M1. B

[1]

M2. C

[1]

M3. B

[1]

M4. (a) $\Delta H = \Sigma\Delta H_f(\text{products}) - \Sigma\Delta H_f(\text{reactants})$

1

$= -201 - 242 - (-394)$

1

$= -49 \text{ kJ mol}^{-1}$

+49 kJ mol^{-1} = 1 mark
units not required, wrong units lose 1 mark

1

(b) $\Delta S = \Sigma S(\text{products}) - \Sigma S(\text{reactants})$

1

$= 238 + 189 - (214 + 3 \times 131)$

1

$= -180 \text{ J K}^{-1} \text{ mol}^{-1}$

+180 = 1 mark
units not required, wrong units lose 1 mark

1

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

If use G not ΔG penalise M1 but not M2 and M3

1

(ΔS is negative so) at high temp $-T\Delta S$ (is positive and) greater than ΔH/large

Do not award M2 or M3 if positive ΔS value used

1

So Δ*G* > 0

Independent mark unless positive ΔS value used

1

(Limiting condition Δ*G* = 0 so) *T* = Δ*H*/Δ*S*

1

= 272 K

Allow 297-298 if used given values.
Do not award M5 if T –ve or if M4 should give T –ve

1

Reaction is too slow at this temperature/to speed up the reaction

1

(d) $CH_3OH + 3/2O_2 \rightarrow CO_2 + 2H_2O$

Allow multiples.
Ignore state symbols.
Do not allow equation for wrong compound but mark on provided number of moles increases or stays the same.
If no equation or equation that gives a decrease in the number of moles,
CE = 0

1

2.5 mol give 3 mol (gases)

Allow statement 'increase in number of moles/molecules'
If numerical values given, they must match the equation in M1
Ignore the effect of incorrect state symbols on the number of moles of particles unless used correctly

1

Therefore Δ*S* is positive/entropy increases

If correct deduction from wrong equation is ΔS = 0 or ΔS very small must say H –ve

1

(combustion exothermic so Δ*H* –ve so Δ*H* – *T*Δ*S*) and hence Δ*G* always negative (less than zero)

1

Allow G instead of ΔG
Can score 3 out of 4 marks if equation wrong but leads to increase or no change in number of moles
M4 dependent on M3

Note, if equation wrong AND there is an incorrect deduction about the change in number of moles, CE = 0

(e) CO_2/CO/CH_4 may be produced during H_2 manufacture/building the plant/transport/operating the plant

1

[17]

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.A

[1]

M7. (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

1

(ii) The negative S^- ion

1

repels the added electron

1

(iii) Step B is the atomisation enthalpy of sulphur

1

Step D is the second ionisation enthalpy of calcium

1

(iv) Electrons nearer to the nucleus

1

Electrons removed from a positive species or more strongly attracted

1

(v) +178 +279 +590 +1145 -200 + 539 + G + 482 = 0

1

G + 3013 = 0 hence G = –3013

1

(b) The model used assumes the ions are spherical and in a lattice

1

The calculated value is smaller than the cycle value or stronger attraction

1

Indicating some covalent character or ions are polarised

1

(c) (i) For a reaction to occur $\Delta G < 0$

1

ΔS is positive and large as a gas is evolved

1

$T\Delta S$ is larger than ΔH and ΔG is negative

1

(ii) ΔS is negative

1

Four moles gaseous reactant forming or more moles of gaseous product

1

At high temperature $T\Delta S$ is larger than ΔH and ΔG is positive

1

[18]

M8.C

[1]

M9.C

[1]