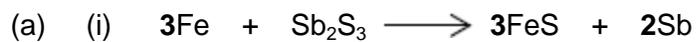


Mark schemes

1



Or multiples.

Ignore state symbols.

1



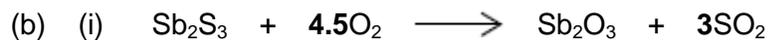
Ignore charge on the electron unless incorrect.

Or multiples.

Credit the electrons being subtracted on the LHS.

Ignore state symbols.

1



Or multiples.

Ignore state symbols.

1



Credit also the following ONLY.

H_2SO_4 or sulfuric acid.

OR

Gypsum / CaSO_4 or plaster of Paris.

1

(c) (i) **M1 (could be scored by a correct mathematical expression)**

Correct answer gains full marks.

M1 $\Delta H_r = \Sigma \Delta H_f(\text{products}) - \Sigma \Delta H_f(\text{reactants})$

OR a correct cycle of balanced equations / correct numbers of moles

Credit 1 mark for +104 (kJ mol⁻¹).

M2 = 2(+20) + 3(-394) - (-705) - 3(-111)

= 40 - 1182 + 705 + 333

= -1142 - (-1038)

(This also scores M1)

M3 = -104 (kJ mol⁻¹)

(Award 1 mark ONLY for + 104)

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.*
- *If no AE, check for a correct method; this requires either a correct cycle with 3CO, 2Sb and 3CO₂ OR a clear statement of **M1** which could be in words and scores **only M1**.*

3

(ii) It / Sb is not in its standard state

OR

Standard state (for Sb) is solid / (s)

OR

(Sb) liquid is not its standard state

Credit a correct definition of standard state as an alternative to the words 'standard state'.

QoL

1

(iii) Reduction **OR** reduced **OR** redox

1

(d) Low-grade ore extraction / it

- uses (cheap) scrap / waste iron / steel
- is a single-step process

uses / requires less / low(er) energy

Ignore references to temperature / heat or labour or technology.

1

[10]

2

(a)



Penalise C₂H₆O for ethanol in M1.

M2 and M3

Mark M2 and M3 independently.

Any **two** conditions in any order for **M2** and **M3** from

- (enzymes from) yeast or zymase
- 25 °C ≤ T ≤ 42 °C OR 298 K ≤ T ≤ 315 K
- anaerobic / no oxygen / no air OR neutral pH

A lack of oxygen can mean either without oxygen or not having enough oxygen and does not ensure no oxygen, therefore only credit "lack of oxygen" if it is qualified.

Penalise 'bacteria', 'phosphoric acid', 'high pressure' using the list principle.

M4 (fractional) distillation or GLC

Ignore reference to 'aqueous' or 'water' (ie not part of the list principle).

M5 Carbon-neutral **in this context** means

There is no net / overall (annual) carbon dioxide / CO₂ emission to the atmosphere

OR

There is no change in the total amount / level of carbon dioxide / CO₂ present in the atmosphere

For M5 – must be about CO₂ and the atmosphere.

The idea that the carbon dioxide / CO₂ given out equals the carbon dioxide / CO₂ that was taken in from the atmosphere.

5

- (b) **M1** $q = m c \Delta T$ (this mark for correct mathematical formula)
*Full marks for **M1**, **M2** and **M3** for the correct answer.*
*In **M1**, do not penalise incorrect cases in the formula.*

M2 = $(75 \times 4.18 \times 5.5)$

1724 (J) **OR** 1.724 (kJ) **OR** 1.72 (kJ) **OR** 1.7 (kJ)

(also scores **M1**)

*Ignore incorrect units in **M2**.*

M3 Using 0.0024 mol

therefore $\Delta H = \underline{-718}$ (kJ mol⁻¹)

(Accept a range from -708 to -719 but do not penalise more than 3 significant figures)

*Penalise **M3** ONLY if correct numerical answer but sign is incorrect.*
*Therefore **+718** gains two marks.*

