

# Electrolysis, Electrode Potentials & Cells

## Question Paper 7

<b>Level</b>	International A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	CIE
<b>Topic</b>	Electrochemistry
<b>Sub-Topic</b>	Electrolysis, Electrode Potentials & Cells
<b>Paper Type</b>	Theory
<b>Booklet</b>	Question Paper 7

**Time Allowed:** 66 minutes

**Score:** /55

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

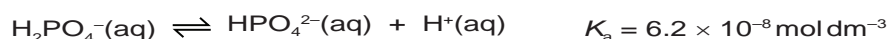
1 (a) (i) What is meant by the term *buffer solution*?

.....  
.....  
..... [2]

(ii) Write equations to show how the hydrogencarbonate ion,  $\text{HCO}_3^-$ , controls the pH of blood.

.....  
..... [2]

(iii) A solution containing both  $\text{Na}_2\text{HPO}_4$  and  $\text{NaH}_2\text{PO}_4$  is commonly used as a buffer solution. The following equilibrium is present in the solution.



Calculate the pH of a buffer solution made by mixing  $100 \text{ cm}^3$  of  $0.5 \text{ mol dm}^{-3}$   $\text{Na}_2\text{HPO}_4$  and  $100 \text{ cm}^3$  of  $0.3 \text{ mol dm}^{-3}$   $\text{NaH}_2\text{PO}_4$ .

(b) Silver phosphate,  $\text{Ag}_3\text{PO}_4$ , is sparingly soluble in water.

(i) Write an expression for the solubility product,  $K_{sp}$ , of  $\text{Ag}_3\text{PO}_4$ , and state its units.

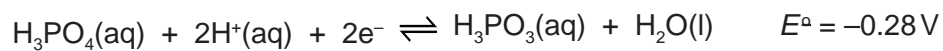
pH = ..... [2]

$K_{sp} =$  ..... units: ..... [1]

(ii) The numerical value of  $K_{sp}$  is  $1.25 \times 10^{-20}$  at 298 K. Use this value to calculate  $[\text{Ag}^+(\text{aq})]$  in a saturated solution of  $\text{Ag}_3\text{PO}_4$ .

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

- (c) The half-equation for the redox reaction between phosphoric(III) acid and phosphoric(V) acid is shown.



Find suitable data from the *Data Booklet* to write an equation for the reaction between  $\text{H}_3\text{PO}_3$  and  $\text{Fe}^{3+}(\text{aq})$  ions, and calculate the  $E^\ominus_{\text{cell}}$  for the reaction.

equation: .....

$$E^\ominus_{\text{cell}} = \dots\dots\dots \text{V} \quad [2]$$

[Total: 12]

2 (a) In this question, **K**, **L** and **M** refer to a halogen atom or halide ion.  
For each part question, read the information and complete the answer lines below.

(i) When concentrated sulfuric acid is added to solid Na**K**, white fumes are produced that turn damp blue litmus paper red. No other colour changes are observed.

identity of **K** = .....

equation for reaction .....

explanation of observation .....

..... [3]

(ii) When silver nitrate solution is added to an aqueous solution of Na**L**, a precipitate forms that remains after the addition of concentrated ammonia solution.

identity of **L** = .....

colour of precipitate .....

equation for reaction ..... [3]

(iii) **M**<sub>2</sub> is a liquid at room temperature with a boiling point higher than that of chlorine but lower than that of iodine.

identity of **M** = .....

explanation .....

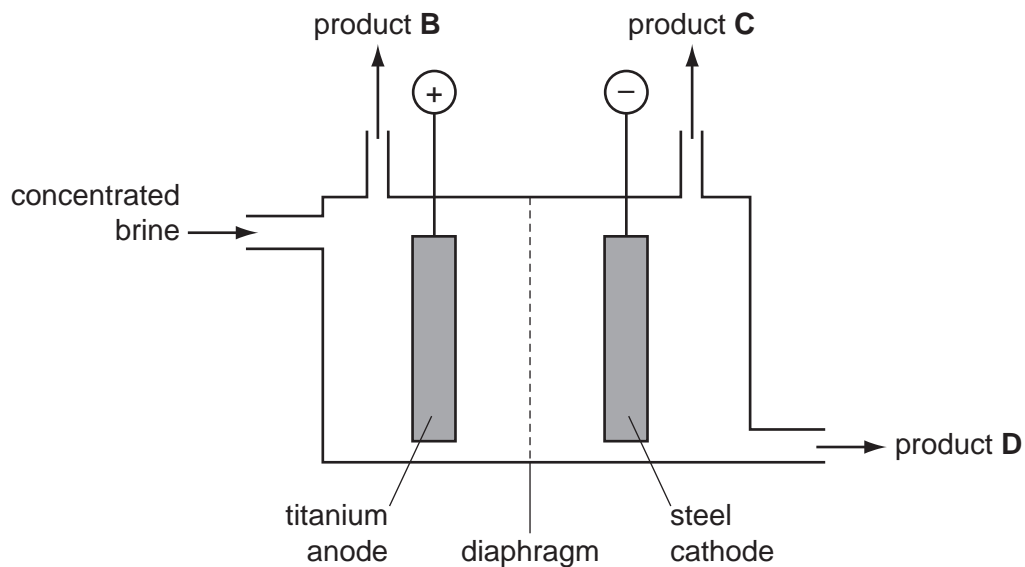
.....

