A-Level Chemistry

Balanced Equations

Mark Scheme

Time available: 65 minutes
Marks available: 57 marks

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Mark schemes

1. amount of CaS = $\frac{2.50}{72.2}$ = 0.0346 mol

M1: amount of CaS

1

amount of $CaSO_4$ = $\frac{9.85}{136.2}$ = 0.0723 mol

M2: amount of $CaSO_4$

1

3 mol of $CaSO_4$ needed for each mol of CaS, and n($CaSO_4$) is not 3 × n(CaO)
(so $CaSO_4$ is the limiting reagent)

M3: limiting reagent justification

1

n(SO_2) = n($CaSO_4$) × $\frac{4}{3}$ = 0.0964 mol

M4: moles of $CaSO_4$ × 4/3

1

mass of SO_2 = n(SO_2) × 64.1 = 6.18g

M5: M4 × 64.1

If CaS used as limiting reagent then allow M4 and M5 ecf.

Must look for M1 and M3

1

[5]

2. (a) M1: Mean titre = $\frac{20.25+20.30}{2}$ = 20.275 cm^3

Allow M1 = 20.28 cm^3

1

M2 Amount of NaOH = 0.35 × (20.275 ÷ 1000) = 0.00709625 mol

Amount of ethanoic acid in 25 cm^3 = 0.00709625 mol

M2 = M1 × 10^{-3} × 0.35

1

M3 Amount of ethanoic acid in 200 cm^3 = 0.05677 mol

M3 = M2 × 8

1

M4 Mass of ethanoic acid in sample = 60.0 × 0.05677 = 3.4062 g

M4 = M3 × 60.0

1

M5 Mass of sodium ethanoate = 5.6 – 3.4062 = 2.1938 g

M5 = 5.6 – M4

1

M6 percentage CH_3COONa = (2.1938 ÷ 5.6) × 100 = 39.1 %

M6 = (M5 ÷ 5.6) × 100

(39.1 – 39.2)

Accept alternative methods

M5 = (M4 ÷ 5.6) × 100) followed by M6 = 100 – M5 1

1

(b) M1 Titre value would increase / larger value

1

M2 Because the sodium hydroxide solution would be more dilute

1

[8]

3. **Percentage yield**

M1 reactant moles = $\frac{1.00}{116.0}$ (= 0.00862)

*Correct **M3** scores **M1-3***

Numerical answers to at least 2sf

*Allow ECF in **M1-M3***

1

M2 product moles = $\frac{0.552}{72.0}$ (= 0.00767)

Alternative for M2/3

***M2** expected mass of product = 0.00862 x 72.0 (= 0.621 g)*

1

M3 % yield = $\frac{0.00767}{0.00862}$ = 88.9(3) or 89%

Alternative for M2/3

M3 *% yield = ($\frac{0.552}{0.621}$ x 100) = 88.9(3) or 89%*

1

M4 idea of getting as much product as possible in the reaction / idea of efficient conversion of reactants to products

1

Atom economy

M5 $\left(\frac{72.0}{74.0+34.0} x\ 100\right) = \left(\frac{72.0}{108.0} x\ 100\right) = 66.7\%$

Alternative for M5: $\left(\frac{72.0}{72.0+36.0} x\ 100\right)$

1

M6 idea of maximising the mass of reactants / atoms that ends up in desired product or idea of minimising the amount of by-products

1

[6]

4. (a) **M1** n($S_2O_3^{2-}$) = 33.50 x 0.100 ÷1000 = <u>0.00335</u>

1

M2 n(I_2) = 0.00335 ÷ **2** = 0.001675 (from eqn 2)

M2 = ***M1***÷*2*

1

M3 n(ClO^-) in 25 cm^3 pipette = 0.001675 (from eqn 1)

M3 = ***M2***

1

M4 n(ClO^-) in 100 cm^3 flask = 0.001675 <u>**x 4**</u> = 0.00670 = n(NaClO) in original 10 cm^3 sample

M4 = ***M3*** *x 4*

1

M5 mass (NaClO) = 0.00670 <u>x 74.5</u> = 0.499 g

M5 = ***M4*** <u>*x 74.5*</u>

1

M6 mass (bleach) = 10.0 x 1.20 = <u>12</u> g

M6 = *mass of bleach*

1

M7 % by mass of NaClO = $\frac{0.499}{12}$ = 4.16 %

M7 = *(**M5**÷**M6**) x 100 to 3 significant figures*
Allow 4.15% to 4.17%

1

(b) 0.45%

1

[8]