*If units are quoted in **M3** they must be correct.*

*If $\Delta T = 278.5$, CE for the calculation and penalise **M2** and **M3**.*

M4 and **M5** in any order

Any **two** from

- incomplete combustion
- heat loss
- heat capacity of Cu not included
- some ethanol lost by evaporation
- not all of the $(2.40 \times 10^{-3}$ mol) ethanol is burned / reaction is incomplete
*If $c = 4.81$ (leads to 1984) penalise **M2** ONLY and mark on for **M3** = - 827*

5

- (c) (i) **M1** enthalpy / heat / energy change (at constant pressure) or enthalpy / heat / energy needed in breaking / dissociating (a) covalent bond(s)
Ignore bond making.

M2 averaged for that type of bond over different / a range of molecules / compounds

Ignore reference to moles.

2

(ii) **M1**

$$\underline{\sum B(\text{reactants}) - \sum B(\text{products}) = \Delta H}$$

OR

$$\underline{\text{Sum of bonds broken} - \text{Sum of bonds formed} = \Delta H}$$

OR

$$B(\text{C-C}) + B(\text{C-O}) + B(\text{O-H}) + 5B(\text{C-H}) + 3B(\text{O=O}) \\ - 4B(\text{C=O}) - 6B(\text{O-H}) = \Delta H = -1279$$

Correct answer gains full marks.

*Credit **1 mark for - 496** (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 2CO₂ and 3H₂O OR a clear statement of **M1** which could be in words and scores **only M1**.*

M2 (also scores **M1**)

$$348+360+463+5(412)+ 3B(\text{O=O})$$

$$(3231) \quad (\text{or } 2768 \text{ if O-H cancelled})$$

$$- 4(805) - 6(463) = \Delta H = - 1279$$

$$(5998) \quad (\text{or } 5535 \text{ if O-H cancelled})$$

$$3B(\text{O=O}) = \underline{1488} \text{ (kJ mol}^{-1}\text{)}$$

*Credit a maximum of one mark if the only scoring point is bonds formed adds up to **5998 (or 5535)** OR bonds broken includes the calculated value of **3231 (or 2768)**.*

M3

$$B(\text{O=O}) = \underline{496} \text{ (kJ mol}^{-1}\text{)}$$

Award 1 mark for -496

Students may use a cycle and gain full marks

3

[15]

3

(a) (Q = mcΔT)

$$= 50 \times 4.18 \times 27.3$$

*If incorrect (eg mass = 0.22 or 50.22 g) **CE = 0 / 2***

1

$$= \mathbf{5706 \text{ J}}$$
 (accept 5700 and 5710)

Accept 5.7 kJ with correct unit. Ignore sign.

1

(b) M_r of 2-methylpropan-2-ol = 74(.0)

For incorrect M_r , lose M1 but mark on.

1

$$\text{Moles} = \text{mass} / M_r$$

$$= 0.22 / 74(.0)$$

$$= \mathbf{0.00297 \text{ moles}}$$

1

$$\Delta H = -5706 / (0.002970 \times 1000)$$

$$= \mathbf{-1921 \text{ (kJ mol}^{-1}\text{)}}$$

If 0.22 is used in part (a), answer = $-8.45 \text{ kJ mol}^{-1}$ scores 3

(Allow -1920 , -1919)

If uses the value given (5580 J), answer = $-1879 \text{ kJ mol}^{-1}$ scores 3

Answer without working scores M3 only.

Do not penalise precision.

Lack of negative sign loses M3

1

(c) $\Delta H = \Sigma \Delta H \text{ products} - \Sigma \Delta H \text{ reactants}$

OR a correct cycle

Correct answer with no working scores 1 mark only.

1

$$\Delta H = -(-360) + (4 \times -393) + (5 \times -286)$$

M2 also implies M1 scored.

1

$$\Delta H = \mathbf{-2642 \text{ (kJ mol}^{-1}\text{)}}$$
 This answer only.

