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	Marks

a) Bromine, $Br_2(l)$ can be produced by a variety of methods

- The first method involves reacting chlorine gas, $Cl_2(g)$, with a solution of potassium bromide, KBr(aq).
- A second method uses manganese(IV) oxide, $MnO_2(s)$, with a solution of potassium bromide, KBr(aq), in acidic conditions.
- The third is the electrolysis of a solution of potassium bromide using platinum electrodes. Bromine is produced at the positive electrode, with a flammable gas being produced at the negative electrode.

i. Give the equation for the reaction of the first method, and indicate the changes in oxidation numbers for bromine and chlorine during the reaction. — 2 marks

The second method involves the two redox couples

$$\mathbf{Br_2(aq)/Br^-(aq)} \quad \text{and} \quad \mathbf{MnO_2(s)/Mn^{2+}(aq)}$$

ii. Use these couples to write the chemical equation for the reaction, and give the changes in oxidation numbers for bromine and manganese during the reaction. — 3 marks

The table below gives the electrode potentials for the likely couples involved under the conditions experienced in the third method using the electrolysis cell.

Couples	*E* / V
$K^+(aq) / K(s)$	– 2.93
$H_2O(l) / H_2(g)$	– 0.41
$O_2(g) / H_2O(aq)$	+ 0.81
$Br_2(aq) / Br^-(aq)$	+ 1.09

iii. Draw a labelled diagram of the electrolysis experiment as described for the third method. Include arrows to show the movement of ions and of electrons during the electrolysis. — 3 marks

iv. Using the data from the table, identify the substances that should be theoretically produced at each electrode and explain your answer. — 2 marks

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	In practice, it is found that bromine is one of the substances.	
	v. Write the overall equation for the reaction taking place during this electrolysis and calculate the minimum voltage that must be applied during the electrolysis to produce bromine.	2 marks
	vi. Calculate the time taken for the electrolysis to produce a mass of 1.00 kg of bromine, $Br_2(l)$, if a steady current of 12.0 A is passed.	2 marks
	Given: 1 Faraday= 9.65×10^4 C mol^{-1} Molar atomic mass (in g mol^{-1}) : Br : 79.9	
b)	Bromine, $Br_2(l)$, is used in the manufacture of potassium hypobromite, KBrO(aq), which is used as a disinfectant. The process involves two stages. • Step 1: bromine reacts with water to produce hydrobromic acid, HBr(aq), and hypobromous acid, HBrO(aq). • Step 2: the hypobromous acid from step1 reacts with an aqueous solution of potassium hydroxide, KOH(aq).	
	Give the equations for the reactions occurring in step 1 and in step 2.	2 marks
c)	25.0 cm^3 of 1.00×10^{-1} mol dm^{-3} hypobromous acid solution is titrated with an aqueous solution of sodium hydroxide, NaOH(aq) with a concentration of 8.00×10^{-2} mol dm^{-3}.	
	i. Give the equation for the reaction taking place during the titration.	1 mark
	ii. Calculate the volume of the sodium hydroxide solution that must be added to reach the equivalence point.	2 marks
	iii. Calculate the initial pH of the solution of hypobromous acid at 25 °C.	2 marks
	iv. Calculate the pH at the equivalence point of the titration at 25 °C.	4 marks
	Given: K_a, for hypobromous acid at 25 °C : 2.00×10^{-9}. pK_w of water at 25 °C : 14.0	

Question B1	Page 1/2
	Marks

a) A secondary alcohol has the molecular formula $C_5H_{12}O$.

i. Give the three possible structural formulas of the secondary alcohol isomers of $C_5H_{12}O$. — 3 marks

One of the isomers you have drawn is <u>not</u> optically active.

ii. Give the IUPAC name of this isomer and explain why it is not optically active. — 3 marks

The alcohol pentan-2-ol is oxidized by an acidified aqueous solution of potassium dichromate, $K_2Cr_2O_7(aq)$.

iii. Give the equation for the reaction and give the IUPAC name of the organic product. — 3 marks

Given: The half-equation for the oxidizing agent is:

$$\mathbf{Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)}$$

iv. Calculate the minimum volume of 2.00×10^{-1} mol dm^{-3} aqueous potassium dichromate solution required to oxidize 25.0 cm^3 of pentan-2-ol. — 3 marks

Given: The density of pentan-2-ol : 8.09×10^{-1} g cm^{-3}.
Molar atomic masses (in g mol^{-1}) :
H : 1.01 C : 12.0 O : 16.0

b) Esterification reactions, represented by the general equation below, are reversible:

$$\textbf{acid + alcohol} \rightleftharpoons \textbf{ester + water}$$

i. Suggest two different ways in which the yield of ester could be increased. — 2 marks

ii. Give the mechanism for the esterification reaction between ethanoic acid and methanol. — 4 marks

iii. Explain why a strong acid is used to catalyze this reaction. — 1 mark

Question B1	Page 2/2
	Marks

c) An organic compound, **X** is a liquid at room temperature and is produced by oxidizing a saturated alcohol.

9.70 g of compound **X** is totally combusted in air to give 9.01 g of water and 12.3 dm^3 of carbon dioxide, measured at 25 ^oC and a pressure of 1.01 x 10^5 Pa.

i. Calculate the molar ratio of carbon to hydrogen in compound **X**. — 3 marks

ii. Assuming that the molar mass is 58.1 g mol^{-1} give the molecular formula of **X**. — 1 mark

iii. Give the structural formulas and the names of the two isomers of **X**. — 2 marks

Given: Molar atomic masses (g mol^{-1}):

H : 1.01 C : 12.0 O : 16.0

Molar volume of a gas at 25 ^oC and 1.01 x 10^5 Pa : 24.5 dm^3 mol^{-1}