M1.(a) P = 100 000 Pa and T = 298 K

Wrong conversion of V or incorrect conversion of P / T lose M1 + M3

1

$n = \frac{PV}{RT}$ or $\frac{100\ 000 \times 4.31}{8.31 \times 298}$

If not rearranged correctly then cannot score M2 and M3

1

n(total) = 174(.044)

1

n (NO) = <u>69.6</u>

Allow student's M3 × 4 / 10 but must be to 3 significant figures

1

(b) (i) $\frac{3000}{17}$

Allow answer to 2 significant figures or more

1

176.5

Allow 176 − 177
But if answer = 0.176 − 0.18 (from 3 / 17) then allow 1 mark

1

(ii) 176.47 × 46 = 8117.62

M1 is for the answer to (b)(i) × 46. But lose this mark if 46 ÷ 2 at any stage
However if 92 ÷ 2 allow M1

1

$$8117.62 \times \frac{80}{100} \ (= 6494 \text{ g})$$

M2 is for M1 × 80 / 100

1

$$\frac{6494}{1000} = 6.5$$

M3 is for the answer to M2 ÷ 1000 to min 2 significant figures (kg)

OR

If 163 mol used:
163 × 46 = 7498 (1)

$$7498 \times \frac{80}{100} = 5998.4 \text{ g} (1)$$

6.00 kg (1)

1

(c) $$0.543 \times \frac{2}{3} \ (= 0.362)$$

if not $\times \frac{2}{3}$ CE = 0/2

1

$$0.362 \times \frac{1000}{250} = 1.45 \ (\text{mol dm}^{-3})$$

Allow 1.447 − 1.5 (mol dm^{-3}) for 2 marks

1

(d) NO_2 contributes to acid rain / is an acid gas / forms HNO_3 / NO_2 is toxic / photochemical smog

Ignore references to water, breathing problems and ozone layer.
Not greenhouse gas

1

(e) Ensure the ammonia is used up / ensure complete reaction or combustion

OR

Maximise the yield of nitric acid or products

1

(f) Neutralisation

Allow acid vs alkali or acid base reaction

1

[14]

M2. (a) P = 100 000 (Pa) and V = 5.00 x 10^{-3} (m^3)

M1 is for correctly converting P and V in any expression or list Allow 100 (kPa) and 5 (dm^3) for M1.

1

$$n = \frac{PV}{RT} = \frac{100\ 000 \times 5.00 \times 10^{-3}}{8.31 \times 298}$$

M2 is correct rearrangement of PV = nRT

1

= 0.202 moles (of gas produced)

This would score M1 and M2.

Therefore $\frac{0.202}{5}$ = 0.0404 moles B_2O_3

M3 is for their answer divided by 5

1

Mass of B_2O_3 = 0.0404 x 69.6

M4 is for their answer to M3 x 69.6

1

= 2.81 (g)

M5 is for their answer to 3 sig figures.

2.81 (g) gets 5 marks.

1

(b) $B + 1.5\ Cl_2 \rightarrow BCl_3$

Accept multiples.

1

<u>3</u> bonds

1

Pairs repel <u>equally</u>/ by the <u>same amount</u>

Do not allow any lone pairs if a diagram is shown.

1

(c) (i) 43.2/117.3 (= 0.368 moles BCl_3)

1

0.368 x 3 (= 1.105 moles HCl)

Allow their BCl_3 moles x 3

1

Conc HCl = $\dfrac{1.105 \times 1000}{500}$

Allow moles of HCl × 1000 / 500

1

= <u>2.20 to 2.22</u> mol dm^{-3}

Allow 2.2

Allow 2 significant figures or more

1

(ii) $H_3BO_3 + 3NaOH \rightarrow Na_3BO_3 + 3H_2O$

Allow alternative balanced equations to form acid salts.

Allow $H_3BO_3 + NaOH \rightarrow NaBO_2 + 2H_2O$

1

(d) $\dfrac{10.8}{120.3}(\times 100)$

Mark is for both M_r values correctly as numerator and denominator.