Allow 1 mark out of 3 for correct value with incorrect sign.

1

(d) $(-2422 - \text{part (b)}) \times 100 / -2422$

Ignore negative sign.

Expect answers in region of 20.7

If error carried forward, 0.22 allow 99.7

If 5580 J used earlier, then allow 22.4

1

- (e) Reduce the distance between the flame and the beaker / put a sleeve around the flame to protect from drafts / add a lid / use a copper calorimeter rather than a pyrex beaker / use a food calorimeter

Any reference to insulating material around the beaker must be on top.

Accept calibrate the equipment using an alcohol of known enthalpy of combustion.

1

- (f) Incomplete combustion

1

[11]

4

- (a) (i) M1 c(oncentrated) phosphoric acid / c(onc.) H₃PO₄
OR c(oncentrated) sulfuric acid / c(onc.) H₂SO₄

In M1, the acid must be concentrated.

Ignore an incorrect attempt at the correct formula that is written in addition to the correct name.

M2 Re-circulate / re-cycle the (unreacted) ethene (and steam) / the reactants

OR pass the gases over the catalyst several / many times

In M2, ignore "remove the ethanol".

Credit "re-use".

2

- (ii) M1
(By Le Chatelier's principle) the equilibrium is driven / shifts / moves to the right
/ L to R / forwards / in the forward direction

M2 depends on a correct statement of M1

The equilibrium moves / shifts to

- oppose the addition of / increased concentration of / increased moles / increased amount of water / steam
- to decrease the amount of steam / water

Mark M3 independently

M3 Yield of product / conversion increase **OR** ethanol increases / goes up / gets more

3

- (iii) M1 Poly(ethene) / polyethene / polythene / HDPE / LDPE

M2 At higher pressures

More / higher cost of electrical energy to pump / pumping cost

OR

Cost of higher pressure equipment / valves / gaskets / piping etc.

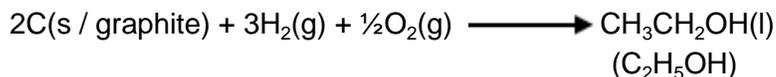
OR expensive equipment

Credit all converse arguments for M2

2

(b) M1 for balanced equation

M2 for state symbols in a correctly balanced equation



Not multiples but credit correct state symbols in a correctly balanced equation.

Penalise C₂H₆O but credit correct state symbols in a correctly balanced equation.

2

(c) (i) M1 The enthalpy change / heat change at constant pressure when 1 mol of a compound / substance / element

*If standard enthalpy of formation **CE=0***

M2 is burned / combusts / reacts completely in oxygen

OR burned / combusted / reacted in excess oxygen

M3 with (all) reactants and products / (all) substances in standard / specified states

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

*For **M3***

Ignore reference to 1 atmosphere

3

(ii) M1

Correct answer gains full marks

$$\underline{\Sigma B(\text{reactants}) - \Sigma B(\text{products}) = \Delta H}$$

Credit 1 mark for (+) 1279 (kJ mol⁻¹)

OR

$$\underline{\text{Sum of bonds broken} - \text{Sum of bonds formed} = \Delta H}$$

OR

$$\begin{aligned} &B(\text{C-C}) + B(\text{C-O}) + B(\text{O-H}) + 5B(\text{C-H}) + 3B(\text{O=O}) \text{ (LHS)} \\ &- 4B(\text{C=O}) - 6B(\text{O-H}) \text{ (RHS)} = \underline{\Delta H} \end{aligned}$$

M2 (also scores **M1**)

$$348+360+463+5(412)+3(496) \text{ [LHS = 4719]}$$

(2060) (1488)

$$- 4(805) - 6(463) \text{ [RHS = - 5998]} = \Delta H$$

(3220) (2778)

OR using only bonds broken and formed (**4256 - 5535**)

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 2C and 6H and 7O OR a clear statement of **M1** which could be in words and scores **only M1**

M3

$$\Delta H = \underline{-1279} \text{ (kJ mol}^{-1}\text{)}$$

Allow a maximum of one mark if the only scoring point is LHS = 4719 OR RHS = 5998

Award 1 mark for +1279

Candidates may use a cycle and gain full marks

3

(d) (i) Reducing agent OR reductant OR electron donor
OR to reduce the copper oxide

Not "reduction".

