

5. This question is about making “green” jet fuel

(a) $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2 + \text{O}_2$ 1
State symbols not required

(b) (i) General formula for an alkane $\text{C}_n\text{H}_{2n+2}$
 $n \text{ CO} + (2n+1) \text{ H}_2 \rightarrow \text{C}_n\text{H}_{2n+2} + n \text{ H}_2\text{O}$ 1
State symbols not required

(ii) $n = 12, 2n+1 = 25$, therefore ratio of $\text{CO}:\text{H}_2 = 12:25$ 1

(c) (i) $\text{CeO}_{2-\delta} + \delta \text{ CO}_2 \rightarrow \text{CeO}_2 + \delta \text{ CO}$ 1
State symbols not required

(ii) $\text{CeO}_{2-\delta} + \delta \text{ H}_2\text{O} \rightarrow \text{CeO}_2 + \delta \text{ H}_2$ 1
State symbols not required

(d) (i) Number of moles of O atoms evolved = $2 \times 367 \text{ cm}^3 / 24,000 \text{ cm}^3 \text{ mol}^{-1}$
= 0.0306 mol
Number of moles of $\text{CeO}_2 = 127 \text{ g} / 172.12 \text{ g mol}^{-1}$ 2
= 0.738 mol of CeO_2
 $\delta = 0.0306/0.738 = 0.0414$
Award 1 mark for if the factor of 2 has been forgotten, i.e. 0.0207 scores 1 mark.

(ii) $2 \times 367 \text{ cm}^3 = 734 \text{ cm}^3$ 1

(e) (i) $(1.7/2.7) \times 747 \text{ cm}^3 / 24,000 \text{ cm}^3 = 0.0196 \text{ mol of H}_2$ ½
(ii) $(1/2.7) \times 747 \text{ cm}^3 / 24,000 \text{ cm}^3 = 0.0115 \text{ mol of CO}$ ½

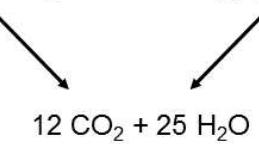
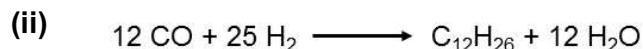
(f) $(26 \times 60 \times 3.6 \times 10^3) \text{ J} + (34 \times 60 \times 0.80 \times 10^3) \text{ J} = 7,248 \text{ kJ}$ 1

(g) (i) $0.0196 \text{ mol} \times -286 \text{ kJ mol}^{-1} + 0.0115 \text{ mol} \times -283 \text{ kJ mol}^{-1}$
= -8.87 kJ 1
Accept if magnitude is correct but minus sign is missing. Allow error carried forward from part (e).

(ii) $8.87 \text{ kJ} / 7248 \text{ kJ} = 0.12\%$ 1
Allow error carried forward from (f) and/or (g)(i).

(h) (i) From $n=7$ to $n=8$, 654 kJ mol^{-1} more heat energy evolved.
 $\Delta_c H^\ominus$ for $n=12 = -5470 - (4 \times 654 \text{ kJ mol}^{-1}) = -8086 \text{ kJ mol}^{-1}$

1



2

$$\begin{aligned} &= (12 \times -283 \text{ kJ mol}^{-1}) + (25 \times -286 \text{ kJ mol}^{-1}) + 8,086 \text{ kJ mol}^{-1} \\ &= -2,460 \text{ kJ mol}^{-1} \end{aligned}$$

1 mark for correct construction of cycle and attempt at calculation with mathematical error. Allow error carried forward from (h)(i).

Question Total 15

Paper Total 75