M1.(a) Temperature on *y*-axis

If axes unlabelled use data to decide that temperature is on y-axis.

1

Uses sensible scales

Lose this mark if the ***plotted points*** *do not cover half of the paper.*

Lose this mark if the temperature axis starts at 0 °C.

1

Plots **all** of the points correctly ± one square

Lose this mark if the graph plot goes off the squared paper.

1

Draws two best-fit lines

Candidate must draw ***two*** *correct lines.*

Lose this mark if the candidate's line is doubled or kinked.

1

Both extrapolations are correct to the 4^{th} minute

Award this mark if the candidate's extrapolations are within one square of your extrapolations of the candidate's best-fit lines at the 4^{th} *minute.*

1

(b) 19.5 (°C)

Accept this answer only.

1

(c) 26.5 ± 0.2 (°C)

Do not penalise precision.

1

(d) (c) – (b)

*Only award this mark if temperature rise is recorded to **1 d.p.***

1

(e) Uses $mc\Delta T$ equation

Allow use of this equation with symbols or values for M1 even if the mass is wrong.

1

Correct value using 25 × 4.18 × (d)

7.0 gives 732 J.

Correct answer with no working scores one mark only.

Do not penalise precision.

Allow answer in J or kJ.

Ignore sign of enthalpy change.

1

(f) $9.0(1) \times 10^{-3}$

Do not allow 0.01

Allow 9×10^{-3} or 0.009 in this case.

1

(g) If answer to (e) in J, then (e) / (1000 × (f))

or

If answer to (e) in kJ, then (e) / (f)

7.0 and 9.01×10^{-3} gives 81.2 kJ mol^{-1}

If answer to (e) is in J must convert to kJ mol^{-1} correctly to score mark.

1

Enthalpy change has negative sign

Award this mark independently, whatever the calculated value of the enthalpy change.

1

(h) The idea that this ensures that all of the solution is at the same temperature

Do not allow ‘to get an accurate reading’ without *qualification.*

1

(i) (i) Chlorine is toxic / poisonous / corrosive

Do not allow 'harmful'.

1

(ii) Explosion risk / apparatus will fly apart / stopper will come out

Ignore 'gas can't escape' or 'gas can't enter the tube'.

1

[16]

M2.(a) q = 500 × 4.18 × 40

Do not penalise precision.

1

= 83600 J

Accept this answer only.

Ignore conversion to 83.6 kJ if 83600 J shown.

Unit not required but penalise if wrong unit given.

Ignore the sign of the heat change.

An answer of 83.6 with no working scores one mark only.

An answer of 83600 with no working scores both marks.

1

(b) Moles (= 83.6 / 51.2) = 1.63

Using 77400 alternative gives 1.51 mol

Allow (a) in kJ / 51.2

Do not penalise precision.

1

Mass = 1.63 × 40(.0) = 65.2 (g)

Allow 65.3 (g)

Using 77400 alternative gives 60.4 to 60.5

Allow consequential answer on M1.

1 mark for M_r (shown, not implied) and 1 for calculation.

Do not penalise precision.

2

(c) Molarity = 1.63 / 0.500 = 3.26 mol dm–3

Allow (b) M1 × 2

Using 1.51 gives 3.02

1

(d) Container splitting <u>and</u> releasing irritant / corrosive chemicals

Must have reference to both aspects; splitting or leaking (can be implied such as contact with body / hands) ***and*** *hazardous chemicals.*

Allow 'burns skin / hands' as covering both points

Ignore any reference to 'harmful'.

Do not allow 'toxic'.

1

(e) (i) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Allow fractions / multiples in equation.

Ignore state symbols.

1

(ii) Iron powder particle size could be increased / surface area lessened

Decrease in particle size, chemical error = 0 / 3

Change in oxygen, chemical error = 0 / 3

1

Not all the iron reacts / less reaction / not all energy released / slower release of energy / lower rate of reaction

Mark points M2 and M3 independently.

1

Correct consequence of M2

An appropriate consequence, for example

- *too slow to warm the pouch effectively*
- *lower temperature reached*
- *waste of materials*

1

(f) (i) Conserves resources / fewer disposal problems / less use of landfill / fewer waste products

Must give a specific point.

Do not allow 'does not need to be thrown away' without qualification.

Do not accept 'no waste'.

1

(ii) Heat to / or above 80 °C (to allow thiosulfate to redissolve)

Accept 'heat in boiling water'.

