Energetics Test ANSWERS

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

averaged over different molecules (environments); |

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

is formed from its elements; |

in their standard states; |

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

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

= –789;
       (+ 789 scores 1 only) |

(c)   (i)   zero; |

     (ii) ΔH = Σ (enthalpies of formation of products)
              –Σ (enthalpies of formation of reactants) |

           = 4 × –242 -(75 + 2 × –133); |

           = –777;
               (+ 777 scores one only) |

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

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2. (a) <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:

$$\underline{MgO\ +\ 2HCl} \qquad \underline{MgCl_2 + H_2O}$$
$$\underline{Mg\ +\ Cl_2\ +\ H_2\ +\ \tfrac{1}{2}O_2}$$
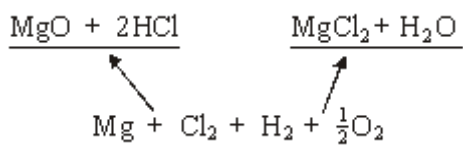
ΔH = -642 – 286 – (–602 + 2 × –92) **(1)**
    = –142 (kJ mol^{-1}) **(1)**

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

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(b) $\Delta H = mcT$ **(1)**   (or $mc\Delta T$)
     = 50 × 4.2 × 32 = 6720 J = 6.72kJ **(1)**

mark is for 6720 J or 6.72 kJ

moles HCl = $\dfrac{vol}{1000}$ × conc = $\dfrac{50}{1000}$ × 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

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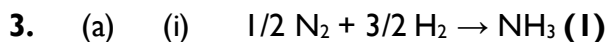   *no units* **(4)** *if units after 6.72 or 6720 (5)*

+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)**

[12]

3.   (a)   (i) $1/2 N_2 + 3/2 H_2 \rightarrow NH_3$ **(1)**

> *Ignore s s*

(ii) $\Delta H = (\Sigma)$bonds broken $- (\Sigma)$bonds formed **(1)**
   $= 1/2 \times 944 + 3/2 \times 436 - 3 \times 388$ **(1)**
   $= -38 \text{ kJ mol}^{-1}$ **(1)**

> *Ignore no units, penalise wrong units*
> *Score 2/3 for -76*
> *1/3 for +38*
> *Allow 1/3 for +76*

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(b)   4 (C–H) + (C=C) + (H–H) – (6 (C–H) + (C–C)) = –136 **(1)**
OR (C=C) + (H–H) – ((C–C) + 2 (C–H)) = –136
2 (C–H) = 836 **(1)**
(C–H) = 418 (kJ mol^{-1}) **(1)**

> *Note: allow (1) for –836*
> *another (1) for –418*

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[7]

4.   (a) $C_3H_6O + 4O_2 \rightarrow 3CO_2 + 3H_2O$ **(1)** (or
multiple)   1
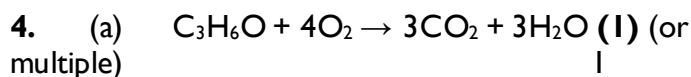
(b)   (i) $\dfrac{1.45}{58}$ **(1)** = 0.0250 **(1)**

> *allow 0.025*
> *allow conseq on wrong M_r*

1.45/100, CE; $\dfrac{1.45}{58.1}$ C.E.

(ii)   heat released = $mc\Delta T$
   $= 100 \times 4.18 \times 58.1$ **(1)**

> *if 1.45 used in place of 100 CE = 0*

   = 24300 J **(1)** (or 24.3kJ)

> *allow 24200 to 24300*
> *ignore decimal places*
> *units tied to answer*
> *If use 0.1 × 4.18 × 51.8 allow ½ for 24.3 with no*
> *units*

(iii) $\dfrac{24.3}{0.0250}$ = −972 (kJ mol^{-1}) **(1)**

    allow −968 to −973
    allow +972
    allow conseq
    allow no units
    penalise wrong units

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(c) (i) Heat loss **(1)** or energy loss

    do not allow incomplete combustion

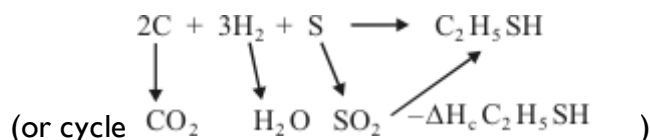(ii) *Difference*: more negative **(1)** (or more exothermic)
    QoL mark

    Explanation: heat (*or energy*) released when water vapour condenses **(1)**
or heat/energy required to vaporise water
or water molecules have more energy in the gaseous state

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(d) $\Delta H = \Sigma \Delta H_{reactants} - \Sigma \Delta H_{products}$ **(1)**

(or cycle)

    = (2 × −394) + (3 × −286) + (−297) − (−1170) **(1)**
    = −773 **(1)**

    ignore units even if wrong
    Allow 1/3 for +773

3

[12]

5.   D

[1]

6.   D

[1]

7.   B

[1]

8.   C

[1]

9.   A

[1]

10.   A

[1]