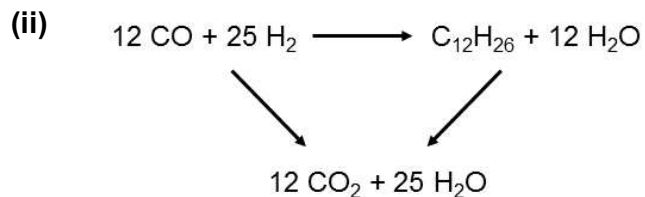


**5. This question is about making “green” jet fuel**

- (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  $\text{C}_n\text{H}_{2n+2}$  1  
 $n \text{ CO} + (2n+1) \text{ H}_2 \rightarrow \text{C}_n\text{H}_{2n+2} + n \text{ H}_2\text{O}$  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 =  $2 \times 367 \text{ cm}^3 / 24,000 \text{ cm}^3 \text{ mol}^{-1}$   
 $= 0.0306 \text{ mol}$   
 Number of moles of  $\text{CeO}_2 = 127 \text{ g} / 172.12 \text{ g mol}^{-1}$  2  
 $= 0.738 \text{ mol of CeO}_2$   
 $\delta = 0.0306 / 0.738 = 0.0414$   
*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)  $(1.7/2.7) \times 747 \text{ cm}^3 / 24,000 \text{ cm}^3 = 0.0196 \text{ mol of H}_2$  1/2
- (ii)  $(1/2.7) \times 747 \text{ cm}^3 / 24,000 \text{ cm}^3 = 0.0115 \text{ mol of CO}$  1/2
- (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)  $0.0196 \text{ mol} \times -286 \text{ kJ mol}^{-1} + 0.0115 \text{ mol} \times -283 \text{ kJ mol}^{-1}$   
 $= -8.87 \text{ kJ}$  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  $n=8$ ,  $654 \text{ kJ mol}^{-1}$  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**