5. (a) Average titre = 26.45 cm^3

M1 = average of concordant titres

1

n(NaOH) = (25 × 0.112 / 1000) = 2.80×10^{-3} mol

M2 – this value only

1

n(acid in titre) = 2.80×10^{-3} / 2 = 1.40×10^{-3} mol

M3 = M2/2

1

n(acid in 250 cm^3) = 1.40×10^{-3} × 250/26.45 = 0.0132 mol

M4 = M3 × 250/M1

1

M_r = mass / moles = 1.300/0.0132 = 98.2-98.5

M5 = (1.300/M4) = answer

Mr must be given to at least 1dp

1

Alternatives:

98.6 – scores 4

92.9 – scores 4

87.8 – scores 3

49.3 – scores 3

49.1 – scores 4

(b) % uncertainty = 0.06/25.0 × 100 = 0.24 %

1

(c) Some solution/acid replaces air bubble /
Solution/acid fills below the tap /
Air bubble takes up volume that would be filled by solution/acid

Score for the idea that:

Acid/solution replaces air/bubble/fills jet space

Allow acid/solution fills the bubble/gap

'The final reading is higher than the volume added' is not enough.

1

(d) Does not react (with the alkali) / does not change the number of moles (of alkali)

Allow water is a product / water is not a reagent

1

[8]

6. (a) Equation: $2\ Mg + TiCl_4 \rightarrow Ti + 2\ MgCl_2$

Allow multiples / ignore ss

1

Role: Reducing agent

Allow electron donor (not electron pair donor)

1

(b) **M1**: moles of water in 210 mg = mass / mr = 0.210 / 18
= <u>0.0117</u> mol ONLY

Equal to moles of magnesium hydroxide produced in stage one

M2: mass of $Mg(OH)_2$ = 0.0117 x 58.3 = 0.680 g

M3: mass of MgO = 3.2 – 0.68

= 2.52 g

M1 *= moles of water*
M2 *= mass of* $Mg(OH)_2$ *=* ***M1*** *x 58.3*
M3 *= subtraction = 3.2 –* ***M2***
M4 *= answer to* ***M3*** *x 100/3.2*

Accept correct alternative methods such as
M1 *= moles of water*
M2 *= mass of* $Mg(OH)_2$ *=* ***M1*** *x 58.3*
M3 *=* ***M2*** *x 100/3.2*
M4 *= 100 –* ***M3***

M4: % of MgO = 2.52/3.2 x 100 = 78.7%

M4*: Allow 78.7 – 78.8 or 79 %*

4

[6]

7. (a) **M1** Amount of $S_2O_3^{2-} = \frac{9.00 \times 0.0800}{1000} = 7.20 \times 10^{-4}$ mol

1

(From equations mol $S_2O_3^{2-}$ = mol Cu^{2+})

M2 Amount of Cu^{2+} in 25 $cm^3 = 7.20 \times 10^{-4}$ mol

M2 = answer to M1 (1:1 ratio)

1

M3 Amount of Cu^{2+} in 250 cm^3 = 7.20 v 10^{-4} **× 10** = 7.20×10^{-3} mol

***M3** = **M2** × 10*

1

M4 Mass of copper = 7.20×10^{-3} mol **× 63.5** = 0.457 g

***M4** = **M3** × 63.5*

1

M5 mass = 0.985 g

***M5** converting 985 mg to g*

1

M6 % Cu = $0.457 \times \frac{100}{0.985} = 46.4$ %

M6** is for the answer to **3 sf

*Allow % Cu = $457 \times \frac{100}{985} = 46.4$ % for **M5** and **M6***

*Allow (**M4** ×1000)/985 v 100 for **M5** and **M6***

1

(b) Use more of the alloy

1

Use a lower concentration of the thiosulfate solution/lower mass of $Na_2S_2O_3$ to make solution

1

(c) Oxidizing agent

Allow electron acceptor

1

(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$

Do not allow [Ar]$3d^9$

1

(e) Full (3)d (sub)shell or (3)d^{10}

1

No (d-d) transitions possible/ cannot absorb visible/white light

M2** is dependent on **M1

Ignore reflects visible/white light

1

(f) **M1**: n = (5.00/253.8) = 0.0197 mol

Allow 254

*If 126.9 or 127 used lose **M1** only*

1

M2: T = 458 K and P = 100 000 Pa

1

M3 $V = \frac{nRT}{P}$ or $\frac{0.0197 \times 8.31 \times 458}{100\,000}$ or 7.50×10^{-4} (m^3)

M3** If rearrangement incorrect can only score **M1** and **M2

1

M4: V = 750 (cm^3)

***M4**: Allow **M3** × 10^6*

***M4**: Allow 749*

1

[16]