Electrolysis, Electrode Potentials & Cells

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Electrochemistry
Sub-Topic	Electrolysis, Electrode Potentials & Cells
Paper Type	Theory
Booklet	Question Paper 2

Time Allowed: **80 minutes**

Score: **/66**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 (a) (i) With the aid of a fully-labelled diagram, describe the standard hydrogen electrode.

(ii) Use the *Data Booklet* to calculate the standard cell potential for the reaction between Cr^{2+} ions and $Cr_2O_7^{2-}$ ions in acid solution, and construct a balanced equation for the reaction.

$E^{\ominus}_{cell}$ = ... V

equation .....

(iii) Describe what you would see if a blue solution of Cr^{2+} ions was added to an acidified solution of $Cr_2O_7^{2-}$ ions until reaction was complete.

.....

.....

[8]

(b) A buffer solution is to be made using 1.00 mol dm^{-3} ethanoic acid, CH_3CO_2H, and 1.00 mol dm^{-3} sodium ethanoate, CH_3CO_2Na.
Calculate to the nearest 1 cm^3 the volumes of each solution that would be required to make 100 cm^3 of a buffer solution with pH 5.50.
Clearly show all steps in your working.
K_a (CH_3CO_2H) = 1.79×10^{-5} mol dm^{-3}

volume of 1.00 mol dm^{-3} CH_3CO_2H = ... cm^3

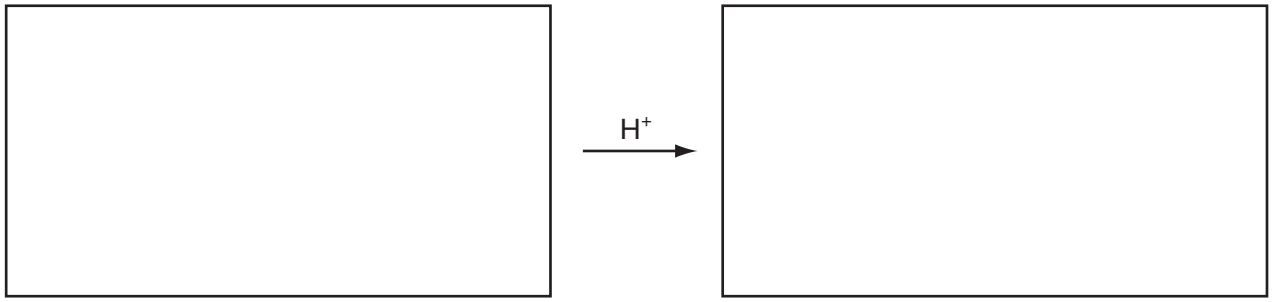
volume of 1.00 mol dm^{-3} CH_3CO_2Na = ... cm^3
[4]

(c) Write an equation to show the reaction of this buffer solution with each of the following.

(i) added HCl .....

(ii) added NaOH .....
[2]

(d) Choose **one** reaction in organic chemistry that is catalysed by an acid, and write the structural formulae of the reactants and products in the boxes below.



[3]

[Total: 17]

2 **(a)** What is meant by the term *standard electrode potential*, SEP?

.....

.....
[2]

(b) Draw a fully labelled diagram of the apparatus you could use to measure the SEP of the Fe^{3+}/Fe^{2+} electrode.

[5]

(c) The reaction between Fe^{3+} ions and I^- ions is an equilibrium reaction.

$$2Fe^{3+}(aq) + 2I^-(aq) \rightleftharpoons 2Fe^{2+}(aq) + I_2(aq)$$

(i) Use the *Data Booklet* to calculate the $E^{\ominus}_{cell}$ f

.....

(ii) Hence state, with a reason, whether there will be more products or more reactants at equilibrium.

.....

.....

(iii) Write the expression for K_c for this reaction, and state its units.

K_c =

units .....

An experiment was carried out using solutions of $Fe^{3+}(aq)$ and $I^-(aq)$ of equal concentrations. 100 cm^3 of each solution were mixed together, and allowed to reach equilibrium.

The concentrations at equilibrium of $Fe^{3+}(aq)$ and $I_2(aq)$ were as follows.

$[Fe^{3+}(aq)] = 2.0 \times 10^{-4}\ mol\ dm^{-3}$

$[I_2(aq)] = 1.0 \times 10^{-2}\ mol\ dm^{-3}$

(iv) Use these data, together with the equation given in **(c)**, to calculate the concentrations of $Fe^{2+}(aq)$ and $I^-(aq)$ at equilibrium.

