A-Level Chemistry

Enthalpy Change

Mark Scheme

Time available: 58 minutes
Marks available: 53 marks

1. (a) Heat (energy) change at constant pressure

allow transfer for change

1

(b) **M1** correctly showing how many of which types of bonds are broken / made

(broken) 2(C–C) + 8(C–H) + 5(O=O) *(5776 + 2(C-C))*

***M1** is for identifying the number and type of bonds broken / made (does not have to explicit if they are broken or made, it is just which bonds and the number of each)*

(made) 6(C=O) + 8(O–H) *(8162)*

1

M2 including 4(41) for vaporisation of water

***M2** is for including 4(41) in some way in the calculation*

1

M3 2(C–C)

= 6(C=O) + 8(O–H) + 4(41) – 2046 – 8(C–H) – 5(O=O)

= 6(743) + 8(463) + 4(41) – 2046 – 8(412) – 5(496)

= 504

***M3** is for calculating total for C-C bonds; allow 340 for 2 marks for omitting 4(41)*

1

M4 (C–C) = $\frac{\text{M3}}{2}$ = 252 (kJ mol^{-1})

***M4** is for dividing their **M3** by two (ie allow ECF from **M3** to **M4**; ECF for 3(C-C) to divide their **M3** by three)*

252 scores 4

170 scores 3 (omits vaporisation of water)

168 scores 3 (3 C-C bonds)

113 scores 2 (3 C-C bonds & omits vaporisation of water)

88 scores 3 (vaporisation of water on wrong side)

Ignore units

1

(c) Oxygen / O_2 is the only substance that has O=O bond

1

[6]

2. (a) Amount of hexane = $\frac{2}{86}$ = 0.0233 mol

1

q = 4154 x 0.0233 (= 96.6 - 96.8 kJ)

ecf = M1 x 4154

1

$C_{cal} = \frac{96.6}{12.4}$ = 7.79 - 7.81 (kJ K^{-1})

ecf = M2/12.4
If no other marks awarded, allow one mark for 4154/12.4 = 335

1

(b) $q = C_{cal}\Delta T$ = 7.79 x 12.2 = 95.0 kJ

Ecf for (a) x 12.2
If candidate converted 12.4 into kelvin in (a), ignore conversion to kelvin in (b)

1

(amount of octane = $\frac{2}{114}$ = 0.0175 mol)

heat change per mole = $\frac{95.0}{0.0175}$ = 5417 kJ mol^{-1}

Allow 5420 kJ mol^{-1}
Using the value given:
6.52 x 12.2 = 79.54(4)
79.54/0.0175 = 4545

1

(c) pressure not constant in bomb calorimeter

Allow enthalpy change requires constant pressure

1

(d) $100 \times \frac{0.2}{12.2}$ = 1.64%

Allow 1.6%
Allow 2% if working shown
NOT 2.0%

1

use bigger mass of fuel (so ΔT greater)

Allow octane or hexane as the fuel
Allow more / greater volume of fuel

1

[8]

3. (a) q = 500 × 4.18 × 40

Do not penalise precision.

1

= 83600 J

Accept this answer only.

Ignore conversion to 83.6 kJ if 83600 J shown.

Unit not required but penalise if wrong unit given.

Ignore the sign of the heat change.

An answer of 83.6 with no working scores one mark only.

An answer of 83600 with no working scores both marks.

1

(b) Moles (= 83.6 / 51.2) = 1.63

Using 77400 alternative gives 1.51 mol

Allow (a) in kJ / 51.2

Do not penalise precision.

1

Mass = 1.63 × 40(.0) = 65.2 (g)

Allow 65.3 (g)

Using 77400 alternative gives 60.4 to 60.5

Allow consequential answer on M1.

1 mark for M_r (shown, not implied) and 1 for calculation.

Do not penalise precision.

2

(c) Molarity = 1.63 / 0.500 = 3.26 mol dm–3

Allow (b) M1 × 2

Using 1.51 gives 3.02

1

(d) Container splitting <u>and</u> releasing irritant / corrosive chemicals

*Must have reference to both aspects; splitting or leaking (can be implied such as contact with body / hands) **and** hazardous chemicals.*

Allow 'burns skin / hands' as covering both points

Ignore any reference to 'harmful'.

Do not allow 'toxic'.

1

(e) (i) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Allow fractions / multiples in equation.

Ignore state symbols.

