Mark schemes

Q1.

(a) The enthalpy change when one mole of a substance is formed from its (constituent) elements.

Allow heat energy change

All substances in their standard states (at 100 kPa and a stated temperature).

2

(b) ($\Delta H = \Sigma\Delta_f H$(products) - $\Sigma\Delta_f H$(reactants))

M1: +56.2 = (-123+90.4) - 2x
2x = -88.8 kJ mol^{-1}

M2: x = -44(.4) kJmol^{-1}

M2 = their M1/2

2

(c) The silver nitrate has to be heated so you cannot measure the temperature change caused by the reaction.

Difficult to measure the temperature (change) of solids / $AgNO_3$ may decompose/silver nitrate(V) may decompose/other oxides of nitrogen would be formed

1

(d) Any three of these - improvements must **match** the identified inaccuracies.

Inaccuracy 1 - Use of a glass beaker.

Improvement 1 - Use a polystyrene cup or use insulation (to reduce heat loss.)

Inaccuracy 2 - Did not record the initial temperature.

Improvement 2 - Record an initial starting temperature before adding the solid sodium chloride/Recording the starting temperature of the silver nitrate solution.

Inaccuracy 3 - Used low concentration of silver nitrate.

Improvement 3 - Use a higher concentration of silver nitrate (so that the temperature change is larger).

Inaccuracy 4 - Does not take into account heat loss/method to determine maximum temperature not effective.

Improvement 4 - Measure the temperature at suitable time intervals after the addition, plot a graph and extrapolate to determine the maximum change.

Inaccuracy 5 - Does not take into account the enthalpy change when the excess NaCl dissolves.

Improvement 5 - Calculates the effect of the excess NaCl dissolving.

Allow

Inaccuracy 6 - uses a measuring cylinder

Improvement 6 - use a burette/volumetric pipette instead

6

[11]

Q2.

(a) **M1** Q = (mc ΔT = 60 × 4.18 × 52.1) = 13066.68 J

M2 moles $=\left(\frac{1.31}{136}\right)= 0.00963$ mol

M3 $\frac{Q}{n} = \frac{13066.68}{0.00963} = 1356541$ (J mol^{-1})

M3 = M1 / M2

M4 ΔH = -1360 kJ mol^{-1}

M4 = - M3 /1000

Allow range -1355 to -1362

4

(b) Any 5 from the following:

M1 Value from calorimetry less exothermic/lower/smaller (than method 1 value)

M1 Allow both are less (than method 1)

M2 (Calorimetry =) because of heat/energy loss

M2 Copper absorbs some heat energy

M3 (Calorimetry =) incomplete combustion

M4 (Calorimetry =) some liquid hydrocarbon could have evaporated

M5 Mean bond enthalpies values use enthalpies taken across a range of compounds

M6 Value from bond enthalpy data ignores energy changes in vaporisation of the fuel or condensing the water

M6 Allow value from mean bond enthalpies does not include changes of state.

M6 Allow value from mean bond enthalpies use gaseous states

5

[9]

Q3.

(a) Correct answer scores 3

M1 temperature rise = 59.2 °C and mass = 250 g

M2 $q = 250 \times 4.18 \times 59.2$ (= 61864 (J))

M3 heat change per mole $\left(= \frac{-61.684}{0.030}\right)$ = −2062 kJ mol^{-1}

Allow ECF at each stage

M1/2 *Allow 78.1-18.9 in place of 59.2*

M3 *allow correct value to at least 2sf, (−2100, −2060, −2062, −2062.1, −2062.13, etc)*

−11572 for using 273 + 59.2 scores ***M2*** *and* ***M3***

Use of 4.81 in place of 4.18 gives -2372 and would score ***M1*** *and* ***M3***

3

(b) **M1** idea that value measured is not accurate due to due to heat loss / incomplete combustion

M2 idea that the result from the experiment must be less exothermic than the true value and so cannot be propan-1-ol / both ethanol & propan-1-ol / the others

M1 *allow evaporation of alcohol*

M2 *allow alternative language for less exothermic: e.g. smaller enthalpy of combustion / less negative*

