M1.(a)   line goes up before it goes down

1

energy given out correctly labelled

1

activation energy labelled correctly

1

(b)   electrostatic force of attraction between shared pair of negatively charged electrons

1

and both positively charged nuclei

1

(c)   bonds formed = 348 +4(412) + 2(276) = 2548 kJ / mol

1

bonds broken − bonds formed = 612 + 4(412) + (Br-Br) − 2548 = 95 kJ / mol

1

Alternative approach without using C-H bonds
For step 1 allow = 348 + 2(276) = 900 kJ / mol
Then for step 2 allow 612 + (Br-Br) − 900 = 95 kJ / mol

193 (kJ / mol)

1

accept (+)193 (kJ / mol) with no working shown for 3 marks

*−193(kJ / mol) scores **2** marks*

allow ecf from step 1 and step 2

(d)   **Level 3 (5–6 marks):**
A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links. A conclusion is reached.

Level 2 (3–4 marks):
An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. A conclusion may be reached but the logic used may not be clear or linked to bond energies.

Level 1 (1–2 marks):
Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.

0 marks:
No relevant content.

Indicative content

Size and strength
- chlorine atoms have fewer electron energy levels / shells
- chlorine atoms form stronger bonds
- Cl–Cl bond stronger then Br–Br
- C–Cl bond stronger that C–Br

Energies required
- more energy required to break bonds with chlorine
- more energy given out when making bonds with chlorine
- overall energy change depends on sizes of energy changes

Conclusions
- if C–Cl bond changes more, then less exothermic
- if C–Cl bond changes more then more exothermic
- can't tell how overall energy change will differ as do not know which changes more.

6

[14]

M2.(a) (i) the products are at a lower energy level than the reactants

accept products have less energy / less energy at the end than the beginning

1

(ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route

accept adsorption or 'increases concentration at the surface'

ignore absorption

1

(that has) <u>lower activation energy</u>

allow weakens bonds

allow idea of increased successful collisions.

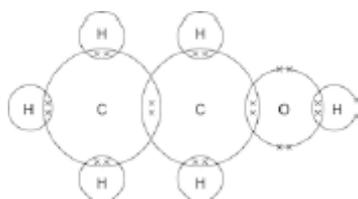*DO NOT ALLOW answers stating catalysts provide energy for M1 and M2*

1

(b) one pair of electrons in each overlap (8 pairs in total)

allow any combination of dots, crosses or other symbols

1

the rest of the diagram correct with four non-bonding electrons on the oxygen giving a total of eight electrons in oxygen outer energy level.

*gains **2** marks*

1

(c) (i) ±3024 (J)

*correct answer with or without working gains **3** marks*

*if the answer is incorrect, award up to **2** marks for the following steps:*

- $\Delta T = 14.4(°C)$
- $50 \times 4.2 \times 14.4$

allow ecf for incorrect ΔT

3

(ii) 0.015(2173913)

*correct answer with or without working gains **3** marks*

if answer is incorrect, allow 1 mark each for any of the following steps up to a max of 2.

- *0.70g*
- *M_r of ethanol = 46*
- *0.70 / 46*

allow ecf in final answer for arithmetical errors

3

    (iii)   ±198 720(J / mole)

        c(i) ÷ c(ii)

        *allow ecf from **(c)(i)** and **(c)(ii)***

        0.015 gives 201600

        0.0152 gives 198947

        0.01522 gives 198686

1

    (d)   (as the molecules get bigger **or** the number of carbon atoms increases) the intermolecular forces

        allow intermolecular bonds

1

(intermolecular forces) increase

        allow more / stronger (intermolecular forces)

1

and therefore require more (heat) energy to overcome

        *breaking covalent bonds or unspecified bonds max **1** mark (M3)*

1

[15]

M3.(a)   31

   1

   (b)   (i)   any **two** from:
   •   incorrect reading of thermometer / temperature
   •   incorrect measurement of volume of acid
   •   incorrect measurement of volume of alkali (burette).

   2

   (ii)   glass is a (heat) conductor **or** polystyrene is a (heat) insulator

   *answer needs to convey idea that heat lost using glass **or** not lost using polystyrene*

   accept answers based on greater thermal capacity of glass (such as "glass absorbs more heat than polystyrene")

   1

   (c)   (i)   temperature increases

   1

   (ii)   no reaction takes place **or** all acid used up **or** potassium hydroxide in excess

   1

   cool / colder potassium hydroxide absorbs energy **or** lowers temperature

   ignore idea of heat energy being lost to surroundings

   1

   (iii)   take more readings

   ignore just "repeat"

   1

   around the turning point **or** between 20 cm³ and 32 cm³

   accept smaller ranges as long as no lower than 20 cm³ and no higher than 32 cm³

   1

   (d)   1.61 **or** 1.6(12903)

   *correct answer with or without working scores **3***
   *if answer incorrect, allow a maximum of **two** from:*
   *moles nitric acid = (2 × 25 / 1000) = 0.05 for **1** mark*
   *moles KOH = (moles nitric acid) = 0.05 for **1** mark*
   concentration KOH = 0.05 / 0.031

   Page 6

answer must be correctly rounded (1.62 is incorrect)

3

(e)   same amount of energy given out

1

which is used to heat a smaller total volume **or** mixture has lower thermal capacity
or
number of moles reacting is the same
but the total volume / thermal capacity is less

> *if no other marks awarded award **1** mark for idea of reacting faster*

1

[14]

M4.(a)   circle round any one (or more) of the covalent bonds

any correct indication of the bond – the line between letters

1

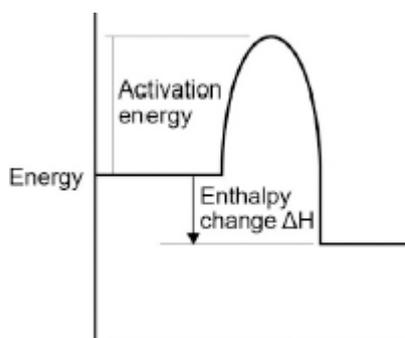(b)   Methane contains atoms of two elements, combined chemically

1

(c)   (i)   activation energy labelled from level of reagents to highest point of curve

ignore arrowheads

1

enthalpy change labelled from reagents to products

*arrowhead **must** go from reagents to products only*

1

(ii)   2 O_2

1

2 H_2O

*if not fully correct, award **1** mark for all formulae correct.*
ignore state symbols

1

(iii)   carbon monoxide is made

1

this combines with the blood / haemoglobin **or** prevents oxygen being carried in the blood / round body **or** kills you **or** is toxic **or** poisonous

dependent on first marking point

1

(iv)   energy is taken in / required to break bonds

accept bond breaking is endothermic

1

energy is given out when bonds are made
accept bond making is exothermic

1

the energy given out is greater than the energy taken in
this mark only awarded if both of previous marks awarded

1

(d)   (i)   energy to break bonds = 1895
calculation with no explanation max = 2

1

energy from making bonds = 1998

1

1895 − 1998 (= −103)
or
energy to break bonds = 656
energy from making bonds = 759
656 − 759 (= −103)
allow:
bonds broken − bonds made =
413 + 243 − 327 − 432 = -103 for 3 marks.

1

(ii)   The C — Br bond is weaker than the C — Cl bond

1

[15]