1. June/2022/Paper_41/No.2(d, e)

(d) Manganese(VII) oxide, Mn_2O_7, can be made by treatment of $KMnO_4$ with concentrated sulfuric acid (reaction 1).

Mn_2O_7 readily decomposes at room temperature to form manganese(IV) oxide and a colourless diatomic gas (reaction 2).

Construct equations for **both** the reactions described.

reaction 1 .....

reaction 2 .....

[2]

(e) Aqueous manganese(II) ions show similar chemical properties to aqueous copper(II) ions when reacted separately with NaOH(aq) and with concentrated HC*l*.

(i) Write the ionic equation, and state the type of reaction, for the reaction of $[Mn(H_2O)_6]^{2+}$ with NaOH(aq).

ionic equation .....

type of reaction .....

[2]

(ii) Write the ionic equation, and state the type of reaction, for the reaction of $[Mn(H_2O)_6]^{2+}$ with concentrated HC*l*.

ionic equation .....

type of reaction .....

[2]

(iii) Table 2.1 lists relevant electrode potentials for some electrode reactions.

Table 2.1

electrode reaction	$E^{\ominus}$/V
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	–1.18
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$2HOCl + 2H^+ + 2e^- \rightleftharpoons Cl_2 + 2H_2O$	+1.64
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+1.23
$MnO_4^- + 4H^+ + 3e^- \rightleftharpoons MnO_2 + 2H_2O$	+1.67

Suggest the formula of the manganese species formed when $Mn^{2+}(aq)$ reacts with Cl_2.

State the type of reaction.

formula of manganese species formed .....

type of reaction .....

[1]

2. June/2022/Paper_41/No.3(c, d)

(c) (i) Define standard electrode potential, $E^{\ominus}$.

.....

.....

..... [1]

(ii) A salt bridge is used in an electrochemical cell.

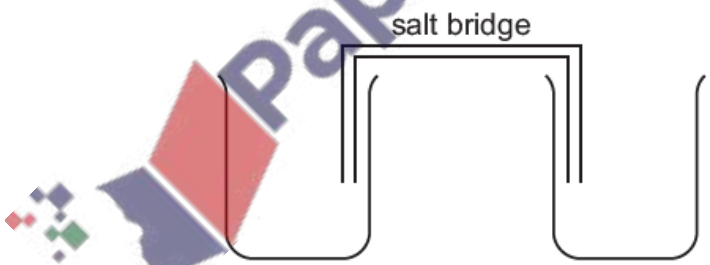
State the function of the salt bridge. Explain your answer.

.....

..... [1]

(iii) Complete the diagram of the apparatus that can be used to measure the $E^{\ominus}$ of the $Cr_2O_7^{2-}(aq)$, $H^+(aq)/Cr^{3+}(aq)$ electrode against the standard hydrogen electrode.

Your diagram should be fully labelled to identify all apparatus, substances and conditions.



[3]

(iv) The $E^{\ominus}$ of the $Cr_2O_7^{2-}(aq)$, $H^+(aq)/Cr^{3+}(aq)$ electrode is +1.33 V.

Label the negative electrode and the direction of electron flow in the external circuit when the current flows in your diagram in **(c)(iii)**. [1]

(d) Table 3.1 lists relevant electrode potentials for some electrode reactions for use in **(d)(i)** and **(d)(ii)**.

Table 3.1

electrode reaction	$E^{\ominus}$/V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$CH_3CHO + 2H^+ + 2e^- \rightleftharpoons CH_3CH_2OH$	–0.61
$CH_3COOH + 2H^+ + 2e^- \rightleftharpoons CH_3CHO + H_2O$	–0.94
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.23

(i) Ethanal is oxidised to ethanoic acid in the presence of $Cr_2O_7^{2-}$ ions.

Construct the ionic equation for the oxidation of ethanal to ethanoic acid using dichromate(VI) in acid conditions. Calculate the $E^{\ominus}_{cell}$ for this reaction.

ionic equation .....

$E^{\ominus}_{cell}$ = ... V
[2]

(ii) In an ethanol-oxygen fuel cell, $CH_3CH_2OH(l)$ and $O_2(g)$ are in contact with two inert electrodes immersed in an acidic solution.

The cell reaction for the oxidation of ethanol by oxygen is shown.

$$CH_3CH_2OH + O_2 \rightarrow CH_3COOH + H_2O \qquad E^{\ominus}_{cell} = +2.01\,V$$

Calculate $\Delta G^{\ominus}$, in kJ mol^{-1}, for the oxidation of ethanol by oxygen.

$\Delta G^{\ominus}$ = ... kJ mol^{-1} [2]

3. June/2022/Paper_42/No.5

(a) Complete Table 5.1 to predict the substance liberated at each electrode during electrolysis of the indicated electrolyte with inert electrodes.

Table 5.1

electrolyte	substance liberated at the anode	substance liberated at the cathode
$PbBr_2(l)$		
concentrated $NaCl(aq)$		
$Cu(NO_3)_2(aq)$		

[3]

(b) An electrolytic cell is set up to determine a value for the Avogadro constant, *L*. The electrolyte is dilute sulfuric acid and both electrodes are copper.

When a current of 0.600A is passed through the acid for 30.0 minutes, the anode decreases in mass by 0.350g.

(i) State the relationship between the Faraday constant, *F*, and the Avogadro constant, *L*.

..... [1]

(ii) Use the experimental information in **(b)** and data from the table on page 23 to calculate a value for the Avogadro constant, *L*.

Show all working.

Avogadro constant, *L* = ... [4]

[Total: 8]