

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<sup>-1</sup> = 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  $\Delta S$  value used*

1

So  $\Delta G > 0$

*Independent mark unless positive  $\Delta S$  value used*

1

(Limiting condition  $\Delta G = 0$  so)  $T = \Delta H/\Delta S$

1

= 272 K

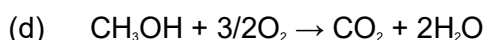
*Allow 297-298 if used given values.*

*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



*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  $\Delta S$  is positive/entropy increases

*If correct deduction from wrong equation is  $\Delta S = 0$  or  $\Delta S$  very small must say H -ve*

1

(combustion exothermic so  $\Delta H$  -ve so  $\Delta H - T\Delta S$ ) and hence  $\Delta G$  always negative (less than zero)

1

*Allow G instead of  $\Delta G$*

*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<sub>2</sub>/CO/CH<sub>4</sub> may be produced during H<sub>2</sub> manufacture/building the plant/transport/operating the plant

1

[17]

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

$$\begin{aligned}\Delta H_R &= (0 + [2 \times -242]) - (4 \times -92) \quad (1) \\ &= -484 + 368 \\ &= -116 \text{ (kJ mol}^{-1}\text{)}\end{aligned}$$

*Allow max 1 for +116*

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

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

$$= 824 - 953$$

$$= -129 \text{ (J K}^{-1} \text{ mol}^{-1}\text{)}$$

*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)

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

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

$$= 822 \text{ K} \quad (1)$$

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
- $\Delta S$  is positive and large as a gas is evolved 1
- $T\Delta S$  is larger than  $\Delta H$  and  $\Delta G$  is negative 1
- (ii)  $\Delta S$  is negative 1
- Four moles gaseous reactant forming or more moles of gaseous product 1
- At high temperature  $T\Delta S$  is larger than  $\Delta H$  and  $\Delta G$  is positive 1

[18]

**M8.C**

[1]

**M9.C**

[1]