17	Methanol, CH ₃ OH, can be made industrially by the reaction of carbon monoxide with hydrogen, as shown in equilibrium 1 .				
	CO	$(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$	$\Delta H = -91 \text{ kJ mol}^{-1}$	Equilibrium 1	
	(a)	Predict the conditions of pressure and temperature that would give the maximum equilibrium yield of $\mathrm{CH_3OH}$ in equilibrium 1 .			
		Explain your answer.			
				[3]	
	(b)	A catalyst is used in the production	of methanol in equilibrium 1 .		
		State two ways that the use of carmore sustainable and less harmful		to make their processes	
		1			
		2			
				[2]	

(c) Standard entropy values are given below.

Substance	CO(g)	H ₂ (g)	CH ₃ OH(g)
S ^e /JK ⁻¹ mol ⁻¹	198	131	238

	A chemist proposed producing methanol at 525 K using equilibrium 1 .			
	Explain, with a calculation, whether the production of methanol is feasible at 525 K.			
	[5]			
(d)	At 298 K, the free energy change, ΔG , for the production of methanol in equilibrium 1 is $-2.48 \times 10^4 \mathrm{J} \mathrm{mol}^{-1}$.			
	ΔG is linked to $K_{\rm p}$ by the relationship: $\Delta G = -RT \ln K_{\rm p}$.			
	R = gas constant T = temperature in K.			
	Calculate $K_{\rm p}$ for equilibrium 1 at 298 K.			
	Give your answer to 3 significant figures.			

 K_{p} = units [3]

© OCR 2020 Turn over