$[Fe^{2+}(aq)]$ = ... $mol\ dm^{-3}$

$[I^-(aq)]$ = ... $mol\ dm^{-3}$

(v) Calculate the K_c for this reaction.

K_c = ...

[8]

[Total: 15]

3 Chlorine gas is manufactured by the electrolysis of brine using a diaphragm cell.

(a) **(i)** Write half-equations, including state symbols, for the reactions occurring at **each** of the electrodes of a diaphragm cell.

anode .....

cathode .....

(ii) In the diaphragm cell, the anode is made of titanium and the cathode is made of steel.

Suggest why steel is never used for the anode.

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.....

[3]

(b) Chlorine is very reactive and will form compounds by direct combination with many elements.

Describe what you would see when chlorine is passed over separate heated samples of sodium and phosphorus.
In **each** case write an equation for the reaction.

sodium

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phosphorus

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..... [4]

(c) Chlorine reacts with aqueous sodium hydroxide in two different ways, depending on the conditions used. In each case, water, sodium chloride and one other chlorine-containing compound are formed.

For **each** condition below, give the formula of the **other** chlorine-containing compound and state the oxidation number of chlorine in it.

condition	formula of **other** chlorine-containing compound	oxidation number of chlorine in this compound
cold dilute NaOH(aq)		
hot concentrated NaOH(aq)		

[4]

(d) Magnesium chloride, $MgCl_2$, and silicon tetrachloride, $SiCl_4$, each dissolve in or react with water.

Suggest the approximate pH of the solution formed in **each** case.

$MgCl_2$ ..... $SiCl_4$ .....

Explain, with the aid of an equation, the difference between the two values.

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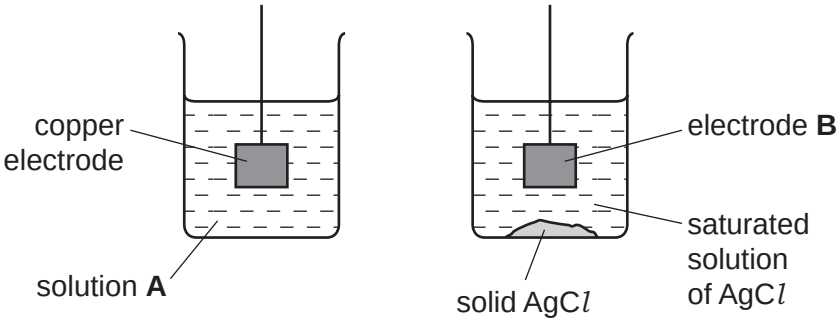
..... [5]

[Total: 16]

4 **(a)** The diagram below shows an incomplete experimental set-up needed to measure the E_{cell} of a cell composed of the standard Cu^{2+}/Cu electrode and an Ag^{+}/Ag electrode.



(i) State the chemical composition of

solution **A**, ...

electrode **B**. .....

(ii) Complete the diagram to show the whole experimental set-up.

[4]

(b) The above cell is not under standard conditions, because the $[Ag^{+}]$ in a saturated solution of AgC*l* is much less than 1.0 mol dm^{-3}. The $E_{electrode}$ is related to $[Ag^{+}]$ by the following equation.

equation 1 $$E_{electrode} = E^{\ominus}_{electrode} + 0.06 \log[Ag^{+}]$$

(i) Use the *Data Booklet* to calculate the $E^{\ominus}_{cell}$ if the cell was operating under standard conditions.

$E^{\ominus}_{cell}$ = ... V

In the above experiment, the E_{cell} was measured at +0.17V.

(ii) Calculate the value of $E_{electrode}$ for the Ag^{+}/Ag electrode in this experiment.

.....

(iii) Use equation 1 to calculate $[Ag^{+}]$ in the saturated solution.

$[Ag^{+}]$ = ... mol dm^{-3}

[3]

(c) Write an expression for K_{sp} of silver sulfate, Ag_2SO_4, including units.

K_{sp} = ... units .....

Using a similar experimental set-up to that illustrated opposite, it is found that $[Ag^+]$ in a saturated solution of Ag_2SO_4 is 1.6×10^{-2} mol dm^{-3}.

(ii) Calculate the value of K_{sp} of silver sulfate.

K_{sp} = ...
[3]

(d) Describe how the colours of the silver halides, and their relative solubilities in $NH_3(aq)$, can be used to distinguish between solutions of the halide ions Cl^-, Br^- and I^-.

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..... [4]

(e) Describe and explain the trend in the solubilities of the sulfates of the elements in Group II.

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..... [4]

[Total: 18]