

## Mark schemes

**1** A

[1]

**2** (a) M1  $(K_c =) \frac{[\text{CH}_3\text{CH}_2\text{OH}]}{[\text{CH}_2 = \text{CH}_2][\text{H}_2\text{O}]}$

*Penalise missing brackets or use of (); allow correct molecular formulae in correct expression (and allow CH<sub>2</sub>CH<sub>2</sub>); ignore powers shown as 1*

1

M2 mol<sup>-1</sup> dm<sup>3</sup>

*Units must be in simplest form on one line (or dm<sup>3</sup> mol<sup>-1</sup>)*

*Units are consequential on expression in M1 (mol<sup>-1</sup> dm<sup>3</sup> only scores if it is the units for the expression in M1)*

1

(b) M1  $\frac{[\frac{4.40}{2.00}]}{[\frac{0.70}{2.00}] \times [\frac{1.20}{2.00}]}$  or  $\frac{2.20}{0.35 \times 0.60}$  or  $\frac{4.40}{0.70 \times 1.20} \times 2.20$

*10.5 (3sf) scores both marks;*

*Correct value to 2sf (10) or 4sf or more (10.476...) scores 1 mark*

*Volume not used is CE=0*

*If use incorrect expression for K<sub>c</sub> in part (b) then no marks in part (b)*

1

M2 10.5 (must be 3sf)

*If a value from the question is copied incorrectly into the expression, could still score M2 if then used correctly in calculation (AE -1)*

*Ignore units*

1

[4]

**3** C

[1]

**4** C

[1]

**5** (a) (i) Curve drawn from origin with peak clearly lower and to right.

*New curve crosses original once only, finishes above original and does **not** clearly curve up*

**IGNORE** relative areas

1

- (ii) (Relative areas under curves indicate) many (owtte) more molecules with E greater than or equal to  $E_a$  (at higher T) or reverse argument

**ALLOW** 'particles'

**IGNORE** 'atoms'

1

(Large) increase in (number of) successful (owtte) collisions per unit time  
OR 'frequency of successful collisions'

1

- (b) (i) Yield increases

*Yield decreases/stays the same  $CE = 0$*

*If not answered mark on*

1

More moles/molecules (of gas) on left/fewer on right/3 on left 1 on right

1

Equilibrium shifts/moves (to right) to reduce pressure/oppose higher pressure

*No M3 if 'more moles on right' in M2*

**IGNORE** 'favours'

**NOT** just 'oppose the change'

*QoL means that M3 is only awarded if these ideas are clearly linked in one statement*

1

- (ii) Higher T would increase rate but decrease yield/make less methanol

**OR**

Lower T decreases rate but increases yield;

*If no mention of both rate **AND** (idea of) yield max 1*

1

Chosen T is a compromise/balance (between rate and yield) owtte

1

[8]

6

- (a) amount of X =  $0.50 - 0.20 = 0.30$  (mol)

1

amount of Y =  $0.50 - 2 \times 0.20 = 0.10$  (mol)

1

- (b) Axes labelled with values, units and scales that use over half of each axis

*All three of values, units and scales are required for the mark*

1

Curve starts at origin

1

Then flattens at 30 seconds at 0.20 mol

1

- (c) Expression =  $K_c = \frac{[Z]}{[X][Y]^2}$

1

$$[Y]^2 = \frac{[Z]}{[X] K_c}$$

1

$$[Y] = (0.35 / 0.40 \times 2.9)^{0.5} = 0.5493 = 0.55 \text{ (mol dm}^{-3}\text{)}$$

*Answer must be to 2 significant figures*

1

- (d) Darkened / went more orange

1

The equilibrium moved to the right

1

To oppose the increased concentration of Y

1

- (e) The orange colour would fade

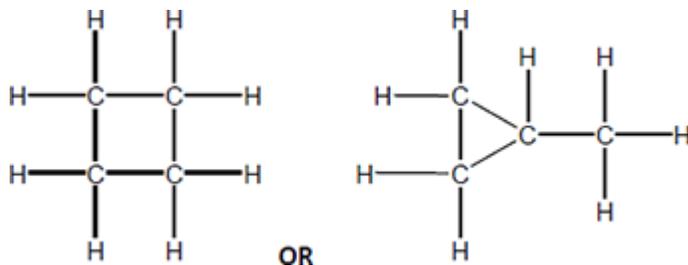
1

[12]

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- (a) Alkenes

1



*Correctly drawn molecule of cyclobutane or methyl cyclopropane, need not be displayed formula*

1

- (b) C<sub>6</sub>H<sub>14</sub> (or correct alkane structure with 6 carbons)

*Allow hexane or any other correctly named alkane with 6 carbons*

1

- (c) Poly(but-2-ene)

1

- (d) High pressure

*Allow pressure ≥ MPa*

*Mention of catalyst loses the mark*

1

- (e) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

### Level 3

All stages are covered and the explanation of each stage is generally correct and virtually complete.

Answer communicates the whole process coherently and shows a logical progression from stage 1 and stage 2 (in either order) to stage 3.

5–6 marks

### Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows progression. Some steps in each stage may be out of order and incomplete.

3–4 marks

### Level 1

Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.

1–2 marks

### Level 0

Insufficient correct chemistry to gain a mark.

