M1.   (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,
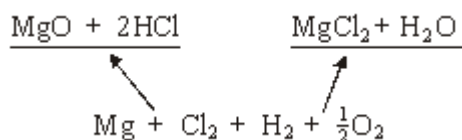   100 kPa or std condits)

          ***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 = $\dfrac{vol}{1000}$ × 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 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]

M2.   (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 = mcΔT
        = 100 × 4.18 × 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

            5
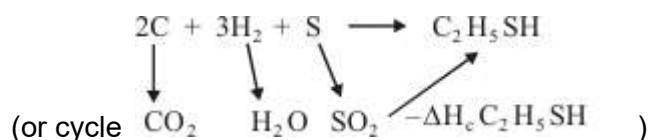
(c)   (i)   Heat loss **(1)** or energy loss

               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

            3

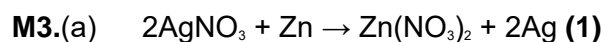(d) $\Delta H = \Sigma \Delta H_{reactants} - \Sigma \Delta H_{products}$ **(1)**

$$2C + 3H_2 + S \longrightarrow C_2H_5SH$$

(or cycle $CO_2 \quad H_2O \quad SO_2 \quad -\Delta H_c C_2H_5SH$)

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

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

            3

                 [12]

M3.(a) $2AgNO_3 + Zn \rightarrow Zn(NO_3)_2 + 2Ag$ **(1)**

               Accept an ionic equation i.e.$2Ag^+ + Zn \rightarrow 2Ag + Zn^{2+}$

(b)   Moles = mv / 1000 **(1) =** 0.20 × 50/1000 = 1.00 × 10⁻²

2

(c)   Heat energy change = mCΔT **(1)** = 50 × 418 × 3.2 J

= 669 J (Ignore signs) **(1)**

Allow 668, 67.0   0.67kJ

Penalise wrong units if given

2

(d) $\dfrac{2 \times 669}{1 \times 10^{-2}}$ = 134 kJ mol⁻¹

Mark one : 2 × (answer to (c))

Mark two : Dividing by answers to (b)

Allow 133 – 134

Penalise incorrect units

Mark conseq to equation in (a) for full marks, also to that in (c)

If No working is shown and answer is incorrect zero

2

(e)   Incomplete reaction or Heat loss **(1)**

1

[8]