M1. (a) enthalpy (or energy) to break (or dissociate) a bond;

1

averaged over different molecules (environments);

1

enthalpy (or heat energy) change when one mole of a compound;

1

is formed from its elements;

1

in their standard states;

1

(b) enthalpy change = Σ(bonds broken) – Σ(bonds formed) or cycle;

1

= 4 × 388 +163 + 2 × 146 + 4 × 463 – (944 + 8 × 463);
(or similar)

1

= –789;
(+ 789 scores 1 only)

1

(c) (i) zero;

1

(ii) *AH* = Σ (enthalpies of formation of products)
–Σ (enthalpies of formation of reactants)

1

= 4 × –242-(75 + 2 × –133);

1

= –777;
(+ 777 scores one only)

1

(d) mean bond enthalpies are not exact
(or indication that actual values are different from real values)

1

[13]

M2.C

[1]

M3. (a) Heat energy change **(1)**

Not energy on its own

measured at constant pressure **(1)**

Mark separately, ignore constant temperature statements

2

(b) (i) Enthalpy change when 1 mol of a substance (or compound / product) **(1)** is formed from its constituent elements **(1)** in their standard states **(1)** under standard conditions **(1)**

Mark separately

(ii) $2Na(s) + S(s) + 2O_2(g) \rightarrow Na_2SO_4(s)$

Balanced (1) State symbols (1), but only if all species are correct

Allow $\frac{1}{8} S_8(s)$

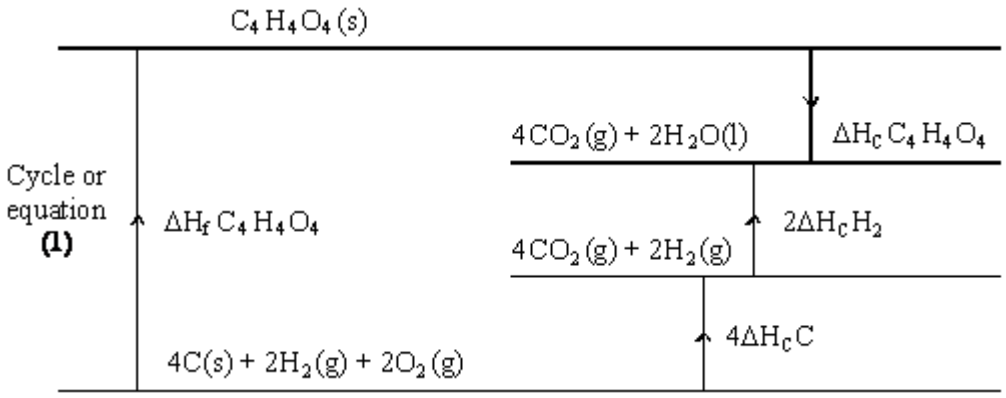
5

(c) Enthalpy change is independent of reaction route **(1)**

Penalise incorrect additional statements

1

(d)



$-1356 + (2 \times 285.8) + (4 \times 393.5) + \Delta H_fC_4H_4O_4 = 0$

$\Delta H_f = -789.6$ kJ mol^{-1}

If answer is incorrect:

Score +789.6 two marks

Score (× 1); (× 2) and (× 4) for species - one mark

If an incorrect negative answer given check for AE for loss of one mark

3

[11]

M4. (a) They are elements **(1)**

Ignore irrelevant comments

1

(b) Enthalpy <u>change</u> **(1)**

or heat energy change or heat change or ΔH or any named enthalpy change C.E. if change not mentioned

Independent of route **(1)**

OR depends on initial and final <u>states</u>
Only give second mark if first mark awarded except allow if energy used instead of enthalpy

2

(c) $\Delta H = \Sigma \Delta H_f^{\ominus}$(products) - $\Sigma \Delta H_f^{\ominus}$(reactants) **(1) (Or a cycle)**
= 2 × –242 + ½ × –394 – (–365) **(1) (also implies first mark)**
= -316 kJ mol^{-1} **(1)**

3

Ignore no units penalise wrong units
+316 scores 1/3

[6]

M5. (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) → 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]

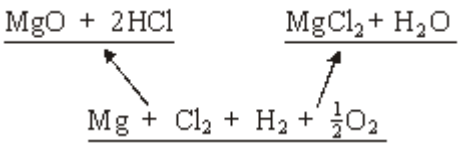
M6. (a) (i) enthalpy (or heat or heat energy) change when
1 mol of a substance **(1)** (QL mark) is formed from its elements **(1)**
all substances in their standard states **(1) (**or normal states at 298K, 100 kPa or std condits)

***not** STP, NTP*

3

(b) enthalpy change (or enthalpy of reaction) 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) $\Delta H = mcT$ **(1)** (or $mc\Delta T$)
= 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 ΔH = 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*

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]