Not "oxidation".

Not "electron pair donor".

1

(ii) CH₃COOH

1

[17]

5

(a) **M1 (could be scored by a correct mathematical expression)**

Correct answer to the calculation gains all of M1, M2 and M3

$$\text{M1 } \Delta H = \Sigma \Delta H_f(\text{products}) - \Sigma \Delta H_f(\text{reactants})$$

Credit 1 mark for - 101 (kJ mol⁻¹)

OR a correct cycle of balanced equations

$$\text{M2} \quad = - 1669 - 3(- 590)$$

$$= - 1669 + 1770$$

(This also scores M1)

$$\text{M3} \quad = + 101 \text{ (kJ mol}^{-1}\text{)}$$

Award 1 mark ONLY for - 101

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 3Sr and 2Al OR a clear statement of M1 which could be in words and scores **only M1***

M4 - Using powders

Any **one** from

- To increase collision frequency / collisions in a given time / rate of collisions
- To increase the surface contact / contact between the solids / contact between (exposed) particles

Ignore dividing final answer by 3

Penalise M4 for reference to molecules.

5

M5 Major reason for expense of extraction

Any **one** from

- Aluminium is extracted by electrolysis OR aluminium extraction uses (large amounts of) electricity
- Reaction / process / It / the mixture requires heat
- It is endothermic

- (b) Calcium has a higher melting point than strontium, because

Ignore general Group 2 statements.

Correct reference to size of cations / proximity of electrons

M1 (For Ca) delocalised electrons closer to cations / positive ions / atoms / nucleus

OR cations / positive ions / atoms are smaller

OR cation / positive ion / atom or it has fewer (electron) shells / levels

Penalise M1 if either of Ca or Sr is said to have more or less delocalised electrons OR the same nuclear charge.

Ignore reference to shielding.

Relative strength of metallic bonding

M2 (Ca) has stronger attraction between the cations / positive ions / atoms / nucleus and the delocalised electrons

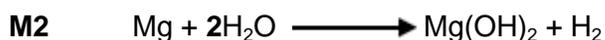
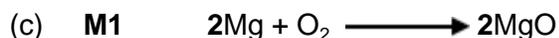
OR

stronger metallic bonding

(assume argument refers to Ca but credit converse argument for Sr)

CE= 0 for reference to molecules or Van der Waals forces or intermolecular forces or covalent bonds.

2



Credit multiples of the equations.

M3 Magnesium hydroxide is used as an antacid / relieve indigestion (heartburn) / neutralise (stomach) acidity / laxative

Not simply "milk of magnesia" in M3

3

[10]

6

- (a) (i) **M1 (could be scored by a correct mathematical expression which must have all ΔH symbols and the Σ or SUM)**

Correct answer gains full marks

Credit 1 mark ONLY if -122 (kJ mol^{-1})

M1 $\Delta H = \Sigma \Delta H_f(\text{products}) - \Sigma \Delta H_f(\text{reactants})$

OR a correct cycle of balanced equations

M2 $\Delta H = 3(-394) - 3(-111) - (-971)$
(This also scores M1)

M3 = (+) **122**(kJ mol^{-1})

Award 1 mark ONLY for -122

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 correct method; this requires either a correct cycle of balanced equations OR a clear statement of M1 which could be in words and scores **M1 only***

3

- (ii) By definition

Ignore reference to "standard state"

