GCSE Chemistry

Bond Energy Calculations

Mark Scheme

Time available: 59 minutes
Marks available: 57 marks

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1.

(a) water vapour

allow steam

allow gaseous water

1

(b) 75 (cm^3)

1

(c) product level below reactants

ignore labelling of products

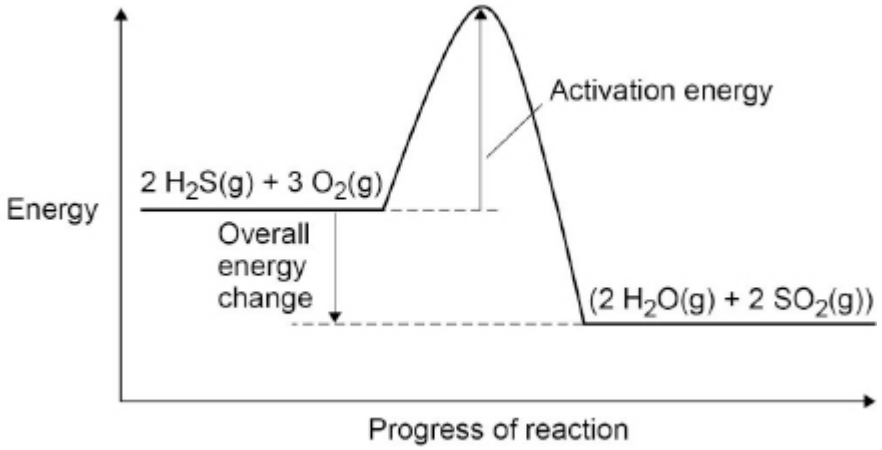
1

activation energy drawn and labelled

1

overall energy change drawn and labelled

if endothermic profile drawn allow corresponding overall energy change



scores **3** marks

1

(d) (bonds broken = 4(364) + 3(498) =) 2950

1

(bonds formed = 2950 + 1034 =) 3984

allow correct use of incorrectly calculated values of bonds broken

1

4**X** + 4(464) = 3984

allow correct use of incorrectly calculated values of bonds formed

1

4**X** = **(**3984 – 1856 =) 2128

1

X = 532 (kJ/mol)

1

alternative approach:

(bonds broken = 4(364) + 3(498) =) 2950 (1)

(bonds formed = 4(464) + 4**X** =) 1856 + 4**X** (1)

(1856 + 4**X**) – 2950 = 1034 (1)

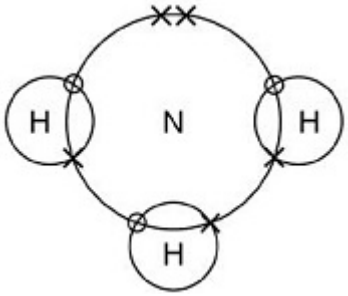
allow correct use of incorrectly calculated values of bonds broken and/or bonds formed

4**X** = (1034 + 2950 – 1856 =) 2128 (1)

X = 532 (kJ/mol) (1)

[10]

2. (a)



*scores **2** marks*

allow dots, crosses, circles or $e^{(-)}$ for electrons

1 bonding pair of electrons in each overlap

1

2 non-bonding electrons on nitrogen

*do **not** accept non-bonding electrons on hydrogen*

ignore inner shell electrons drawn on nitrogen

1

(b) does not show the shape
or
only two-dimensional
allow is not three-dimensional

1

(c) (ammonia has) small molecules
allow (ammonia has) a simple molecular (structure)

1

(ammonia has) weak intermolecular forces
allow (ammonia has) weak intermolecular bonds
*do **not** accept weak covalent bonds*

1

(so) little energy is needed to overcome the intermolecular forces
allow (so) little energy is needed to break the intermolecular bonds
allow (so) little energy is needed to separate the molecules
*do **not** accept references to breaking covalent bonds*

1

(d) Cr_2O_3

1

(e)
*an answer of (-)1272 (kJ) scores **3** marks*

(for bonds broken)
((12 x 391) + (3 x 498) =) 6186

1

(for bonds made)
((2 x 945) + (12 x 464) =) 7458

1

(overall energy change = 6186-7458 =) (-)1272 (kJ)
allow correct calculation using incorrectly calculated values from step 1 and/or step 2

1

(f)

allow ecf from part (e)

7458 (kJ) (released in making bonds) is greater than 6186 (kJ) (used in breaking bonds)
or
the products have 1272 (kJ) less energy than the reactants

allow the (overall) energy change is -1272 (kJ)