1

8.98(%)

Allow 9(%).

1

Sell the HCl

1

(e) Alternative method

Cl = 86.8%

Cl = 142 g

1

B $\frac{13.2}{10.8}$ Cl $\frac{86.8}{35.5}$

B $\frac{21.6}{10.8}$ *Cl* $\frac{142}{35.5}$

1

1.22 2.45 or ratio 1:2 or BCl_2

2:4 ratio

1

BCl_2 has M_r of 81.8 so
81.8 x 2 = 163.6
Formula = B_2Cl_4

B_2Cl_4

Allow 4 marks for correct answer with working shown.

Do not allow $(BCl_2)_2$

1

[20]

M3.(a) Co-ordinate / dative / dative covalent / dative co-ordinate

Do not allow covalent alone

1

(b) (lone) pair of electrons on <u>oxygen/O</u>

If co-ordination to O^{2-}, CE=0

1

forms co-ordinate bond with <u>Fe</u> / donates electron pair to <u>Fe</u>

'Pair of electrons on O donated to Fe' scores M1 and M2

1

(c) 180° / 180 / 90

Allow any angle between 85 and 95

Do not allow 120 or any other incorrect angle

Ignore units eg °C

1

(d) (i) 3 : 5 / 5 FeC_2O_4 reacts with 3 MnO_4^-

Can be equation showing correct ratio

1

(ii) **M1** Moles of MnO_4^- per titration = 22.35 × 0.0193/1000 = $\underline{4.31 \times 10^{-4}}$

Method marks for each of the next steps (no arithmetic error allowed for M2):

Allow $\underline{4.3 \times 10^{-4}}$ (2 sig figs)

Allow other ratios as follows:

eg from given ratio of 7/3

1

M2 moles of FeC_2O_4= ratio from (d)(i) used correctly × 4.31×10^{-4}

M2 *= 7/3 × 4.31×10^{-4} = 1.006×10^{-3}*

1

M3 moles of FeC_2O_4 in 250 cm^3 = M2 ans × 10

__M3__ = 1.006 × 10^{-3} × 10 = 1.006 × 10^{-2}

1

M4 Mass of $FeC_2O_4.2H_2O$ = M3 ans × 179.8

__M4__ = 1.006 × 10^{-2} × 179.8 = 1.81 g

1

M5 % of $FeC_2O_4.2H_2O$ = (M4 ans/1.381) × 100

__M5__ = 1.81 × 100/1.381 = 131 % (130 to 132)

1

(OR for M4 max moles of $FeC_2O_4.2H_2O$ = 1.381/179.8 (= 7.68 × 10^{-3})
for M5 % of $FeC_2O_4.2H_2O$ = (M3 ans/above M4ans) × 100)
eg using correct ratio 5/3:
Moles of FeC_2O_4 = 5/3 × 4.31 × 10^{-4} = 7.19 × 10^{-4}
Moles of FeC_2O_4 in 250 cm^3 = 7.19 × 10^{-4} × 10 = 7.19 × 10^{-3}
Mass of $FeC_2O_4.2H_2O$ = 7.19 × 10^{-3} × 179.8 = 1.29 g
% of $FeC_2O_4.2H_2O$ = 1.29 × 100/1.381 = 93.4 (allow 92.4 to 94.4)
Note correct answer (92.4 to 94.4) scores 5 marks

Allow consequentially on candidate's ratio

eg __M2__ = 5/2 × 4.31 × 10^{-4} = 1.078 × 10^{-3}

__M3__ = 1.0078 × 10^{-3} × 10 = 1.078 × 10^{-2}

__M4__ = 1.078 × 10^{-2} × 179.8 = 1.94 g

__M5__ = 1.94 × 100/1.381 = 140 % (139 to 141)

Other ratios give the following final % values

1:1 gives 56.1% (55.6 to 56.6)

5:1 gives 281% (278 to 284)

5:4 gives 70.2% (69.2 to 71.2)

[10]

M4.(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]