.....

.....

..... [2]

(b) The diagram below is a simplified representation of a diaphragm cell.



(i) Identify each of the products.

**B** .....

**C** .....

**D** .....

[3]

(ii) Give the equations for the two electrode reactions.

anode .....

cathode .....

[2]

[Total: 13]

3 (a) Complete the following electronic configuration of the  $\text{Cu}^{2+}$  ion.

$1s^2 2s^2 2p^6$  ..... [1]

(b) In a free, gas-phase transition metal ion, the d-orbitals all have the same energy, but when the ion is in a complex the orbitals are split into two energy levels.

(i) Explain why this happens.

.....  
.....

(ii) How does this splitting help to explain why transition metal complexes are often coloured?

.....  
.....  
.....  
.....

(iii) Why does the colour of a transition metal complex depend on the nature of the ligands surrounding the transition metal ion?

.....  
.....

[5]

(c) Draw a fully-labelled diagram of the apparatus you could use to measure the  $E^\ominus$  of a cell composed of the  $\text{Fe}^{3+}/\text{Fe}^{2+}$  electrode and the  $\text{Cu}^{2+}/\text{Cu}$  electrode.

(d) The  $E^\ominus$  for  $\text{Cu}^{2+}/\text{Cu}$  is +0.34 V. When  $\text{NH}_3(\text{aq})$  is added to the electrode solution, the  $E_{\text{electrode}}$  changes.

(i) Describe the type of reaction taking place between  $\text{Cu}^{2+}(\text{aq})$  and  $\text{NH}_3(\text{aq})$ .

.....

(ii) Write an equation for the reaction.

.....

(iii) Describe the change in the colour of the solution.

.....

(iv) Predict and explain how the  $E_{\text{electrode}}$  might change on the addition of  $\text{NH}_3(\text{aq})$ .

.....

.....

[4]

(e) Fehling's reagent is an alkaline solution of  $\text{Cu}^{2+}$  ions complexed with tartrate ions. It is used in organic chemistry to test for a particular functional group.

(i) Name the functional group involved.

.....

(ii) Describe the appearance of a positive result in this test.

.....

(iii) Write an equation for the reaction between  $\text{Cu}^{2+}$  and  $\text{OH}^-$  ions and a two-carbon compound containing the functional group you named in (i).

.....

[3]

(f) A solution containing a mixture of tartaric acid and its sodium salt is used as a buffer in some pre-prepared food dishes.

Calculate the pH of a solution containing  $0.50 \text{ mol dm}^{-3}$  of tartaric acid and  $0.80 \text{ mol dm}^{-3}$  sodium tartrate.

$[K_a(\text{tartaric acid}) = 9.3 \times 10^{-4} \text{ mol dm}^{-3}]$

pH = .....

[2]

[Total: 20]

4 (a) What do you understand by the term *standard electrode potential*?

.....  
..... [2]

(b) By reference to relevant  $E^\ominus$  data in the *Data Booklet*, explain how the halogen/halide electrode potentials relate to the relative reactivity of the halogens as oxidising agents.

.....  
.....  
..... [2]

(c) Use data from the *Data Booklet* to construct redox equations, and calculate the standard cell potentials, for the reactions between

(i) Acidified  $\text{H}_2\text{O}_2(\text{aq})$  and  $\text{KI}(\text{aq})$ ,

.....

(ii)  $\text{Cl}_2(\text{aq}) + \text{SO}_2(\text{aq})$ .

..... [4]

(d) Use data from the *Data Booklet* to predict the likely product of the reaction between  $\text{I}_2(\text{aq})$  and tin metal, writing a balanced equation for the reaction.

..... [2]

[Total: 10]