1. (a) (i) **M1** The peak of the new curve is displaced to the right.

M2 All of the following are required

- The new curve starts at the origin
- The peak of the new curve is lower than the original
- and the new curve only crosses the original curve once
- and an attempt has been made to draw the new curve correctly towards the energy axis but not to touch the original curve
- the new curve must not start to diverge from the original curve

M1 is low demand

M2 is higher demand.

2

(ii) **M1** Increase in the number/proportion of molecules with $E \geq E_a$

OR more molecules have $E \geq E_a$

OR more molecules have sufficient energy to react

M2 More effective/productive/successful collisions

Ignore "molecules have more energy"

Ignore "more energetic collisions"

Ignore "molecules gain activation energy"

Ignore "more collisions"

Accept "particles" for "molecules" but NOT "atoms"

Ignore "chance of collision"; this alone does not gain M2

2

(b) (i) Iron ***OR*** Fe

1

(ii) **M1** Catalysts provide an alternative route/pathway/mechanism

OR

(in this case) surface adsorption/surface reaction occurs.

For M1, not simply "provides a surface" alone

M2 that has a lower activation energy

OR

lowers the activation energy

For M2, the candidate may use a definition of activation energy without referring to the term

2

[7]

2. (a) Gradient (or slope) (or draw a tangent)

1

(b) (i) Curve **X** is lower and starts at origin

1

And levels out at same volume as original curve

1

(ii) Curve **Y** is steeper than original and starts at origin

1

Then levels out at half the volume of the original

1

(c) (i) $2H_2O_2 \rightarrow 2H_2O + O_2$

1

(ii) Speeds up (alters the rate of) a chemical reaction

1

Remains unchanged (or not used up)

1

(iii) Remains unchanged (or not used up or not in the overall reaction equation)

1

Offers alternative reaction route (or acts as an intermediate)

1

[10]

3. (a) (i) acid 0.46

1

alcohol 1.46

1

water 5.54

1

(ii) $K_c = \dfrac{[CH_3CH_2COOCH_2CH_3][H_2O]}{[CH_3CH_2COOH][CH_3CH_2OH]} = \dfrac{[\text{ester}][\text{water}]}{[\text{acid}][\text{alcohol}]}$

penalise ( )
allow molecular formulae or minor slip in formulae

1

(iii) $\frac{(0.54/V)(5.54/V)}{(0.46/V)(1.46/V)}$

Allow without V

Conseq on values in (a)(i)
If values used wrongly
or wrong values inserted
or wrong K_c no marks for calc

1

4.45 or 4.5

Part (a)(iii) for info 0.46 × 1.46 = 0.6716

1

cancel (as equal no of moles on each side of equation)

1

Possible wrong answers

acid	*0.46*	✓	*Gives*
alcohol	*1.46*	✓	*K_c = 3.59*
water	*4.46*	✗	✓✓

acid	*0.46*	✓	*Gives*
alcohol	*1.46*	✓	*K_c = 0.434*
water	*0.54*	✗	✓✓

(b) (i) decrease or be reduced or fewer

1

(ii) decrease or be reduced or less time or faster or quicker

1

(iii) decrease or be reduced

1

[10]

4. no change

1

equal number of gaseous moles on either side

1

both sides affected equally

1

increases

1

equilibrium moves to lower the temperature/oppose the change

1

endothermic reaction favoured /forward reaction is endothermic

1

[6]

5. (a) T_2

(Must be correct to score any marks in this section)

1

Exothermic

1

Reduce T to shift equilibrium to the right
or forward reaction favoured by low T
or K_p increases for low T
or low T favours exothermic reaction

1

(b) Increase

1

None

1

[5]

6. high pressure expensive (due to energy or plant costs)

1

(Rate is) slow (at lower temperatures)

1

[2]

7. D

[1]

8. D

[1]

9. A

[1]

10. C

[1]

11. D

[1]

12. A

[1]

13. C

[1]

14. D

[1]

15. A

[1]

16. C

[1]