M1.(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) $\Delta H = \Sigma\Delta H^{e}_{c}$ (reactants) – $\Sigma\Delta H^{e}_{c}$ (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]

M2. (a) Particles are in maximum state of order

(or perfect order or completely ordered or perfect crystal or minimum disorder or no disorder)

(entropy is zero at 0 k by definition)

1

(b) (Ice) melts

(or freezes or changes from solid to liquid or from liquid to solid)

1

(c) Increase in disorder

1

Bigger (at T_2)

1

Second mark only given if first mark has been awarded

(d) (i) Moles of water = 1.53/18 (= 0.085)

1

Heat change per mole = 3.49/0.085 = 41.1 (kJ mol^{-1})

(allow 41 to 41.1, two sig. figs.)

(penalise –41 (negative value), also penalise wrong units but allow kJ only)

1

(ii) $\Delta G = \Delta H - T\Delta S$

1

(iii) $\Delta H = T\Delta S$ or $\Delta S = \Delta H/T$

(penalise if contradiction)

1

ΔS = 41.1/373 = 0.110 kJ K^{-1} (mol^{-1}) (or 110 (J K^{-1} (mol^{-1}))

(allow 2 sig. figs.)

(if use value given of 45, answer is 0.12 (or 120 to 121)

(if ΔH is negative in (d) (i), allow negative answer)

(if ΔH is negative in (d) (i), allow positive answer)

(if ΔH is positive in (d) (i), penalise negative answer)

1

Correct units as above (mol^{-1} not essential)

1

[10]

M3. (a) (i) <u>enthalpy change</u> when 1 mol of a substance (or compound) (QL mark)

1

is (completely) burned in oxygen (or reacted in <u>excess</u> oxygen)

1

at 298 K and 100 kPa (or under standard conditions)

1

(ii) heat produced = mass of water × Sp heat capacity $x\Delta T$ (or $mc\Delta T$)

1

= 150 × 4.18 × 64 (note if mass = 2.12 lose first 2 marks then conseq) = 40100 J or = 40.1 kJ (allow 39.9 - 40.2 must have correct units)

1

moles methanol = mass/M_r = 2.12/32 (1)
= 0.0663

1

ΔH = – 40.1/0.0663 = – 605 kJ (mol^{-1})

1

(allow –602 to –608 or answer in J)
(note allow conseq marking after all mistakes but note use of 2.12 g loses 2 marks

(b) (i) equilibrium shifts to left at high pressure

1

because position of equilibrium moves to favour fewer moles (of gas)

1

(ii) at high <u>temperature</u> reaction yield is low (or at low <u>*T*</u> yield is high)

1

at low <u>temperature</u> reaction is slow (or at high <u>*T*</u> reaction is fast)

1

therefore use a balance (or compromise) between <u>rate</u> and <u>yield</u>

1

(c) $\Delta H = \Sigma\Delta H_c^{\ominus}$(reactants) – $\Sigma\Delta H_c^{\ominus}$(products) (or correct cycle)

1

$\Delta H_c^{\ominus}(CH_3OH) = \Delta H_c^{\ominus}(CO) + 2 \times \Delta H_c^{\ominus}(H_2) - \Delta H$

1

= (–283) + (2 × –286) – (–91) (mark for previous equation or this)
= –764 (kJ mol^{-1}) (*units not essential but lose mark if units wrong)*
(note + 764 scores 1/3)

1

[15]