OR

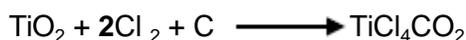
Because it is an element / elemental

1

- (b) (i) $\text{TiO}_2 + 2\text{Cl}_2 + 2\text{C} \longrightarrow \text{TiCl}_4 + 2\text{CO}$

Allow multiples

OR

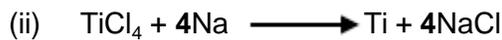


Ignore state symbols

M1 use of Cl_2 and C

M2 a correct balanced equation

2



Allow multiples

OR

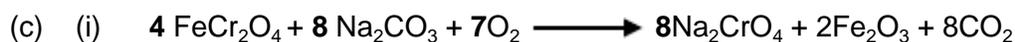


Ignore state symbols

M1 use of Na **OR** Mg

M2 a correct balanced equation

2



Allow multiples

Ignore state symbols

1



Allow multiples

Ignore state symbols

1

[10]

7

- (a) The enthalpy change / heat (energy) change (at constant pressure) in a reaction is independent of the route / path taken (and depends only on the initial and final states)

Ignore the use of ΔH for enthalpy

1

(b) $\Delta H_{\text{exp}} + \Delta H_2 - \Delta H_1 = 0$

Any correct mathematical statement that uses all three terms

OR

$\Delta H_{\text{exp}} + \Delta H_2 = \Delta H_1$ **OR** $\Delta H_1 = \Delta H_{\text{exp}} + \Delta H_2$

OR

$\Delta H_{\text{exp}} = \Delta H_1 - \Delta H_2$ **OR** $\Delta H_{\text{exp}} = \Delta H_1 + (-\Delta H_2)$

1

(c) $\Delta H_{\text{exp}} = \Delta H_1 - \Delta H_2$

$\Delta H_{\text{exp}} = -156 - 12 = -168 \text{ (kJ mol}^{-1}\text{)}$

Ignore units

Award the mark for the correct answer without any working

1

(d) (i) M1 $q = m c \Delta T$ OR calculation (25.0 x 4.18 x 14.0)

Award full marks for correct answer

M2 = **1463J** OR **1.46** kJ (This also scores **M1**)

*In **M1**, do not penalise incorrect cases in the formula*

M3 must have both the correct value within the range specified **and** the minus sign

*Penalise **M3** ONLY if correct numerical value but sign is incorrect;
e.g. **+69.5 to +69.7 gains 2 marks** (ignore +70 after correct answer)*

For 0.0210 mol, therefore

$$\Delta H_1 = - 69.67 \text{ to } - 69.52 \text{ (kJ mol}^{-1}\text{)}$$

$$\text{OR } \Delta H_1 = - 69.7 \text{ to } - 69.5 \text{ (kJ mol}^{-1}\text{)}$$

*Penalise **M2** for arithmetic error but mark on*

Accept answers to 3sf or 4sf in the range - 69.7 to - 69.5

$\Delta T = 287$, score $q = m c \Delta T$ only

Ignore -70 after correct answer

*If $c = 4.81$ (leads to 1684J) penalise **M2** ONLY and mark on for **M3**
= -80.17 (range - 80.0 to - 80.2)*

Ignore incorrect units

3

(ii) The idea of heat loss

NOT impurity

OR

Incomplete reaction (of the copper sulfate)

NOT incompetence

OR

Not all the copper sulfate has dissolved

NOT incomplete combustion

1

- (e) Impossible to add / react the exact / precise amount of water
Not just "the reaction is incomplete"

OR

Very difficult to measure the temperature rise of a solid

OR

Difficult to prevent solid dissolving

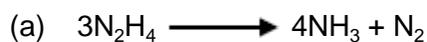
OR

(Copper sulfate) solution will form

1

[8]

8



Or multiples

Ignore state symbols

1

- (b) M1 enthalpy / heat (energy) change / required / needed to break / dissociate a covalent bond (or a specified covalent bond)

