TOPIC 4 HW MS

1. (a) (Q = mcΔT)

= 50 × 4.18 × 27.3

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

1

= **5706 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

Moles = mass / M_r

= 0.22 / 74(.0)

= **0.00297 moles**

1

Δ*H* = –5706 / (0.002970 × 1000)

= **–1921 (kJ mol^{-1})**

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

(Allow –1920, –1919)

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

Answer without working scores M3 only.

Do not penalise precision.

Lack of negative sign loses M3

1

(c) Δ*H* = ΣΔH products – ΣΔH reactants
OR a correct cycle

Correct answer with no working scores 1 mark only.

1

Δ*H* = −(−360) + (4 × −393) + (5 × −286)

M2 also implies M1 scored.

1

Δ*H* = **–2642** (kJ mol^{-1}) This answer only.

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

1

(d) (–2422 – part (b)) × 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]

2. (a) $2AgNO_3 + Zn \rightarrow Zn(NO_3)_2 + 2Ag$ **(1)**

Accept an ionic equation i.e. $2Ag^+ + Zn \rightarrow 2Ag + Zn^{2+}$

1

(b) Moles = mv / 1000 **(1) =** $0.20 \times 50/1000 = 1.00 \times 10^{-2}$

2

(c) Heat energy change = mCΔT **(1)** = $50 \times 418 \times 3.2$ J

= 669 J (Ignore signs) **(1)**

Allow 668, 67.0 0.67kJ

Penalise wrong units if given

2

(d) $\frac{2 \times 669}{1 \times 10^{-2}}$ = 134 kJ mol^{-1}

Mark one : 2 × (answer to (c))

Mark two : Dividing by answers to (b)

Allow 133 – 134

Penalise incorrect units

Mark conseq to equation in (a) for full marks, also to that in (c)

If No working is shown and answer is incorrect zero

2

(e) Incomplete reaction or Heat loss **(1)**

1

[8]

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

Correct answer gains full marks.

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

OR a <u>correct cycle of balanced equations / correct numbers of moles</u>

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 = **<u>−104</u>** (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 3CO_2 OR a clear statement of **M1** which could be in words and scores **only M1**.*

3

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

OR

<u>Standard state</u> (for Sb) <u>is solid / (s)</u>

OR

<u>(Sb) liquid is not its standard state</u>

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

QoL

1

(d) Low-grade ore extraction / it

- uses (cheap) <u>scrap / waste</u> <u>iron / steel</u>
- is a single-step process
  uses / requires <u>less / low(er) energy</u>

Ignore references to temperature / heat or labour or technology.

1

[5]

4. (a) (Energy required) to break a given <u>covalent</u> bond **(1)**
averaged over a range of compounds **(1)**

Penalise first mark if 'energy' / 'enthalpy' evolved

2

(b) (i) 4 × C−H = 4 × 413 = +1652
1 × C−C = 1 × 347 = 347
1 × C=O = 1 × 736 = 736
2½ × O=O = 2.5 × 498 = 1245 **(1)**
= 2735 + 1245 = +3980 **(1)**

first mark for 4 : 1: 1 or 2735 ignore sign

(ii) 4 × H−O = -4 × 464 = –1856
4 × C−O = -4 × 736 = –2944 **(1)**
= –4800 **(1)**

First mark for 4 : 4

(iii) ΔH_R = ΣBonds broken − ΣBonds made
= +3980 − 4800 = −820 **(1)**

Conseq Mark for incorrect answers in (i) and (ii) as (i) Answer + (ii) Answer =

5

[7]

5. (a) (Enthalpy change) when 1 mol **(1)** of a compound is formed from its constituent elements **(1)** in their standard states **(1)**

3

Allow energy or heat, Ignore evolved or absorbed
Mark each point independently

(b) (The enthalpy change for a reaction is) independent of the route **(1)**

1

(c) ΔH_R = $\Sigma\Delta H_f$ products − $\Sigma\Delta H_f$ reactants **(1)**
= [(3 × -286) + (3 × -394)] − (-248) **(1)**
= -1792 **(1)** (kJ mol^{-1})

