9.1 Redox Processes

Question Paper

Course	DP IB Chemistry
Section	9. Redox Processes
Topic	9.1 Redox Processes
Difficulty	Hard

Time allowed: 70

Score: /54

Percentage: /100

Question 1a

a)
A student sets up a titration to determine the amount of iron(II) sulfate in an iron tablet. They titrate the iron(II) sulfate solution with potassium manganate(VII) solution.

i)
Write the balanced, ionic half equations to show the reduction of the manganate(VII) ion and the oxidation of the Fe^{2+}.

[2]

ii)
Use your answers to part (i) to write an overall redox equation for the titration of iron(II) sulfate with potassium manganate(VII) solution.

[1]

[3 marks]

Question 1b

b)
The iron(II) sulfate solution is acidified before titration to stop the manganate ion forming unwanted manganese dioxide.

Explain the effect that not acidifying the iron(II) sulfate would have on the final calculation of the estimated mass of iron.

[2]

[2 marks]

Question 1c

c)
The student dissolved the iron tablet in excess sulfuric acid and made the solution up to 250 cm^3 in a volumetric flask. 25.0 cm^3 of this solution was titrated with 0.0100 mol dm^{-3} potassium manganate(VII) solution. The average titre was found to be 26.65 cm^3 of potassium manganate(VII) solution.

i)
Calculate the amount, in moles, of iron(II) ions in the 250 cm^3 solution.

[3]

ii)
Calculate the mass of iron, in mg, in the tablet.

[2]

[5 marks]

Question 1d

d)
Iron sulfate reacts with chromium to produce chromium(III) sulfate, $Cr_2(SO_4)_3$, and iron

Deduce the overall ionic equation for the reaction occurring

[1]

[1 mark]

Question 2a

a)
Molten potassium bromide can be electrolysed using graphite electrodes.

i)
Draw the essential components of this electrolytic cell.

[3]

ii)
Identify the products at each electrode.

[2]

[5 marks]

Question 2b

b)
State the half equations for the oxidation and reduction processes and deduce the overall cell reaction, including state symbols.

Oxidation half equation ………………

Reduction half equation ……………….

Overall equation …………………………

[3]

[3 marks]

Question 2c

c)

Explain why solid potassium bromide does not conduct electricity.

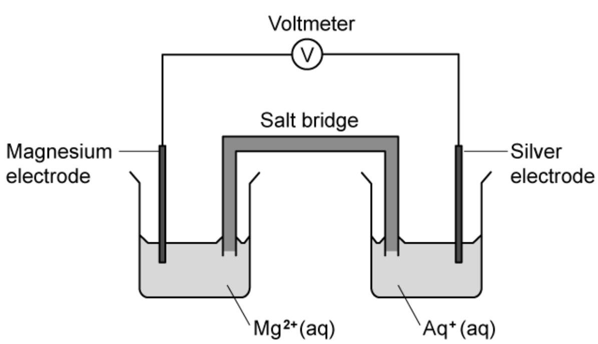
[1]

[1 mark]

Question 2d

d)

A voltaic cell is made from a half-cell containing a magnesium electrode in a solution of magnesium nitrate and a half-cell containing a silver electrode in a solution of silver(I) nitrate.



i)

Use section 25 of the data booklet to determine which electrode is positive and to write the equation for the reaction at the positive electrode, including state symbols.

[1]

ii)

Compare the processes at the positive electrodes in voltaic and electrolytic cells.

[2]

[3 marks]

Question 3a

a)
State the oxidation state of phosphorus in the following compounds.

$H_2PO_4^-$ ……………………………………………………..

HPO_3 ……………………………………………………..

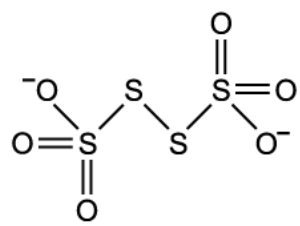
H_3PO_3 ……………………………………………………..

[3]

[3 marks]

Question 3b

b)
The tetrathionate ion is shown below:



i)

Determine the oxidation state of sulfur in the ion.

[1]

ii)
Justify your answer to part ii).

[1]

[2 marks]

Question 3c

c)
Sodium tetrathionate can be formed by reacting sodium thiosulfate, $Na_2S_2O_3$, with iodine.

i)
State the balanced symbol equation for this reaction.

[2]

ii)
Identify the oxidising agent in this reaction.

[1]

[3 marks]

Question 3d

d)
Describe the expected observation to show that this reaction had gone to completion.

[1]

[1 mark]

Question 4a

a)
A 150.0 cm^3 sample of pond water was analysed using the Winkler method to determine its biological oxygen demand (BOD). Initially it took 29.40 cm^3 of 0.010 mol dm^{-3} $Na_2S_2O_3$ to react with iodine.

After five days it required 13.70 cm^3 of 0.010 mol dm^{-3} $Na_2S_2O_3$ to react with iodine.

The unbalanced equations for the Winker method are shown below.

......Mn^{2+} (aq) + ...OH^- (aq) + O_2 (aq) → ......MnO_2 (s) + ...H_2O (l)

MnO_2 (s) + ...I^- (aq) + ...H^+ (aq) → Mn^{2+} (aq) + I_2 (aq) + ...H_2O (l)

......$S_2O_3{}^{2-}$ (aq) + I_2 (aq) → $S_4O_6{}^{2-}$ + ...I^- (aq)

Balance the equations for the Winkler method.

[3]

[3 marks]

Question 4b

b)
Deduce the reducing agent in the reaction between $S_2O_3{}^{2-}$ and I_2. Justify your answer.

[3 marks]

Question 4c

c)
Use the information in part a) and section 6 in your data booklet to determine the initial concentration, in ppm, of oxygen.

[3 marks]

Question 4d

d)
Use the information in part a) and section 6 in the data booklet to determine the concentration, in g dm^{-3}, of oxygen after five days.

[3]

[3 marks]

Question 4e

e)
Determine the BOD of the pond water in ppm.

[2]

[2 marks]

Question 5a

a)
15.00 cm^3 of ethanedioic acid, $H_2C_2O_4$ (aq), requires 10.30 cm^3 of a 0.250 mol dm^{-3} solution of sodium hydroxide, NaOH (aq), for complete neutralisation using a phenolphthalein indicator for the first permanent colour change.

15.00 cm^3 of the same $H_2C_2O_4$ solution required 12.35 cm^3 of potassium permanganate solution, $KMnO_4$ (aq), solution for complete oxidation to carbon dioxide and water in the presence of dilute sulfuric acid to further acidify the $H_2C_2O_4$ solution for the first permanent colour change.

i)
Using the following equation, calculate the amount, in moles, of $H_2C_2O_4$ (aq).

$$H_2C_2O_4\,(aq) + 2NaOH\,(aq) \rightarrow Na_2C_2O_4\,(aq) + 2H_2O\,(l)$$

[2]

ii)
Calculate the concentration, in mol dm^{-3}, of $H_2C_2O_4$ (aq).

[1]

[3 marks]

Question 5b

b)
Deduce the following half equations and overall redox equation for the reaction outlined in part a).

MnO_4^- (aq) to Mn^{2+} (aq) ....

$H_2C_2O_4$ (aq) to CO_2 (g) ....

Overall equation ....

[3]

[3 marks]

Question 5c

c)
Calculate the concentration, in mol dm^{-3}, of the potassium manganate(VII), $KMnO_4$, solution.

[2 marks]