Ignore bond making

Ignore standard conditions

M2 requires an attempt at M1

M2 average / mean over different molecules / compounds / substances

2

- (c) M1
 $\sum (\text{bonds broken}) - \sum (\text{bonds formed}) = \Delta H$
M1 could stand alone

OR

Sum of bonds broken – Sum of bonds formed = ΔH
Award full marks for correct answer

M2 (also scores **M1**)
Ignore units

$4(+388) + 163 + 2(146) + 4(463) - 944 - 8(463) = \Delta H$
 OR broken +3859 (2007) formed – 4648 (2796)

M3

$\Delta H = -789$ (kJ mol⁻¹)
Two marks can score with an arithmetic error in the working

Award 1 mark for + 789
*Credit **one mark only** for calculating either the sum of the bonds broken or the sum of the bonds formed provided this is the only mark that is to be awarded*

Students may use a cycle and gain full marks

3
[6]

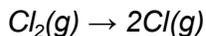
9

- (a) (Enthalpy change to) break the bond in 1 mol of chlorine (molecules)
Allow (enthalpy change to) convert 1 mol of chlorine molecules into atoms
Do not allow energy or heat instead of enthalpy, allow heat energy

1

To form (2 mol of) gaseous chlorine atoms / free radicals

Can score 2 marks for 'Enthalpy change for the reaction':



Equation alone gains M2 only

Can only score M2 if 1 mol of chlorine molecules used in M1 (otherwise it would be confused with atomisation enthalpy)

Any mention of ions, CE = 0

1

- (b) (For atomisation) only 1 mol of chlorine atoms, not 2 mol (as in bond enthalpy) is formed / equation showing $\frac{1}{2}$ mol chlorine giving 1 mol of atoms

Allow breaking of one bond gives two atoms

Allow the idea that atomisation involves formation of 1 mol of atoms not 2 mol

Allow the idea that atomisation of chlorine involves half the amount of molecules of chlorine as does dissociation

Any mention of ions, CE = 0

1

- (c) (i) $\frac{1}{2}\text{F}_2(\text{g}) + \frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{ClF}(\text{g})$

1

- (ii) $\Delta H = \frac{1}{2}E(\text{F}-\text{F}) + \frac{1}{2}E(\text{Cl}-\text{Cl}) - E(\text{Cl}-\text{F})$

Allow correct cycle

1

$$E(\text{Cl}-\text{F}) = \frac{1}{2}E(\text{F}-\text{F}) + \frac{1}{2}E(\text{Cl}-\text{Cl}) - \Delta H$$

$$= 79 + 121 - (-56)$$

$$= 256 \text{ (kJ mol}^{-1}\text{)}$$

-256 scores zero

Ignore units even if wrong

1

- (iii) $\frac{1}{2}\text{Cl}_2 + 3/2 \text{F}_2 \rightarrow \text{ClF}_3$

If equation is doubled CE=0 unless correct answer gained by / 2 at end

This would score M1

1

$$\Delta H = \frac{1}{2}E(\text{Cl}-\text{Cl}) + 3/2E(\text{F}-\text{F}) - 3E(\text{Cl}-\text{F})$$

$$= 121 + 237 - 768 / (\text{or } 3 \times \text{value from (c)(ii)})$$

This also scores M1 (note = 358 - 768)

1

$$= -410 \text{ (kJ mol}^{-1}\text{)}$$

If given value of 223 used ans = -311

Allow 1 / 3 for +410 and +311

1

- (iv) (Bond enthalpy of Cl-F bond in ClF is different from that in ClF₃)

Allow Cl-F bond (enthalpy) is different in different compounds (QoL)

1

- (d) NaCl is ionic / not covalent

1

[11]

10

- (a) (i) **M1** (could be scored by a correct mathematical expression which must have all ΔH_f symbols and the Σ or SUM)

M1 $\Delta H_r = \Sigma \Delta H_f$ (products) - $\Sigma \Delta H_f$ (reactants)