Deduct one mark for each error to zero

3

[7]

6. (a) Heat energy change **(1)**

Not energy on its own

measured at constant pressure **(1)**

Mark separately, ignore constant temperature statements

2

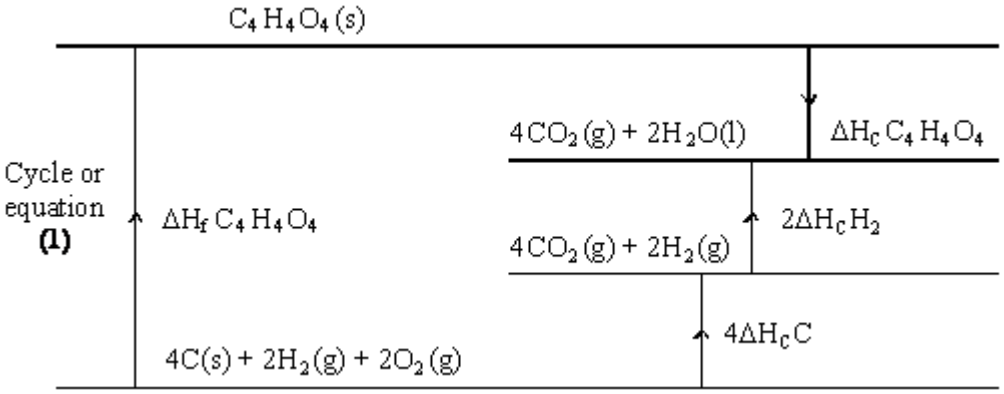
(b) $2Na(s) + S(s) + 2O_2(g) \rightarrow Na_2SO_4(s)$

Balanced (1) State symbols (1), but only if all species are correct

Allow $\frac{1}{8} S_8(s)$

2

(c)



$-1356 + (2 \times 285.8) + (4 \times 393.5) + \Delta H_f C_4H_4O_4 = 0$

$\Delta H_f = -789.6$ kJ mol^{-1}

If answer is incorrect:

Score +789.6 two marks

Score (× 1); (× 2) and (× 4) for species - one mark

If an incorrect negative answer given check for AE for loss of one mark

3

[7]

7. (a) **M1** q = m c ΔT (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 × 4.18 × 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 ΔH = **− 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 ΔT = 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 × 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

(b) **M1**

∑ B(**reactants**) − ∑ B(**products**) = ∆*H*

OR

Sum of bonds broken − Sum of bonds formed = ∆*H*

OR

B(C-C) + B(C-O) + B(O-H) + 5B(C-H) + 3B(O=O)
– 4B(C=O) – 6B(O–H) = ∆*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 $2CO_2$ and $3H_2O$ 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(O=O)

(**3231**) (or **2768** if O–H cancelled)
− 4(805) − 6(463) = ∆*H* = − 1279

(**5998**) (or **5535** if O–H cancelled)

3B(O=O) = **1488** (kJ mol^{-1})

*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(O=O) = **496** (kJ mol^{-1})

Award 1 mark for −496

Students may use a cycle and gain full marks

3

[8]

8. (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 4th 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 4th 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 <u>toxic / poisonous / corrosive</u>

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]

9. (a) $\Delta H_{exp} + \Delta H_2 - \Delta H_1 = 0$

Any correct mathematical statement that uses <u>all three terms</u>

OR

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

OR

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

1

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

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

Ignore units

Award the mark for the correct answer without any working

1

(c) (i) M1 q = m c ΔT OR calculation (25.0 x 4.18 x 14.0)

Award full marks for correct answer

M2 = **1463**J 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

ΔH_1 = **− 69.67** to **− 69.52** (kJ mol^{-1})

OR ΔH_1 = **− 69.7** to **− 69.5** (kJ mol^{-1})

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

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

ΔT = 287, score q = m c ΔT 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

[7]

10. C

[1]

11. A

[1]

12. C

[1]

13. D

[1]