Access Tuition

A-Level Chemistry

Calorimetry

Mark Scheme

Time available: 57 minutes
Marks available: 48 marks

Mark schemes

1. (a) Enthalpy change when one mole of a substance burns completely in oxygen

Allow heat energy change / allow fully combust

1

With all substances in their standard states (at stated temperature and 100kPa)

1

(b) $q = m\,c\,\Delta T = 150 \times 4.18 \times 13.9 = 8715.3$ J

1

n(propan-1-ol)= $\frac{0.497}{60.0}$ = 0.00828 mol

1

$\Delta H = - \frac{8.7153}{0.00828} = -1050$ kJ mol^{-1}

M3 = – M1×10^{-3}/M2

Minimum of 2 sf needed

Must be negative

1

(c) Incomplete combustion

Evaporation of fuel

Experiment not completed under standard conditions

1

[6]

2. (a) Heat energy change at constant pressure

1

(b)

This question is marked using Levels of Response.	
Level 3: All stages are covered and the explanation of each stage is generally correct and virtually complete. Answer is well structured with no repetition or irrelevant points. Accurate and clear expression of ideas with no errors in use of technical terms.	5-6 marks
Level 2: All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete. Answer shows some attempt at structure. Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. Some minor errors in use of technical terms.	3-4 marks
Level 1: Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete. Answer includes isolated statements but these are not presented in a logical order or show some confusion. Answer may contain valid points which are not clearly linked to an argument structure. Errors in the use of technical terms.	1-2 marks
Level 0: Insufficient correct chemistry to gain a mark.	0 marks

Indicative Chemistry

Stage 1: Apparatus
1a. Use a burette/pipette (instead of a measuring cylinder)
1b. Use a polystyrene cup (instead of a beaker) / insulate beaker
1c. Reweigh the watchglass after adding the solid 1d: Use powdered solid

Stage 2: Temperature Measurements
2a. Measure and record the initial temperature of the solution for a few minutes before addition
2b. Measure and record the temperature after the addition at regular intervals (eg each minute) for 8+ minutes/until a trend is observed

Stage 3: Temperature Determination
3a. Plot a graph of temperature against time
3b. Extrapolate to the point of addition
3c. Determine ΔT at the point of addition

6

(c) n(HCl) or n(NaOH) = 50 x 0.500 / 1000 = 0.025 moles

1

q = –ΔH x n = 57.1 x 0.025 = 1.4275 kJ

__M2__ = 57.1 × __M1__

1

ΔT = q/mc

1

ΔT = (1.4275 x 1000) / (100 x 4.18) = 3.4(2) °C

__M4__ = (__M2__ × 1000) / (100 × 4.18)

1

Final Temperature = 18.5 + 3.4 = 21.9 °C

__M5__ = __M4__ + 18.5 (but final temperature must be higher than 18.5 °C)

1

(d) Increase the concentration of the solutions

1

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3. (a) Amount of hexane = $\frac{2}{86}$ = 0.0233 mol

1

q = 4154 x 0.0233 (= 96.6 - 96.8 kJ)

ecf = M1 x 4154

1

C_{cal} = $\frac{96.6}{12.4}$ = 7.79 - 7.81 (kJ K^{-1})

ecf = M2/12.4

If no other marks awarded, allow one mark for 4154/12.4 = 335

1

(b) $q = C_{cal}\Delta T$ = 7.79 x 12.2 = 95.0 kJ

Ecf for (a) x 12.2

If candidate converted 12.4 into kelvin in (a), ignore conversion to kelvin in (b)

1

(amount of octane = $\frac{2}{114}$ = 0.0175 mol)

heat change per mole = $\frac{95.0}{0.0175}$ = 5417 kJ mol^{-1}

Allow 5420 kJ mol^{-1}

Using the value given:

6.52 x 12.2 = 79.54(4)

79.54/0.0175 = 4545

1

(c) pressure not constant in bomb calorimeter

Allow enthalpy change requires constant pressure

1

(d) $100 \times \frac{0.2}{12.2} = 1.64\%$

Allow 1.6%

Allow 2% if working shown

NOT 2.0%

1

use bigger mass of fuel (so Δ*T* greater)

Allow octane or hexane as the fuel

Allow more / greater volume of fuel

1

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4. (a) **M1** moles (= $\frac{25}{1000}$ × 2.0) = 0.050

1

M2 heat released = 0.050 × 56.1 (= 2.805 kJ or 2805 J)

1

M3 $\Delta T = \frac{q}{mc}$

1

M4 $\Delta T = \frac{2805}{50 \times 4.18}$ or $\frac{1000 \times 0.050 \times 56.1}{50 \times 4.18}$ = 13(.4) (°C)

Correct answer (to at least 2 sig fig) scores 4 marks

*27 or 26.8°C (from moles of two reagents being added together for **M2**, or use of 25 cm^3 in **M4**) scores 3 marks*

*0.013(.4)°C (from not converting kJ to J) scores 3 marks (loses **M4**) [0.027 or 0.0268°C would score 2 marks (loses **M2** and **M4**)*

M1** moles can be shown for either substance or without specifying the substance; if it is shown for both substances, must be correct for both for **M1

