[AQA A2 Paper 1 2017]

A mixture of carbon monoxide and hydrogen was allowed to reach equilibrium at 600 K. At equilibrium, the mixture contained 2.76 mol of carbon monoxide, 4.51 mol of hydrogen and 0.360 mol of methanol. The total pressure was 630 kPa.

a) Calculate a value for the equilibrium constant, Kp, for this reaction at 600 K and state its units.

① Determine the reaction equation:

$$CO + 2H_2 \rightleftharpoons CH_3OH$$

② Write the expression for Kp:

$$K_p = \frac{p(CH_3OH)}{p(CO) \times p(H_2)^2}$$

③ Calculate the total moles of gas:

$\Rightarrow 2.76 + 4.51 + 0.360$

$= 7.63$ moles

mole fraction = moles / total moles

④ Set up a table to find partial pressures:

	CO	H_2	CH_3OH
moles	2.76	4.51	0.360
mole fraction	0.361...	0.591...	0.0471...
partial pressure (kPa)	228	372	29.7

partial pressure = mole fraction × total pressure

⑤ Sub in partial pressures to find K_p:

$$K_p = \frac{29.7}{228 \times (372)^2}$$

$$= 9.41 \times 10^{-7}$$

⑥ Use the K_p expression to find its units:

$$\frac{\cancel{kPa}}{\cancel{kPa}(kPa)^2} \Rightarrow kPa^{-2}$$