0 marks

#### ***Indicative chemistry content***

***Stage 1: consider effect of higher temperature on yield***

*(Or vice versa for lower temperature)*

- *Le Chatelier's principle predicts that equilibrium shifts to oppose any increase in temperature*
- *Exothermic reaction, so equilibrium shifts in endothermic direction / to the left*
- *So a Higher T will reduce yield*

**Stage 2:** consider effect of higher temperature on rate

(Or vice versa for lower temperature)

- At higher temperature, more high energy molecules
- more collisions have  $E > E_a$
- So rate of reaction increases / time to reach equilibrium decreases

**Stage 3:** conclusion

Industrial conditions chosen to achieve (cost-effective) balance of suitable yield at reasonable rate

[11]

8

(a) Stage 1: Moles of acid at equilibrium

Moles of sodium hydroxide in each titration

$$= (3.20 \times 2.00 \times 10^{-1}) / 1000 = 6.40 \times 10^{-4}$$

*Extended response*

1

Sample = 10 cm<sup>3</sup> so moles of acid in 250 cm<sup>3</sup> of equilibrium mixture

$$= 25 \times 6.40 \times 10^{-4} = 1.60 \times 10^{-2}$$

*M2 can only be scored if = answer to M1 × 25*

1

Stage 2: Moles of ester and water formed

$$\text{Moles of acid reacted} = 8.00 \times 10^{-2} - 1.60 \times 10^{-2} = 6.40 \times 10^{-2}$$

= moles ester and water formed

*M3 is  $8.00 \times 10^{-2} - M2$*

1

Stage 3: Moles of ethanol at equilibrium

$$\text{Moles of ethanol remaining} = 1.20 \times 10^{-1} - 6.40 \times 10^{-2} = 5.60 \times 10^{-2}$$

*M4 is  $1.20 \times 10^{-1} - M3$*

1

Stage 4: Calculation of equilibrium constant

$$K_c = [\text{CH}_3\text{COOCH}_2\text{CH}_3] [\text{H}_2\text{O}] / [\text{CH}_3\text{COOH}] [\text{CH}_3\text{CH}_2\text{OH}]$$

1

$$= (6.40 \times 10^{-2})^2 / (1.60 \times 10^{-2})(5.60 \times 10^{-2})$$

$$= 4.5714 = 4.57$$

*M6 is  $M3^2 / M2 \times M4$*

*Answer must be given to 3 significant figures*

1

(b)

	<b>Rough</b>	<b>1</b>	<b>2</b>	<b>3</b>
<b>Final burette reading / cm<sup>3</sup></b>	4.60	8.65	12.85	16.80
<b>Initial burette reading / cm<sup>3</sup></b>	0.10	4.65	8.65	12.85
<b>Titre / cm<sup>3</sup></b>	4.50	4.00	4.20	3.95

1

(c) Mean =  $4.00 + 3.95 / 2 = 3.98$  (cm<sup>3</sup>)

*Allow 3.975 (cm<sup>3</sup>)*

1

Titres 1 and 3 are concordant

*Allow titre 2 is not concordant*

1

(d) Thymol blue

1

(e) Percentage uncertainty:  $0.15 / 3.98 \times 100 = 3.77\%$

*Allow consequential marking on mean titre from 2.3*

1

(f) Use a lower concentration of NaOH

1

So that a larger titre is required (reduces percentage uncertainty in titre)

1

[13]

**9** A

[1]

(a) (i)

**M1**

High (temperature) OR Increase (the temperature)

*If M1 is incorrect CE = 0 for the clip**If M1 is blank, mark on and seek to **credit the correct information in the text*****M2**The (forward) reaction / to the right is endothermic or takes in / absorbs heat  
**OR**The reverse reaction / to the left is exothermic or gives out / releases heat**M3 depends on correct M2 and must refer to temperature / heat***M3 depends on a correct statement for M2*At high temperature, the (position of ) equilibrium shifts / moves left to right to oppose the increase in temperature*For M3, the position of equilibrium shifts / moves**to absorb heat OR**to lower the temperature OR**to cool down the reaction*

3

(ii)

**M1**The reaction gets to equilibrium faster / in less time**OR**Produces a small yield faster / in less time**OR**Increases the rate (of reaction / of attainment of equilibrium)*Mark independently***M2**High pressure leads to **one** of the following

- more particles / molecules in a given volume
- particles / they are closer together
- higher concentration of particles / molecules

**AND**

- more collisions in a given time / increased collision frequency

*Penalise M2 for reference to increased energy of the particles*

2

(iii) **M1** Increase in / more / large(r) / big(ger) surface area / surface sites*Mark independently**For M1 accept "an increase in surface"***M2** increase in / more successful / productive / effective collisions (in a given time) (on the surface of the catalyst / with the nickel)*For M2 not simply "more collisions"**Ignore "the chance or likelihood" of collisions*

2

(b) **M1**  
No effect / None

*If **M1** is incorrect **CE = 0** for the clip*

*If **M1** is blank, mark on and seek to **credit the correct information in the text***

**M2 requires a correct M1**

Equal / same number / amount of moles / molecules / particles on either side of the equation

**OR**

2 moles / molecules / particles on the left and 2 moles / molecules / particles on the right

***M2** depends on a correct statement for **M1***

*In **M2 not** "atoms"*

2

[9]