

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

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

1

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

*If not rearranged correctly then cannot score M2 and M3*

1

$$n(\text{total}) = 174(.044)$$

1

$$n(\text{NO}) = \underline{69.6}$$

*Allow student's M3  $\times$  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)  $176.47 \times 46 = 8117.62$

*M1 is for the answer to (b)(i)  $\times$  46. But lose this mark if  $46 \div$   
2 at any stage*

*However if  $92 \div 2$  allow M1*

1

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

*M2 is for  $M1 \times 80 / 100$*

1

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

*M3 is for the answer to  $M2 \div 1000$  to min 2 significant figures (kg)*

**OR**

If 163 mol used:

$$163 \times 46 = 7498 \text{ (1)}$$

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

6.00 kg (1)

1

(c)  $0.543 \times \frac{2}{3} (= 0.362)$   
if not  $\times \frac{2}{3}$  CE = 0/2

1

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

*Allow 1.447 – 1.5 (mol dm<sup>-3</sup>) for 2 marks*

1

- (d) NO<sub>2</sub> contributes to acid rain / is an acid gas / forms HNO<sub>3</sub> / NO<sub>2</sub> 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  $V = 5.00 \times 10^{-3}$  (m<sup>3</sup>)

*M1 is for correctly converting P and V in any expression or list Allow 100 (kPa) and 5 (dm<sup>3</sup>) 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<sub>2</sub>O<sub>3</sub>

*M3 is for their answer divided by 5*

1

Mass of B<sub>2</sub>O<sub>3</sub> = 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

3 bonds 1

Pairs repel equally/ by the same amount  
*Do not allow any lone pairs if a diagram is shown.* 1

(c) (i)  $43.2/117.3 (= 0.368 \text{ moles } BCl_3)$  1

$0.368 \times 3 (= 1.105 \text{ moles } HCl)$   
*Allow their  $BCl_3$  moles  $\times 3$*  1

Conc HCl =  $\frac{1.105 \times 1000}{500}$   
*Allow moles of HCl  $\times 1000 / 500$*  1

= 2.20 to 2.22 mol dm<sup>-3</sup>  
*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)  $\frac{10.8}{120.3} (\times 100)$

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	Cl	
13.2	86.8	
<u>10.8</u>	<u>35.5</u>	
	B	Cl
	21.6	142
	<u>10.8</u>	<u>35.5</u>

1

1.22      2.45 or ratio 1:2 or  $\text{BCl}_2$   
2:4 ratio

1

$\text{BCl}_2$  has  $M_r$  of 81.8 so

$81.8 \times 2 = 163.6$

Formula =  $\text{B}_2\text{Cl}_4$

$\text{B}_2\text{Cl}_4$

Allow 4 marks for correct answer with working shown.

Do not allow  $(\text{BCl}_2)_2$

1

[20]

- M3.(a)** Co-ordinate / dative / dative covalent / dative co-ordinate  
*Do not allow covalent alone* 1
- (b) (lone) pair of electrons on oxygen/O  
*If co-ordination to O<sup>2-</sup>, CE=0* 1
- forms co-ordinate bond with Fe / donates electron pair to Fe  
*'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<sub>2</sub>O<sub>4</sub> reacts with 3 MnO<sub>4</sub><sup>-</sup>  
*Can be equation showing correct ratio* 1
- (ii) **M1** Moles of MnO<sub>4</sub><sup>-</sup> per titration =  $22.35 \times 0.0193/1000 = 4.31 \times 10^{-4}$   
 Method marks for each of the next steps (no arithmetic error allowed for M2):  
*Allow  $4.3 \times 10^{-4}$  ( 2 sig figs)*  
*Allow other ratios as follows:*  
*eg from given ratio of 7/3* 1
- M2** moles of FeC<sub>2</sub>O<sub>4</sub>= ratio from (d)(i) used correctly  $\times 4.31 \times 10^{-4}$   
**M2** =  $7/3 \times 4.31 \times 10^{-4} = 1.006 \times 10^{-3}$  1

**M3** moles of  $\text{FeC}_2\text{O}_4$  in  $250 \text{ cm}^3 = \text{M2 ans} \times 10$

$$\mathbf{M3} = 1.006 \times 10^{-3} \times 10 = 1.006 \times 10^{-2}$$

1

**M4** Mass of  $\text{FeC}_2\text{O}_4 \cdot 2\text{H}_2\text{O} = \text{M3 ans} \times 179.8$

$$\mathbf{M4} = 1.006 \times 10^{-2} \times 179.8 = 1.81 \text{ g}$$

1

**M5** % of  $\text{FeC}_2\text{O}_4 \cdot 2\text{H}_2\text{O} = (\text{M4 ans}/1.381) \times 100$

$$\mathbf{M5} = 1.81 \times 100/1.381 = 131 \% \text{ (130 to 132)}$$

1

(OR for M4 max moles of  $\text{FeC}_2\text{O}_4 \cdot 2\text{H}_2\text{O} = 1.381/179.8 (= 7.68 \times 10^{-3})$

for M5 % of  $\text{FeC}_2\text{O}_4 \cdot 2\text{H}_2\text{O} = (\text{M3 ans}/\text{above M4ans}) \times 100$

eg using correct ratio 5/3:

$$\text{Moles of } \text{FeC}_2\text{O}_4 = 5/3 \times 4.31 \times 10^{-4} = 7.19 \times 10^{-4}$$

$$\text{Moles of } \text{FeC}_2\text{O}_4 \text{ in } 250 \text{ cm}^3 = 7.19 \times 10^{-4} \times 10 = 7.19 \times 10^{-3}$$

$$\text{Mass of } \text{FeC}_2\text{O}_4 \cdot 2\text{H}_2\text{O} = 7.19 \times 10^{-3} \times 179.8 = 1.29 \text{ g}$$

$$\% \text{ of } \text{FeC}_2\text{O}_4 \cdot 2\text{H}_2\text{O} = 1.29 \times 100/1.381 = 93.4 \text{ (allow 92.4 to 94.4)}$$

Note correct answer ( 92.4 to 94.4) scores 5 marks

*Allow consequentially on candidate's ratio*

$$\text{eg } \mathbf{M2} = 5/2 \times 4.31 \times 10^{-4} = 1.078 \times 10^{-3}$$

$$\mathbf{M3} = 1.0078 \times 10^{-3} \times 10 = 1.078 \times 10^{-2}$$

$$\mathbf{M4} = 1.078 \times 10^{-2} \times 179.8 = 1.94 \text{ g}$$

$$\mathbf{M5} = 1.94 \times 100/1.381 = 140 \% \text{ (139 to 141)}$$

*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)**  $q = 500 \times 4.18 \times 40$

*Do not penalise precision.*

1

$$= 83600 \text{ J}$$

*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 =  $1.63 \times 40(.0)$  = 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<sup>-3</sup>  
*Allow (b)  $M1 \times 2$   
Using 1.51 gives 3.02*

1

- (d) Container splitting and 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)  $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$   
*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]