Electrolysis, Electrode Potentials & Cells

Question Paper 5

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Electrochemistry
Sub-Topic	Electrolysis, Electrode Potentials & Cells
Paper Type	Theory
Booklet	Question Paper 5

Time Allowed: **66 minutes**

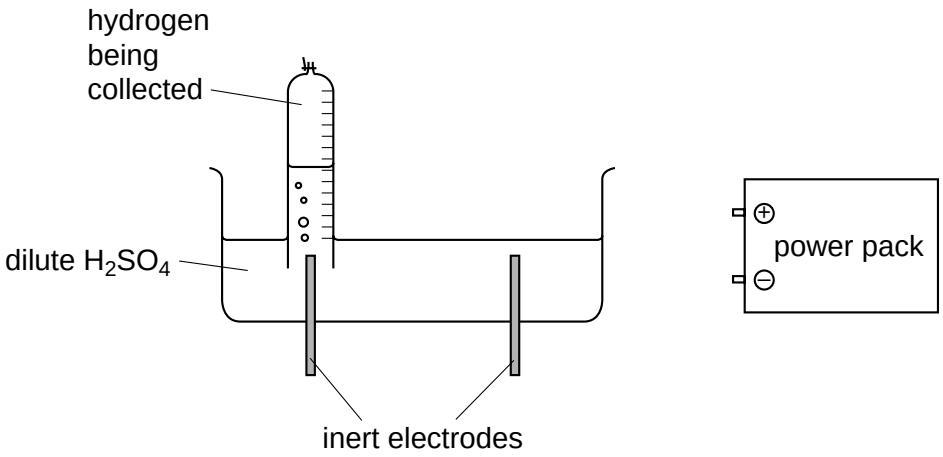
Score: **/55**

Percentage: **/100**

Grade Boundaries:

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

1 A student decided to determine the value of the Faraday constant by an electrolysis experiment. The following incomplete diagram shows the apparatus that was used.



(a) **(i)** Apart from connecting wires, what **two** additional pieces of equipment are needed for this experiment?

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(ii) Complete the diagram, showing additional equipment connected in the circuit, and showing the powerpack connected to the correct electrodes.

(iii) List the measurements the student would need to make in order to use the results to calculate a value for the Faraday constant.

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[7]

(b) **(i)** Using an equation, state the relationship between the Faraday constant, *F*, the Avogadro constant, *L*, and the charge on the electron, *e*.

.....

(ii) The value the student obtained was: 1 Faraday = 9.63×10^4 Coulombs

Use this value and your equation in **(b)(i)** to calculate the Avogadro constant (take the charge on the electron to be 1.60×10^{-19} Coulombs)

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[2]

[Total: 9]

2 Silver bromide, AgBr, is widely used in photography. In a photographic film, AgBr crystals are precipitated into a gelatine base as 'grains' of diameter about 1×10^{-6} m.

(a) Calculate the approximate number of silver ions contained in a grain of AgBr of mass 2.5×10^{-12} g.

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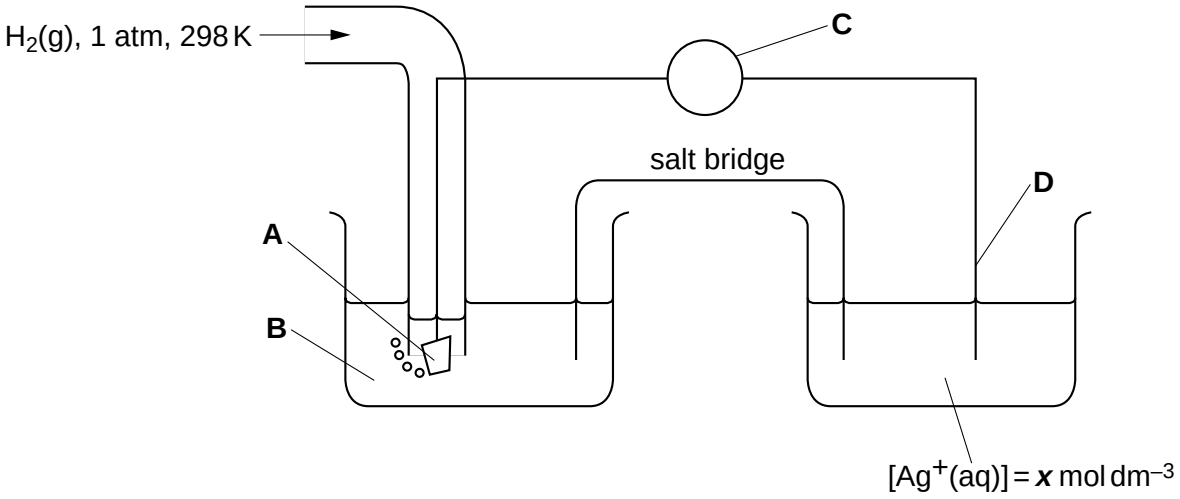
..... [2]

(b) AgBr is only sparingly soluble in water. The $[Ag^+]$ in a saturated solution of AgBr can be estimated by measuring the E_{cell} of the following cell.



