Alcohols

Question Paper

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Alcohols-Lower functional group level
Booklet	Question Paper

Time Allowed: **23 minutes**

Score: **/19**

Percentage: **/100**

Grade Boundaries:

1. The use of methanol, CH_3OH, in fuel cells is the subject of considerable research. A commercial production of methanol involves a two step process.

Step 1 production of hydrogen gas

equation 4.1 $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta_r H^{\ominus} = +206\,kJ\,mol^{-1}$

A temperature of 850 °C and pressure of 1500 kPa are used in this step.

Step 2 reaction of hydrogen and carbon monoxide to form methanol

equation 4.2 $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta_r H^{\ominus} = -92\,kJ\,mol^{-1}$

A temperature of 300 °C and pressure of 7500 kPa are used in this step, with a catalyst of ZnO/CrO_3.

(a) (i) Write an expression for the equilibrium constant, K_p, for the reaction in equation **4.2**.

[1]

(ii) After the reaction shown in equation **4.2** had reached equilibrium, a mixture of gases was extracted. It contained 38.0 g of hydrogen, 462 g of carbon monoxide and 7200 g of methanol.

Calculate the mole fraction of each gas in the mixture.

mole fraction of hydrogen = ...

mole fraction of carbon monoxide = ...

mole fraction of methanol = ...

[2]

(iii) Use your values from **(a)(ii)** to calculate the value of the equilibrium constant, K_p, for the reaction shown in equation **4.2**.

K_p = ...[2]

(b) **(i)** Elevated temperatures are used in both steps, with the temperature used in step 1 being much higher than in step 2.

Explain why.

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.....[3]

(ii) Pressures higher than atmospheric are used in both steps, with the pressure used in step 2 being much higher than in step 1.

Explain why.

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.....[3]

(c) In a direct methanol fuel cell, DMFC, methanol is oxidised at the anode.

The protons produced migrate across the proton exchange membrane, PEM, to the cathode where oxygen is reduced to water.

The standard electrode potential of the oxygen cathode is +1.23V.

(i) Write the half-equation for the reduction of oxygen to water in acidic conditions at the cathode.

.....[1]

(ii) The electrode potential for

$$6H^+ + 6e^- + CO_2 \rightleftharpoons CH_3OH + H_2O$$

is +0.02V.

Write the overall equation for the reaction taking place in the DMFC and calculate the standard cell potential.

equation .....

standard cell potential = ...V [2]

(d) One method for the construction of a DMFC involves electroplating a layer of platinum onto the surface of the proton exchange membrane, PEM. The electrolyte for this process consists of a solution of tetraammineplatinum(II) chloride, $Pt(NH_3)_4Cl_2$, and the PEM is the cathode in the electrolytic cell.

(i) State the shape and bond angle of the tetraammineplatinum(II) ion, $[Pt(NH_3)_4]^{2+}$.

shape .....

bond angle ..... [1]

(ii) Suggest the half-equation for the cathode reaction that deposits platinum on the PEM.

..... [1]

(e) In one such preparation a PEM with a surface area of 25 cm^2 was immersed in an electrolyte bath and a current of 3.5×10^{-3} A cm^{-2} was passed for 95 minutes.

Calculate the mass of platinum deposited onto the surface of the PEM.

[3]

[Total: 19]