1

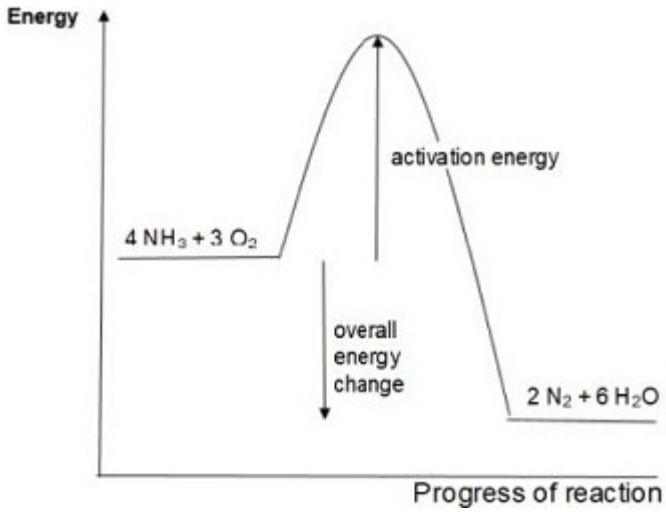
(so) energy is released (to the surroundings)

dependent on MP1 being awarded
allow (so) heat is released (to the surroundings)

*if no values given, allow **1** mark for more energy released in making bonds than used in breaking bonds*

1

(g)



*scores **2** marks*

allow discontinuous lines
ignore arrow heads

activation energy labelled

1

(overall) energy change labelled

1

[14]

3. (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

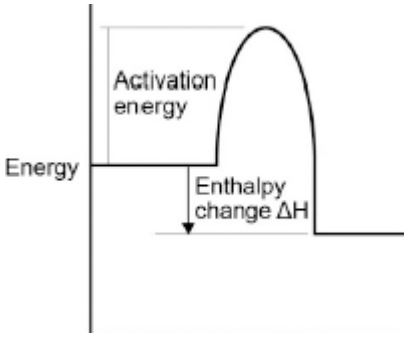
1

(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 bon

1

[15]

4. (a) products are at a lower energy level than reactants

if candidate has drawn a profile for an endothermic reaction penalise first marking point only

1

activation energy correctly drawn and labelled

1

ΔH correctly labelled

1

(b) (i) –93 (kJ per mole)

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

*allow **2** marks for +93 kJ per mole*

*if any other answer is seen award up to **2** marks for any two of the steps below:*

*bonds broken (614 + 193) = 807 (kJ) **or** (614 + 193 + (4 × 413)) = 2459(kJ)*

*bonds formed (348 + 276 + 276) = 900(kJ) **or** 348 + (2 × 276) + (4 × 413) = 2552(kJ)*

bonds broken – bonds formed

allow ecf for arithmetical errors

3

(ii) more energy is released when the bonds (in the products) are formed

1

than is needed to break the bonds (in the reactants)

*if no other marks gained, allow **1** mark for energy released for bond making **and** energy used for bond breaking*

1

[8]

5. (a) neutron(s)

answers can be in either order

1

proton(s)

1

(b) same number (17) protons **or** same number electrons

if candidate chooses to quote numbers, they must be correct

1

different numbers of neutrons (^{35}Cl has 18 and ^{37}Cl has 20)

1

(c) (i) −184kJ / mol

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

*allow **2** marks for 184 kJ / mol*

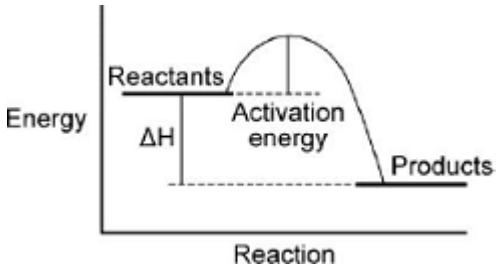
*If answer incorrect award up to **2** marks for any two of the steps below:*

- *bonds broken: (436 + 242) = 678 (kJ)*
- *bonds formed: (2 × 431) = 862 (kJ)*
- *bonds broken − bonds formed*

allow ecf for arithmetical errors

3

(ii)



the reactants and the products at the correct level

ignore labels on the axes

1

ΔH correctly labelled

allow −538 if in correct place

1

E_a correctly labelled

*correctly labelled endothermic reaction gains max. **2** marks*

1

[10]