M1. (a) (i) ΔH atomisation/sublimation of magnesium

1

(ii) Bond/dissociation enthalpy of Cl-Cl

OR 2 × *H* atomisation of chlorine

1

(iii) Second ionisation enthalpy of magnesium

1

(iv) 2 × electron affinity of chlorine

1

(v) Lattice formation enthalpy of $MgCl_2$

1

(b) Equation $2MgCl(s) \rightarrow MgCl_2(s) + Mg(s)$

State symbols not required but penalise if incorrect

1

Calculation ΔH reaction = $\Sigma \Delta H_f$ products – $\Sigma \Delta H_f$ reactants

1

= – 653 – (2 × –133)

1

= – 427 ($kJmol^{-1}$)

Allow +427 to score (1) mark

Other answers; award (1) for a correct ΔH reaction expression

1

(c) ΔH soln $MgCl_2$ = – ΔH Lat.form. + ΔH hyd.Mg^{2+} + 2ΔH hyd.Cl^-

1

or cycle

= 2502 – 1920 – (2 × 364)

1

= – 146 ($kJmol^{-1}$)

Allow + 146 to score (1) mark

Other answers; award (1) for a correct ΔH soln $MgCl_2$ expression/cycle

1

[12]

M2.A

[1]

M3. (a) *M1* $K_p = (_PY)^3 . (_PZ)^2 / (_PW)^2 . (_PX)$ *NB [ ] wrong*

1

M2 temperature

1

M3 increase

1

M4 particles have more energy or greater velocity/speed

1

M5 more collisions with $E > E_a$ or more successful collisions

1

M6 Reaction exothermic or converse

1

M7 Equilibrium moves in the left

1

Marks for other answers

Increase in pressure or concentration	*allow M1, M5, M6*	*Max 3*
Addition of a catalyst;	*allow M1, M5, M6*	*Max 3*
Decrease in temperature;	*allow M1, M2, M6*	*Max 3*
Two or more changes made;	*allow M1, M6*	*Max 2*

(b) (i) Advantage; reaction goes to completion, not reversible or faster

1

Disadvantage; reaction vigorous/dangerous

(exothermic must be qualified)

or HCl(g) evolved/toxic
or CH_3COCl expensive

NB Allow converse answers
Do not allow reactions with other reagents e.g. water or ease of separation

1

(ii) $\Delta S = \Sigma S$ products – ΣS reactants

1

□□□□□□□□ $\Delta S = (259 + 187) – (201 + 161)$

1

□□□□□□□□ $\Delta S = 84$ ($JK^{-1}\ mol^{-1}$) *(Ignore units)*

*Allow – 84 to score **(1)** mark*

1

□□□□□□□□ $\Delta G = \Delta H – T\Delta S$

1

$= – 21.6 – 298 \times 84/1000$
$= – 46.6$ kJ mol^{-1} or – 46 600 J mol^{-1}

1

*Allow **(2)** for – 46.6 without units*
(Mark ΔG consequentially to incorrect ΔS)
(e.g. ΔS = –84 gives ΔG = +3.4 kJ mol^{-1})

1

[15]

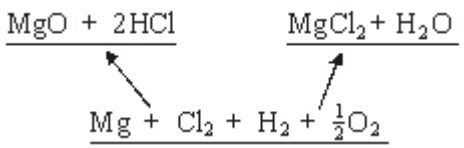
M4. (a) (i) enthalpy (or heat or heat energy) change when
1 mol of a substance **(1)** (QL mark) is formed from its elements **(1)**
all substances in their standard states **(1) (**or normal states at 298K, 100 kPa or std condits)

***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*

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]

M5. (a) *Standard enthalpy change, $\Delta H^{\ominus}$*: $\Delta H_R = \Sigma\Delta H_{f\text{products}} - \Sigma\Delta H_{f\text{reactants}}$ **(1)**
or cycle

$\Delta H_R = (0 + [2 \times -242]) - (4 \times -92)$ **(1)**
$= -484 + 368$
$= -116$ (kJ mol^{-1})
Allow max 1 for +116

Standard entropy change, $\Delta S^{\ominus}$: $\Delta S = \Sigma\Delta H_{f\text{ products}} - \Sigma\Delta H_{f\text{ reactants}}$

$\Delta S = ([2 \times 223] + [2 \times 189]) - (205 + [4 \times 187])$ **(1)**

$= 824 - 953$

$= -129$ (J K^{-1} mol^{-1})
allow max one for +129

6

(b) (i) *Effect*: Equilibrium displaced to right / to products **(1)**
Explanation: Reaction is endothermic **(1)**
Constraint reduced **(1)**
mark separately

(ii) Feasible when $\Delta G \leq 0$ **(1)**

$\Delta G = \Delta H - T\Delta S$ **(1)**

$T = \Delta H/\Delta S = 208 \times 1000$ **(1)** / 253

$= 822$ K **(1)**

7

[13]

M6. D

[1]

M7. C

[1]