is electroplated with silver using sodium argentocyanide. Predict the mass changes at each electrode.

[1 mark]