M1. (a) (i) **M1** The enthalpy change / heat change at constant pressure when 1 mol of a compound / substance / product

1

M2 Is formed from its (constituent) elements

1

M3 With all reactants and products / all substances in standard states

OR

All reactants and products / all substances in normal states under standard conditions / 100 kPa / 1 bar and specified T / 298 K

Ignore reference to 1 atmosphere

1

(ii) By definition

OR

Because they are elements

1

(iii) **M1** $\Delta H_r = \Sigma\Delta H_f$ **(products)** – $\Sigma\Delta H_f$**(reactants)**

1

M2 = –1669 – 3(–558)

(This also scores M1)

1

M3 = **(+) 5** (kJ mol^{-1})

Correct answer gains full marks.

Assume the value is positive unless specifically stated as negative.

Credit 1 mark if – 5 (kJ mol^{-1}).

For other incorrect or incomplete answers, proceed as follows:

- *check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (M1 and M2)*
- *If no AE, check for a correct method; this requires either a correct cycle with 3BaO OR a clear statement of M1 which could be in words and scores only M1*

1

(b) (i) *One from*

- Aluminium is expensive (to extract *OR* due to electrolysis)

- High energy cost
- The cost of heating strongly

This requires a clear statement about cost

1

(ii) *One from*

- increase collision frequency
- OR more collisions
- OR more chance of colliding

The answer MUST refer to more collisions.
Ignore "more available to collide"

1

(c) (i) $Ba + \mathbf{2}H_2O \rightarrow Ba(OH)_2 + H_2$

Ignore state symbols
Allow multiples and correct ionic equations

1

(ii) **M1** $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$
(or the ions together)

Allow crossed out Na^+ ions, but penalise if not crossed out

1

M2 White precipitate / white solid

Ignore state symbols
Ignore "milky"

1

(iii) **M1** Barium meal or (internal) X-ray or to block X-rays

1

M2 $BaSO_4$ / barium sulfate is insoluble (and therefore not toxic)

Accept a correct reference to M1 written in the explanation in M2, unless contradictory.

For M2 NOT barium ions
NOT barium
NOT barium meal and NOT "It".

Ignore radio-tracing.

1

[14]

M2. (a) The enthalpy change when 1 mol of a compound **1**

is completely burnt in oxygen **1**

under standard conditions, or 298K and 100kPA **1**

(b) (i) $C_2H_6 + 3½O_2 \rightarrow 2CO_2 + 3H_2O$ **1**

(ii) $\Delta H = 2 \times \Delta H_f^{\ominus} (CO_2) + 3 \times \Delta H_f^{\ominus} (H_2O) - \Delta H_f^{\ominus} (C_2H_6)$ **1**

$= – 788 – 858 – (–85)$ **1**

$= – 1561$ kJ mol^{-1} **1**

(c) moles methane = $\frac{0.10}{16} = 6.25 \times 10^{-3}$ **1**

kJ evolved = $6.25 \times 10^{-3} \times 890 = 5.56$ **1**

5.56×10^3 joules = $(mc)\Delta T$ **1**

$\Delta T = \frac{5.56 \times 10^3}{120} = 46.4$ K **1**

[11]

M3. (a) enthalpy change/ heat energy change when 1 mol of a substance **1**

is completely burned in oxygen

1

at 298K and 100 kPa or standard conditions

1

(not 1atm)

(b) $\Delta H = \sum$ bonds broken – $\sum$ bonds formed

1

= (6 × 412) + 612 +348 + (4.5 × 496) – ((6 × 743) + (6 × 463))

1

= – 1572 kJ mol^{-1}

1

(c) by definition ΔH_f is formation from an element

1

(d) $\Delta H_c = \sum \Delta H_f$ products -$\sum \Delta H_f$ reactants or cycle

1

= (3 × – 394) + (3 × –242) – (+20)

1

= − 1928 kJ mol^{-1}

1

(e) bond enthalpies are mean/average values

1

from a range of compounds

1

[12]

M4.(a) Enthalpy change when 1 mol of compound (1)

Is formed from it's elements (1)

All substances in their standard state (1)

3

(b) $\Delta H = \Sigma \Delta H^{\ominus}_c$ (reactants) – $\Sigma \Delta H^{\ominus}_c$ (products) (1)

= $(7x - 394) + (4x - 286) - (-3909)$ (1)

= + 7 kJmol^{-1} (1)

3

(c) Heat change = m c ΔT (1)

= 250 × 4.18 × 60 = 62700J = 62.7kJ (1)

Moles C_7H_8 = 2.5 /92 = 0.0272 (1)

ΔH = 62.7 / 0.0272 = – 2307 kJ mol^{-1} (1)

(allow –2300 to –2323)

4

(d) Mass of water heated = 25 + 50 = 75g
Temp rise = 26.5 – 18 = 8.5 °C

*both for **(1)** mark*

Heat change = 75 × 4.18 × 8.5 = 2665 J = 2.665 kJ (1)

Moles HCl = 0.05 (1)

ΔH = – 2.665 / 0.05 = –53.3 kJmol^{-1} (1)

(allow –53 to –54)

4

(e) Less heat loss (1)

1

[15]