

- 15** The reversible reaction between methanol and ethanoic acid liquids is catalysed by adding a small volume of concentrated sulfuric acid.

Two statements about this reaction are listed.

- 1 The sulfuric acid is a homogeneous catalyst.
- 2 The sulfuric acid lowers the activation energy of the reverse reaction.

Which statements are correct?

- A** both 1 and 2
- B** 1 only
- C** 2 only
- D** neither 1 nor 2

- 14** When two aqueous solutions are mixed, the reaction between them is very slow.

An effective catalyst is added to the mixture without any change in temperature.

Which statement about this catalyst is correct?

- A** It increases the average energy of the reactant particles.
- B** It changes the distribution of energies of the reactant particles.
- C** It allows a greater number of reactant particles to react per unit time.
- D** It increases the number of reactant particles with the most probable energy.

2 Aluminium oxide, Al_2O_3 , and phosphorus(V) oxide, P_4O_{10} , are both used as reagents and catalysts.

(a) The melting point of Al_2O_3 is $2072^\circ C$. The melting point of P_4O_{10} is $340^\circ C$.

Explain the difference in the melting points of these two compounds.

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(b) A 5.00 dm^3 sealed flask contains 0.400 mol of $CO(g)$ and 0.800 mol of $H_2(g)$ and an Al_2O_3 catalyst. The flask is heated to a temperature of $290^\circ C$ and allowed to reach equilibrium. Equation 1 shows the reaction.



The equilibrium constant, K_c , of equation 1 is given.

$$K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$$

(i) State the units of K_c .

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(ii) The equilibrium mixture contains 0.280 mol of $CH_3OH(g)$.

Calculate the value of K_c .

Give your answer to **three** significant figures.

value of K_c = [3]

(iii) State and explain the effect, if any, on the value of K_c when the overall pressure in the sealed flask is increased.

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(c) P_4O_{10} catalyses the reversible reaction of CO with H_2 to form CH_3OH .



P_4O_{10} then acts as a dehydrating agent, causing CH_3OH to form CH_3OCH_3 .

(i) Explain how the presence of a catalyst affects a chemical reaction.

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(ii) Construct an equation for the dehydration reaction of CH_3OH to form CH_3OCH_3 .

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(iii) Write an equation to show the reaction of P_4O_{10} with an excess of water.

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[Total: 11]