*Allow ECF from **M1** to **M2***

*Allow ECF from **M2** to **M4** (providing an attempt to calculate q has been made – no ECF if 56100 or 56.1 is used as q)*

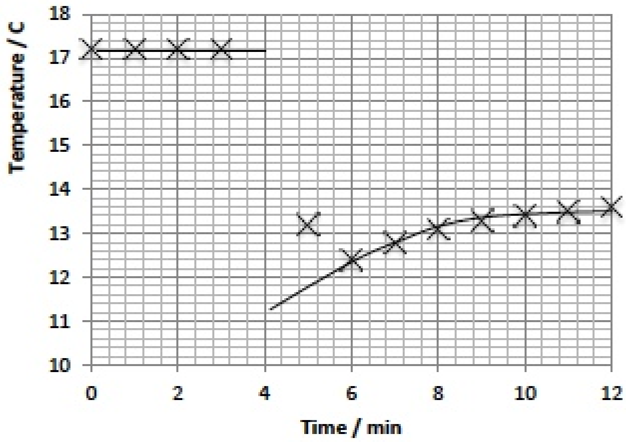
*Correct **M4** scores **M3**. If error made in **M4**, **M3** could score from substituted values in this expression in **M4***

***M4** final answer to at least 2 sig fig.*

*Penalise **M4** for negative temperature rise*

1

(b) **M1** draws suitable best fit curve to 4 minutes



__M1__ line must be a curve and ignore value at 5 minutes

__M1__ line should not go to times before 4 minutes

1

M2 (17.2 – value read from graph line at 4 minutes) ± 0.2 (°C)

__M2__ allow use of any curved or straight line that is an attempt to draw a line through the values after 4 minutes (that may include the point at 5 minutes)

__M2__ allow negative values

1

[6]

5. (a)

M1 moles cyclohexane = $\frac{192.730-192.100}{84(.0)}$ or $\frac{0.630}{84(.0)}$ (= 0.00750)

Correct answer scores 4 marks

1

M2 heat released = 1216 x 1000 x 0.0075 (= 9120) (J)
[or 1216 x 0.0075 = (9.12) (kJ)]

*0.0075 scores **M1** with or without working*

*9120 or 9.12 scores **M1** and **M2** with or without working*

1

M3 $\Delta T \left(= \frac{q}{mc} = \frac{9120}{50(.0) \times 4.18}\right)$ = 43.6

Allow ECF at each stage

*correct **M3** scores **M1** and **M2***

1

M4 final temperature = 19.1 + **M3** = 62.7 or 63 (°C)

1

Alternative **M3/4**

M3 9120 = 50 × 4.18 × (Final T – 19.1)

M4 Final T = 62.7 or 63 (°C)

*Ignore negative sign for q in **M2** and/or ΔT in **M3**, but penalise if used as a temperature fall in **M4** (if alternative method used for **M3/4** and negative value for q is used, allow **M3** for expression with negative q value but do not allow **M4**)*

(temperatures to at least 2sf)

*If candidates use a value in kJ rather than J to find ΔT / final T then they lose **M3**, but ECF to **M4** [e.g. 9.12 rather than 9120 giving ΔT = 0.0436 and final temperature = 19.1(436) – this would give 3 marks]*

*If candidates use 0.63 g for m in **M3**, they will get ΔT = 3.46 and final temperature = 22.56 – this would give 3 marks]*

*Cannot score **M2** using moles = 1*

(b) thermal energy / heat loss or

or idea of heat being transferred to calorimeter

incomplete combustion or

allow idea that it is not under standard conditions

evaporation

allow no lid / poor/no insulation

1

(c) **M1** 6 × (–394), 6 × (–286) and –3920

1

M2 (ΔH =) [6 × (–394)] + [6 × (–286)] + 3920
(or (ΔH =) [–2364)] + [–1716)] + 3920)
(or (ΔH =) –4080 + 3920)

1

M3 = –160 (kJ mol–1)

1

–160 scores 3 marks; +160 scores 2 marks

–8000 scores 2 marks; +8000 scores 1 mark

–1876 scores 2 marks; +1876 scores 1 mark

***M1** is for correct coefficients, i.e. 6 × $\Delta_c H$ H_2 & 6 × $\Delta_c H$ C & 1 x $\Delta_c H$ C_6H_{12} (ignore whether + or –)*

*ECF from **M1** to **M2**/3 for incorrect coefficients / arithmetic error / transposition*

*ECF from **M2** to **M3** for use of products – reactants*

Ignore any cycle

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6. (a)

	Temp/ °C		Mass /g
Initial		Burner before	
Final		Burner after	
(ΔT)		(Mass heptane burned)	

M1 for Temperature data including units

M2 for Burner mass data including units If either unit missing MAX 1

M1
M2

(b) Any two from:

Glass is a poorer conductor than copper

M1

Tripod and gauze would reduce heat transfer

Tripod and gauze would have a fixed height above the flame

Heat capacity of metal is less than glass or vice versa

M2

(c) Heat loss to surroundings or to copper/calorimeter

M1

Incomplete combustion

M2

(d) Use a wind shield (to reduce heat loss)

Allow use a lid

Insulate the sides of the calorimeter

1

[7]