Past-paper walk-through

Homogeneous and heterogeneous catalysts ▪ 8.3

eXercise

Questions in this set

- 9701/11 N25 Q15 ▪ 1 mark
- 9701/14 N25 Q14 ▪ 1 mark
- 9701/24 N25 Q2 ▪ 11 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 15

9701/11 N25 ▪ Q15 ▪ 1 mark

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

Question 15

D neither 1 nor 2

Solution 15

Answer: **A**

Why

- The acid and both reactants are liquids, so the catalyst is in the same phase – homogeneous.
- A catalyst offers an alternative pathway, and that same lower-energy pathway serves the reverse reaction too.
- So it lowers the activation energy in both directions; both statements are correct.

Question 14

9701/14 N25 ▪ Q14 ▪ 1 mark

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.

Solution 14

Answer: **C**

Why

- A catalyst adds no energy, so it cannot change the average energy or the distribution – A and B are wrong.
- It lowers the activation energy by offering a different route.
- With a lower barrier, a greater proportion of the particles already present have enough energy to react.

Question 2

9701/24 N25 ▪ Q2 ▪ 11 marks

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 °C. The melting point of P_4O_{10} is 340 °C.

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

Question 2

(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 °C and allowed to reach equilibrium. Equation 1 shows the reaction.

equation 1 $$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

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.

Question 2

(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.

Question 2

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

Question 2

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

equation 1 $\quad CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

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.

Question 2

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

Question 2

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

Question 2

[Total: 11]

Solution 2

(a)

Mark scheme

- M1 Al2O3 is ionic **M2**
- P4O10 is a (simple) molecule **M3**
- ionic bonds are stronger than intermolecular forces
- 3

Solution 2

(b)(i)

Mark scheme

- mol–2 dm6
- 1

Solution 2

(b)(ii)

Mark scheme

- M1 at equilibrium: moles of CO $= 0.120$ AND moles of H2 $= 0.240$ **M2**

$CH_3OH = 0.056$ AND $[CO] = 0.024$ AND $[H_2] = 0.048$ **M3**

- use of Kc with correct evaluation $= 1.01 \times 103$
- 3

Solution 2

(b)(iii)

Mark scheme

- no effect AND Kc is not affected by pressure
- 1

Solution 2

(c)(i)

Mark scheme

- increases rate by providing a different mechanism with a lower activation energy
- 1

(c)(ii)

Mark scheme

- $2CH3OH \rightarrow CH3OCH3 + H2O$
- 1

Solution 2

(c)(iii)

Mark scheme

- P4O10 + 6H2O → 4H3PO4
- 1