1

(ii) Iron powder particle size could be increased / surface area lessened

Decrease in particle size, chemical error = 0 / 3

Change in oxygen, chemical error = 0 / 3

1

Not all the iron reacts / less reaction / not all energy released / slower release of energy / lower rate of reaction

Mark points M2 and M3 independently.

1

Correct consequence of M2

An appropriate consequence, for example

- *too slow to warm the pouch effectively*
- *lower temperature reached*
- *waste of materials*

1

(f) (i) Conserves resources / fewer disposal problems / less use of landfill / fewer waste products

Must give a specific point.

Do not allow 'does not need to be thrown away' without qualification.

Do not accept 'no waste'.

1

(ii) Heat to / or above 80 °C (to allow thiosulfate to redissolve)

Accept 'heat in boiling water'.

If steps are transposed, max 1 mark.

1

Allow to cool before using again

Reference to crystallisation here loses this mark.

1

[14]

4. (a) ΔH = Σ(bonds broken) – Σ(bonds formed) (or cycle)

1

= +146 – 496/2 (or 2 × 463 + 146 –(2 × 463 + 496/2)

1

= – 102 (kJ mol^{-1}) **(1)**

*(accept no units, wrong units loses a mark; +102 scores **(1)** only)*

1

(b) $C(s) + 2H_2(g) \rightarrow CH_4(g)$ equation **(1)** Correct state symbols **(1)**

2

(c) (i) Macromolecular

(accept giant molecule or carbon has many (4) bonds)

1

(ii) $\Delta H = \Sigma\Delta H_f$(products) – $\Sigma\Delta H_f$(reactants) (or cycle)

1

= 715 + 4 × 218 – (–74.9)

1

= 1662 (kJ mol^{-1})

(accept no units, wrong units loses one mark,
allow 1660 to 1663, –1662 scores one mark only)

1

(iii) 1662/4 = 415.5

(mark is for divide by four, allow if answer to (c)(ii) is wrong)

1

[10]

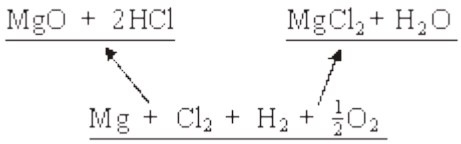
5. (a) (i) enthalpy (or heat or heat energy) <u>change</u> when
<u>1 mol</u> of a substance **(1)** (QL mark) is formed from its elements **(1)**
<u>all</u> substances in their standard states **(1) (**or normal states at 298K, 100 kPa or std condits)

not *STP, NTP*

3

(b) <u>enthalpy change</u> (or <u>enthalpy of reaction</u>) is independent of route **(1)**

$\Delta H = \Sigma\Delta H_f^{\ominus}$ prods - $\Sigma\Delta H_f^{\ominus}$ reactants (or cycle) **(1)**
minimum correct cycle is:



ΔH = -642 – 286 – (–602 + 2 × –92) **(1)**
= –142 (kJ mol^{-1}) **(1)**

penalise this mark for wrong units
+142 scores 1 mark out of the last three

4

(c) ΔH = *mcT* **(1)** (or *mcΔT*)

= 50 × 4.2 × 32 = 6720 J = 6.72J **(1)**

mark is for 6720 J or 6.72 kJ

moles HCl = $\frac{\text{vol}}{1000}$ × conc = $\frac{50}{1000}$ × 3 **(1)**

= 0.15 **(1)**

if error here mark on conseq.

Therefore moles of MgO reacted = moles HCl/2 **(1)**
(mark is for/2, CE if not/2)
= 0.15/2 = 0.075

Therefore Δ*H* = 6.72/0.075 **(1)**

= –90 kJ (mol^{-1})

kJ must be given, allow 89 to 91

*value **(1)***

*sign **(1)**; this mark can be given despite CE for /2*

8

Note various combinations of answers to part (c) score as follows:

–89 to –91 kJ **(8)** (or –89000 to 91000J)

*no units **(7)***

+89 to +91 kJ **(7)** (or + 89000 to +91000J)

*no units **(6)***

–44 to –46 kJ **(5)** (or -44000 to -46000J)

*no units **(4)** if units after 6.72 or 6720 (5)*

+44 to +46 kJ **(4)** (or +44000 to + 46000)

if no units and
*if no units after 6.72 or 6720 **(3)***
*otherwise check, could be **(4)***

[15]