

# Electrolysis, Electrode Potentials & Cells

## Question Paper 7

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

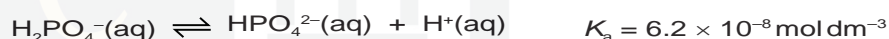
1 (a) (i) What is meant by the term *buffer solution*?

.....  
.....  
..... [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,  $K_{\text{sp}}$ , of  $\text{Ag}_3\text{PO}_4$ , and state its units.

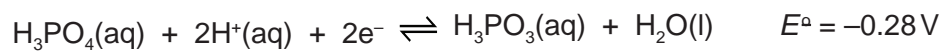
pH = ..... [2]

CHEMISTRY ONLINE  
TUITION  
 $K_{\text{sp}} =$  \_\_\_\_\_ units: ..... [1]

(ii) The numerical value of  $K_{\text{sp}}$  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  $E^\circ_{\text{cell}}$  for the reaction.

equation: .....

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

[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 .....

.....

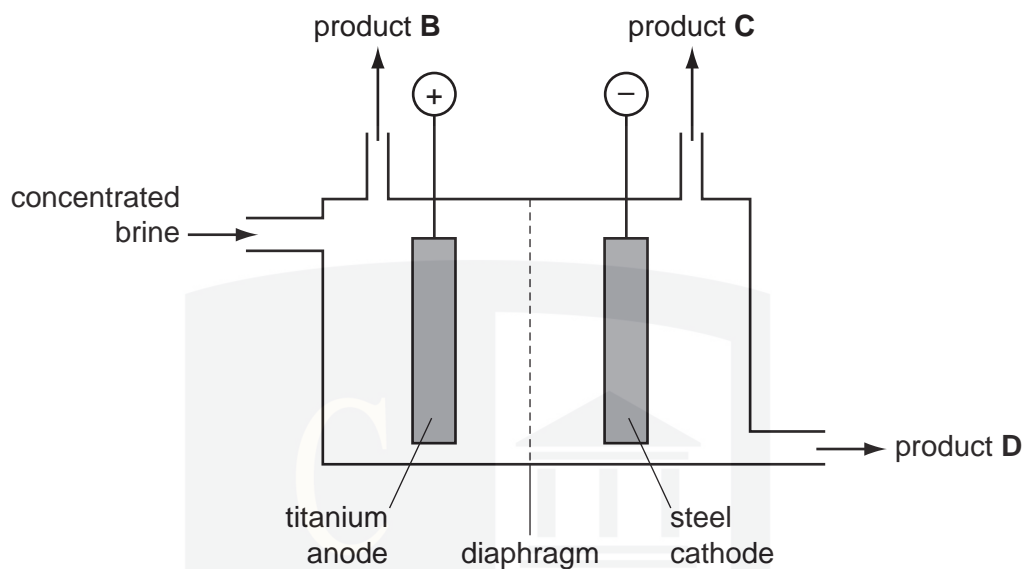
.....

.....

..... [2]

CHEMISTRY ONLINE  
— TUITION —

(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]

CHEMISTRY ONLINE  
— TUITION —

[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  $E^\circ$  of a cell composed of the  $\text{Fe}^{3+}/\text{Fe}^{2+}$  electrode and the  $\text{Cu}^{2+}/\text{Cu}$  electrode.

CHEMISTRY ONLINE  
— TUITION —

(d) The  $E^\circ$  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)  $\text{Cl}_2(\text{aq}) + \text{SO}_2(\text{aq})$ .

.....  
CHEMISTRY ONLINE  
— TUITION —

(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]