OR a correct cycle of balanced equations with 1C, 3H₂ and 1O₂

M2 $\Delta H_r = -201 + (-242) - (-394)$

$\Delta H_r = -201 - 242 + 394$

$\Delta H_r = -443 + 394$

(This also scores M1)

M3 = -49 (kJ mol⁻¹)

(Award 1 mark ONLY for + 49)

Correct answer gains full marks

Credit 1 mark ONLY for + 49 (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 correct cycle of balanced equations with 1C, 3H₂ and 1O₂ OR a clear statement of M1 which could be in words and scores only M1*

3

- (ii) It is an element / elemental
Ignore reference to "standard state"

OR

By definition

1

(b) **M1** (The yield) increases / goes up / gets more

*If M1 is given as “decreases” / “no effect” / “no change” then CE= 0
for clip, but mark on only **M2** and **M3** from a blank M1*

M2 There are more moles / molecules (of gas) on the left / of reactants

OR fewer moles / molecules (of gas) on the right

/ products

OR there are 4 moles / molecules (of gas) on the left and 2 moles / molecules on the right.

OR (equilibrium) shifts / moves to the side with less moles / molecules

*Ignore “volumes”, “particles” “atoms” and “species” for **M2***

M3: Can only score M3 if M2 is correct

The (position of) equilibrium shifts / moves (from left to right) to oppose the increase in pressure

*For **M3**, not simply “to oppose the change”*

*For **M3** credit the equilibrium shifts / moves (to right) to lower / decrease the pressure*

(There must be a specific reference to the change that is opposed)

3

(c) **M1** Yield increases goes up

M2 The (forward) reaction / to the right is endothermic OR takes in/ absorbs heat

OR

The reverse reaction / to the left is exothermic OR gives out / releases heat

*If M1 is given as “decrease” / “no effect” / “no change” then CE= 0
for clip, but mark on only **M2** and **M3** from a blank **M1***

Can only score M3 if M2 is correct

M3 The (position of) equilibrium shifts / moves (from left to right) to oppose the increase in temperature (QoL)

*For **M3**, not simply “to oppose the change”*

*For **M3**, credit the (position of) equilibrium shifts / moves (QoL)*

*to absorb the heat **OR***

*to cool the reaction **OR***

to lower the temperature

(There must be a specific reference to the change that is opposed)

3

(d) (i) An activity which has no net / overall (annual) carbon emissions to the atmosphere

OR

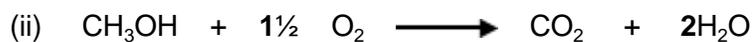
An activity which has no net / overall (annual) greenhouse gas emissions to the atmosphere.

OR

There is no change in the total amount / level of carbon dioxide /CO₂ carbon /greenhouse gas present in the atmosphere.

The idea that the carbon /CO₂ given out equals the carbon /CO₂ that was taken in from the atmosphere

1



Ignore state symbols

Accept multiples

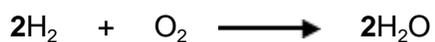
1



Ignore state symbols

OR

Accept multiples



Extra species must be crossed through

1

(e) **M1** $q = m c \Delta T$

Award full marks for correct answer

Ignore the case for each letter

OR $q = 140 \times 4.18 \times 7.5$

M2 = 4389 (J) OR 4.389 (kJ) OR 4.39 (kJ) OR 4.4 (kJ)(also scores M1)

M3 Using 0.0110 mol

therefore $\Delta H = -\underline{399}$ (kJmol⁻¹)

OR -400

*Penalise **M3** ONLY if correct numerical answer but sign is incorrect;
+399 gains 2 marks*

*Penalise **M2** for arithmetic error and mark on*

*In **M1**, do not penalise incorrect cases in the formula*

If $\Delta T = 280.5$; score $q = m c \Delta T$ only

*If $c = 4.81$ (leads to 5050.5) penalise **M2** ONLY and mark on for **M3**
= - 459*

+399 or +400 gains 2 marks

Ignore incorrect units

3

[16]