2

(c) Correct answer (286) with working scores 3

M1 Δ*H* (or −3388) = ΣB(reactants) − ΣB(products) **or**
Δ*H* (or −3388) = ΣBonds broken - ΣBonds formed
or
Δ*H* (or −3388) = 4 B(C−C) + 11 B(C−H) + B(C−O) + B(O−H) + 7½ B(O=O) − 10 B(C=O) − 12 B(O−H)

If no other marks scored, allow 1 mark for

13606 for bonds formed or

9075 for bonds broken (apart from C−C)

M2 −3388 = 4 B(C−C) + 11(412) + 360 + 463 + 7½(496) − 10(805) − 12(463) **or**
−3388 = 4 B(C−C) + 9075 − 13606 **or**
−3388 = 4 B(C−C) − 4531 **or**
4 B(C−C) = 1143

M2 also scores **M1**

M3 B(C−C) = $\frac{M2}{4}$ = (+)286 (kJ mol^{-1}) (allow ECF from **M2** to **M3**)

229 scores 2 marks (for assuming there are 5 not 4 C−C bonds)

−1979.75 scores 2 marks (rearrangement error)

***M3** ignore units; allow 285.75, 285.8, 286 (not 290)*

3

(d) Correct answer scores 2

M1 amount of butan-1-ol in 1 dm^3 = $\frac{810}{74(.0)}$ (= 10.95 mol)

M2 energy from 1 dm^3 = **M1** × 2676 = 29300 (kJ dm^{-3})

Allow correct answers to at least 2sf (29291.351..)

Ignore sign of final answer

Overall calculation is: $\frac{2676 \times 810}{74(.0)}$

29.3 scores 1 mark

*Allow ECF from **M1** to **M2** if **M1** is an attempt using 74(.0)*

Alternative

***M1** energy per gram of fuel =* $\frac{2676}{74(.0)}$ *(= 36.1 kJ g^{-1})*

***M2** energy per dm^3 = **M1** × 810 = 29300 (kJ dm^{-3})*

2

[10]

Q4.

(a) M1 3 $CH_3(CH_2)_{14}COOH$

M2 $CH_2(OH)CH(OH)CH_2OH$

Penalise additional product(s) once

2

(b) M1 $M_r = 256$

M2 $n(CH_3(CH_2)_{14}COOH) = \frac{0.387}{M1} = 1.51 \times 10^{-3}$

M3 $Q = 150 \times 4.18 \times 13.6 = 8527.2$ (J)

M4 $\Delta H = \frac{M3}{M2} \div 1000 = (-)5641$

M5 $\Delta H = -5640$ kJ mol^{-1}

Must be negative and 3sf (allow ecf on M4)

5

(c) M1 Less exothermic

Allow Less negative (value) / Lower

M2 Incomplete combustion

Allow products of incomplete combustion

2

(d)

		C 37.08	H 5.15	O 24.72	S M1 = 33.05
M2	÷ A_r	= 3.09	= 5.15	= 1.55	= 1.030
	÷ smallest	= 3	= 5	= 1.50	= 1
M3	Empirical formula = $C_6H_{10}O_3S_2$				

M1 % S = 33.05
M2 Calculation of moles
M3 Ratio of moles AND Empirical Formula
If no Sulfur used ecf for M2 and M3
M2 3.09 : 5.15 : 1.55
M3 $C_6H_{10}O_3$

3

(e) M1 Acid rain

Allow smog

M2 SO_2

Allow NO_x

2

(f) M1 Bonds broken = 9459 kJ mol^{-1}

(5C-C + 7C-O + 7C-H + 5O-H)

Allow if they cancel the common bonds

M1 4233

M2 Bonds formed = 9682 kJ mol^{-1}

(2C-C + 10C-H + 2C-O + 2O-H + 4C=O)

M2 4456

M3 ΔH = M1 - M2 = -223 kJ mol^{-1}

M3 can be awarded as ecf from their M1 and M2

3

(g) M1 $\Delta H = -235 - (2 \times -394) - (3 \times -242)$

M2 = +1279 kJ mol^{-1}

If no sign assume positive

2

[19]