If steps are transposed, max 1 mark.

1

Allow to cool before using again

Reference to crystallisation here loses this mark.

1

[14]

M3. (a) **Three conditions <u>in any order</u> for M1 to M3**

M1 yeast or zymase

M2 30 °C ≥ T ≤ 42 °C

M3 anaerobic/no oxygen/no air OR neutral pH

M4 $C_6H_{12}O_6 \longrightarrow \mathbf{2}C_2H_5OH + \mathbf{2}CO_2$

OR

$\mathbf{2}C_6H_{12}O_6 \longrightarrow \mathbf{4}C_2H_5OH + \mathbf{4}CO_2$

Mark independently

Penalise "bacteria" and "phosphoric acid" using the list principle

Ignore reference to "aqueous" or "water" (i.e. not part of the list principle)

Or other multiples

4

(b) **M**1 Carbon-neutral

Ignore "biofuel"

1

M2 6 (mol/molecules) CO_2/carbon dioxide taken in/used/used up (to form glucose or in photosynthesis)

1

M3 6 (mol/molecules) CO_2/carbon dioxide given out due to **2** (mol/molecules) CO_2/carbon dioxide from fermentation/ Process 2 and **4** (mol/molecules) CO_2/carbon dioxide from combustion/Process 3

It is NOT sufficient in M2 and M3 for equations alone without commentary or annotation or calculation

1

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

(Sum of) bonds broken – (Sum of) bonds made/formed = Δ*H*

OR

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

(where B = bond enthalpy/bond energy)

For M1 there must be a correct mathematical expression using ΔH or "enthalpy change"

M2 Reactants = (+) 4719
OR
Products = (–) 5750

M3 Overall + 4719 – 5750 = **–1031** (kJ mol^{-1}) **(This is worth 3 marks)**

Award full marks for correct answer.

Ignore units.

M2 is for either value underlined

M3 is NOT consequential on M2

3

Award 1 mark ONLY for +1031

Candidates may use a cycle and gain full marks.

M4 Mean bond enthalpies are not specific for this reaction *OR* they are average values from many different compounds/molecules

Do not forget to award this mark

1

(d) **M1** q = m c ΔT (this mark for correct mathematical formula)

M2 = 6688 (J) OR 6.688 (kJ) OR 6.69 (kJ) OR 6.7 (kJ)

M3 0.46g is 0.01 mol
therefore ΔH = **<u>– 669</u>** kJ mol^{-1} OR – **<u>670</u>** $kJmol^{-1}$
OR **<u>–668.8</u>** kJ mol^{-1}

Award M1, M2 and M3 for <u>correct answer</u> to the calculation

Penalise M3 ONLY if correct answer but sign is incorrect

In M1, do not penalise incorrect cases in the formula

If m = 0.46 or m = 200.46 OR if ΔT = 281, CE and penalise M2 and M3

If c = 4.81 (leads to 7696) penalise M2 ONLY and mark on for M3 = –769.6 OR –770

Ignore incorrect units in M2

M4 Incomplete combustion

Do not forget to award this mark. Mark independently

4

[15]

M4. (a) (i) q = mc ΔT

Ignore case except T

1

(ii) 8.80 × 1.92 × 9.5 = **161** (J) to 160.5(12) (J)

Credit 0.161 provided it is clear that it is kJ.
Penalise wrong units

1

(iii) 11.95 × 0.96 × 9.5 = **109** (J) to 108.98(4) (J)

Credit 0.109 provided it is clear that it is kJ.
Penalise wrong units.

1

(iv) **M1** Addition of (a)(ii) and (a)(iii)

M2 Multiply by 10 and convert to kJ (divide by 1000) <u>leading to an answer</u>

Consequential on (a)(ii) and (a)(iii)

Penalise wrong units
Ignore the sign

Therefore ΔH = **(–) 2.69 *OR* (–) 2.7(0)** (kJ mol^{-1})

Ignore greater numbers of significant figures (2.69496)
Subtraction in M1 is CE

2

(b) One from:

- No account has been taken of the intermolecular forces initially in the two liquids OR each liquid has its own intermolecular forces in operation before mixing.
- The liquids may react or reference to reaction or reference to bonds broken or formed

Any statement which shows that there are other intermolecular forces to consider.
Ignore heat loss and ignore poor mixing.

1

[6]