(i) In the spaces below, identify what the four letters **A** – **D** in the above diagram represent.

A ..... **C** .....

B ..... **D** .....

(ii) Predict how the potential of the right hand electrode might vary as $[Ag^+]$ is decreased.

.....

In its saturated solution, $[AgBr(aq)] = 7.1 \times 10^{-7}$ mol dm^{-3}.

(iii) Write an expression for the solubility product of AgBr, and calculate its value, including units.

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.....

[7]

(c) **(i)** Write a chemical equation representing the lattice energy of AgBr.

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(ii) Use the following data to calculate a value for the lattice energy of AgBr(s).

first ionisation energy of silver	=	+731 kJ mol^{-1}
electron affinity of bromine	=	–325 kJ mol^{-1}
enthalpy change of atomisation of silver	=	+285 kJ mol^{-1}
enthalpy change of atomisation of bromine	=	+112 kJ mol^{-1}
enthalpy change of formation of AgBr(s)	=	–100 kJ mol^{-1}

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(iii) How might the lattice energy of AgC*l* compare to that of AgBr? Explain your answer.

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.....

[4]

In photography a bromide ion absorbs a photon and releases an electron which reduces a silver ion to a silver atom.

$$Br^- \longrightarrow Br + e^-$$

$$Ag^+ + e^- \longrightarrow Ag$$

(d) Predict whether it would require **more** energy or **less** energy to initiate this process in a AgC*l* emulsion, compared to a AgBr emulsion. Explain your answer.

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..... [1]

[Total: 14]

3 Magnesium is used extensively in the form of alloys as a constructional material due to its low density ($1.7\,g\,cm^{-3}$, compared to $7.8\,g\,cm^{-3}$ for iron). It is usually prepared by the electrolysis of magnesium chloride, $MgCl_2$, at a temperature a little above its melting point of 715 °C.

(a) Suggest the half-equation that represents the production of magnesium at the cathode during the electrolysis.

.....[1]

(b) What will be the product at the other electrode?

.....[1]

(c) Suggest **two** properties of its atoms that could explain why magnesium is less dense than iron.

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.....[2]

One of the reasons the melting point of magnesium chloride is quite high is because it has a fairly high lattice energy.

(d) **(i)** Explain the term *lattice energy*.

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(ii) Write a balanced equation including state symbols to represent the lattice energy of magnesium chloride.

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.....[4]

(e) Suggest, with an explanation in each case, how the lattice energy of magnesium chloride might compare with that of

(i) sodium chloride, NaCl,

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(ii) calcium chloride, $CaCl_2$.

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.....[4]

(f) Use the following data to calculate a value for the lattice energy of sodium chloride.

ΔH_f (NaC*l*)	=	$-411\ kJ\ mol^{-1}$
ΔH_{at} (Na)	=	$107\ kJ\ mol^{-1}$
ΔH_{at} (C*l*)	=	$122\ kJ\ mol^{-1}$
first ionisation energy of Na	=	$494\ kJ\ mol^{-1}$
electron affinity of C*l*	=	$-349\ kJ\ mol^{-1}$

lattice energy of NaC*l* = ... $kJ\ mol^{-1}$ [3]

[Total: 15]

4 **(a)** **(i)** Describe, with the aid of a fully labelled diagram, the industrial electrolysis of brine (aqueous NaC*l*). State what the electrodes are made of and show clearly the inlet and the outlets.

(ii) Write equations for the reactions at each electrode, giving state symbols.

anode .....

cathode .....

(iii) Explain in terms of changes in oxidation number why redox processes take place at the electrodes.

anode .....

cathode .....

(iv) Name the chemical which is produced in solution by this electrolysis.

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(v) Suggest **two** large scale uses of this chemical.

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[10]

(b) Hydrochloric acid is manufactured by burning the hydrogen formed in this electrolysis in chlorine and dissolving the product in water.

(i) Construct an equation for the burning of hydrogen in chlorine.

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(ii) When the product of **(i)** dissolves in water there is a change in bonding. Explain with the aid of an equation what change in bonding has occurred.

[2]

(c) Describe, with the aid of equations including state symbols, what happens when

(i) hydrochloric acid is added to aqueous silver nitrate,

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(ii) an excess of aqueous ammonia is added to the resulting mixture.

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.....[5]

[Total : 17]