4. This question is about hangovers

(a) it is oxidised [✓ it is reduced] it is hydrolysed it is isomerised it remains chemically unchanged 1

No marks if more than one answer circled.

(b) Molar mass of ethanol = (2 × 12.01 + 6 × 1.008 + 16.00) g mol^{-1}

= 46.068 g mol^{-1}

Concentration = 80 mg / 100 cm^3

= 800 mg dm^{-3} = 0.8 g dm^{-3}

= 0.8 g dm^{-3} / 46.068 g mol^{-1}

= 0.017 mol dm^{-3} or 0.017 M or 17 mM 1

(c) **(i)** If $[C_2H_5OH] >> K_M$, then $K_M + [C_2H_5OH] \approx [C_2H_5OH]$

$$rate = \frac{k_{cat}[AD][C_2H_5OH]}{K_M + [C_2H_5OH]}$$

$$rate = \frac{k_{cat}[AD][C_2H_5OH]}{[C_2H_5OH]}$$

$$rate = k_{cat}[AD]$$

1

(ii) If $K_M >> [C_2H_5OH]$, then $K_M + [C_2H_5OH] \approx K_M$

$$rate = \frac{k_{cat}[AD][C_2H_5OH]}{K_M + [C_2H_5OH]}$$

$$rate = \frac{k_{cat}[AD][C_2H_5OH]}{K_M}$$

1

(d) Zero *or* 0 *or* Zeroth Order

At the UK drink drive limit $[C_2H_5OH]$ is much greater than K_M, meaning the case in (c)(i) applies. This is why it is possible to roughly calculate how long it will take someone to 'sober up' as the rate of loss of alcohol is approximately constant. 1

(e) **(i)** This is obtained from the gradient of the graph in the period up to 18 h where there is a constant gradient.

Gradient = 17.0 (mg / 100 cm^3) h^{-1} 1

Allow values between 15.5-18.5 (mg / 100 cm^3) h^{-1}

(ii) From part (b) 80 mg / 100 cm^3 = 0.0174 mol dm^{-3}

Therefore 1 mg / 100 cm^3 = 2.175×10^{-4} mol dm^{-3}

17 (mg / 100 cm^3) h^{-1} = 3.698×10^{-3} mol dm^{-3} h^{-1}

= 1.03×10^{-6} mol dm^{-3} s^{-1} **2**

Allow error carried forward from (e)(i). Answer should be 6.04× 10^{-8} *multiplied by the answer for part (e)(i). Also allow error carried forward from (b) if the same wrong conversion factor has been used.*

(f) From part (c)(i) $rate \approx k_{cat}[AD]$

$[AD] = rate / k_{cat}$

$[AD] = 1.03 \times 10^{-6}$ mol dm^{-3} s^{-1} / 1.33 s^{-1} **1**

$[AD] = 7.74 \times 10^{-7}$ mol dm^{-3}

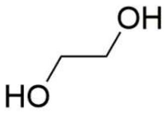
Allow error carried forward from (e)(ii). Answer should be the answer for part (e)(ii) divided by 1.33.

(g) it increases it is constant [✓ it decreases] it is impossible to determine from the graph **1**

(h) **(i)** $H_3C{-}OH$ *Methanol* **1**

Structure or name acceptable for 1 mark

(ii)



Ethane-1,2-diol

or

Ethylene glycol **1**

Structure or name acceptable for 1 mark

(i)

	Tick all that apply
✓	The maximum rate of metabolism is faster for ethanol
	The maximum rate of metabolism is faster for the poisonous alcohol
	The maximum rate of metabolism is the same for both
	A higher concentration of ethanol is needed for the reaction to proceed at half of its maximum rate
✓	A higher concentration of the poisonous alcohol is needed for the reaction to proceed at half of its maximum rate
	The same concentration of ethanol and the poisonous alcohol are needed for the reactions to proceed at half of their maximum rate
	The metabolism of the poisonous alcohol follows a rate law different from that of ethanol

Award 1 mark for each correct tick. If the last box is ticked, minus 1 mark from the overall total for this part. Ticks in other boxes are not negatively marked unless two or three contradictory statements have been ticked, in which case 0 marks are scored for this question. The lowest mark possible for this part is 0. **2**

The maximum rate of metabolism occurs at high alcohol concentration when the enzyme is saturated with substrate. In this case $rate \approx k_{cat}[AD]$ *and the alcohol with the higher* k_{cat} *value is metabolised more quickly.*

When $K_M = [C_2H_5OH]$ *then*

$$rate = \frac{k_{cat}[AD]}{2}$$

and the reaction proceeds at half the maximum rate. Therefore alcohols with a high K_M *value must be present at higher concentration for the reaction to proceed at half of its maximum rate.*

Interestingly, as ethanol is a ‘better’ substrate for alcohol dehydrogenase than either methanol ($K_M = 3.0 \times 10^{-2}$ mol dm^{-3}) *or ethylene glycol* ($K_M = 3.2 \times 10^{-2}$ mol dm^{-3})*, it is often used to treat cases of poisoning with these substances as it is metabolised preferentially by the enzyme.*

Question Total 14