

- M1.** (a) $\text{Fe} + \text{H}_2\text{SO}_4 \rightarrow \text{FeSO}_4 + \text{H}_2$ 1
- (b) $\text{MnO}_4^- + 8\text{H}^+ + 5\text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} + 5\text{Fe}^{3+}$ 1
- (c) Moles MnO_4^- in 19.6 cm^3
 $= 19.6 \times 0.022 \times 10^{-3} = 4.312 \times 10^{-4}$ 1
- Moles Fe^{2+} in 25 cm^3
 $= 5 \times 4.312 \times 10^{-4} = 2.156 \times 10^{-3}$ 1
- Moles Fe^{2+} in 250 cm^3
 $= 10 \times 2.156 \times 10^{-3} = 2.156 \times 10^{-2}$ 1
- Mass $\text{Fe}^{2+} = \text{moles} \times A_r$
 $A_r = 2.156 \times 10^{-2} \times 55.8 = 1.203 \text{ g}$ 1
- Percentage by mass of carbon
 $= (1.270 - 1.203) \times 100 / 1.270$
 $= 5.28\%$ 1
- (d) Repeat the titration and take an average of the concordant results 1
- (e) Analyse several samples from different parts of the molten iron 1

[9]

M2. (penalty for sig fig error =1 mark per question)

(a) neutron: relative mass = 1 relative charge = 0
(not 'neutral')

1

electron: relative mass = 1/1800 → 0/negligible or

$5.56 \times 10^{-4} \rightarrow 0$ relative charge = -1

1

(b) $^{17}\text{O}/\text{O}^{17}$ mass number (Do not accept 17.0)

1

oxygen symbol 'O'

(if 'oxygen' + — 'mass number = 17'(1))

(if 'oxygen'+ — 'mass number = 17'(0))

(if at N° given but $\neq 8$, treat as 'con' for M2)

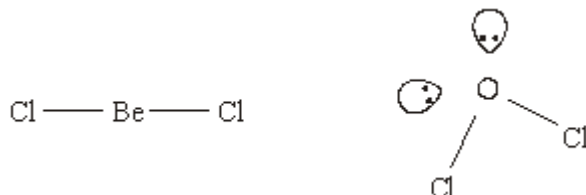
(if lp on Be, diagram = 0)

(ignore bond angles)

(not dot and cross diagrams)

1

(c)



2

QoL Linear (1)

bent / V-shaped / angular (1)

(mark name and shape independently)

(accept (distorted) tetrahedral)

(if balls instead of symbols, lose M1 – can award M2)

(penalise missing 'Cl' once only)

(not 'non-linear')

2

(d) $M_r(\text{Mg}(\text{NO}_3)_2) = 58(.3)$ (if At N° used, lose M1 and M2)

1

moles $\text{Mg}(\text{OH})_2 = 0.0172$ (conseq on wrong M2) (answer to 3+ s.f.)

1

moles $\text{HCl} = 2 \times 0.0172 = 0.0344$ or 0.0343 (mol) (process mark)

1

$$\text{vol HCl} = \frac{0.0343 \times 1000}{1} = 34.3 - 34.5 \text{ (cm}^3\text{) (unless wrong unit)}$$

(if candidate **used** 0.017 or 0.0171 lose M2)
 (just answer with no working, if in range = (4).
 if, say, 34 then =(2))
 (if not 2:1 ratio, lose M3 and M4)
 (if work on HCl, CE = 0/4)

1

[12]

M3.C

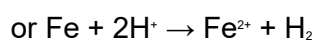
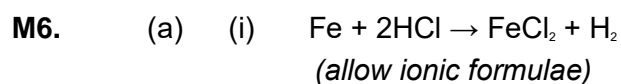
[1]

M4.D

[1]

M5.C

[1]



1

(ii) $PV = nRT$ $n = PV/RT$
 (allow either formula but penalise contradiction)

1

$$n = \frac{110000 \times 102 \times 10^{-6}}{8.31 \times 298}$$

1

$$= 4.53 \times 10^{-3} \text{ (mol)}$$

(answer must have at least 3 sig. figs. Ignore units)

1

- (iii) Moles of iron = $4.5(3) \times 10^{-3}$ mol
(allow conseq on (a)(ii))

(or = $4.2(5) \times 10^{-3}$ if candidate uses given moles of hydrogen)

1

Mass of iron = $4.53 \times 10^{-3} \times 55.8 = 0.253$ g
(mark is for method mass = moles $\times A_r$)
(Mass of iron can be 56)

1

- (iv) $0.253 \times 100 / 0.263 = 96.1$ % (mark is for answer to 2 sig. figs.)
*(allow conseq on mass of iron. E.g. = 90% from
 $4.2(5) \times 10^{-3}$ moles of H_2 and Fe)
(Do not allow answers greater than or equal to 100%)*

1

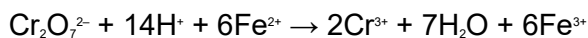
- (b) (i) $Fe^{2+} \rightarrow Fe^{3+} + e^-$

(ignore state symbols)

1



1



1

- (ii) Moles of dichromate = moles $Fe^{2+} / 6$
 $= 4.53 \times 10^{-3} / 6 = 7.55 \times 10^{-4}$

(Allow conseq, mark is for method (a)(iii)/6)

1

Volume of dichromate = moles/concentration
(= $(7.55 \times 10^{-4} \times 1000) / 0.0200$)
(mark is for this method)

1

$$V = 37.75 \text{ (cm}^3\text{)}$$

(allow 37.7 to 37.8, allow no units but penalise wrong units)

(allow conseq on moles of dichromate)

*(if value of 3.63×10^{-3} used answer is 30.2 to 30.3,
otherwise ans = moles $Fe^{2+} / 0.00012$)*

*(if mole ratio wrong and candidate does not divide by 6,
max score is ONE for volume method)*

1

(iii) (KMnO₄) will also oxidise (or react with) Cl⁻ (or chloride or HCl) 1

[14]

M7. (a) (i) Avogadro's number/constant of molecules/particles/species / 6×10^{23}
[Not 'atoms'] 1

Or same number of particles as (there are atoms)
[Not molecules]

in 12.(00)g of ¹²C 1

(ii) Moles O₂ = $\frac{0.350}{32}$ (= 1.09×10^{-2} mol) 1

= 29 ($\times 1.09 \times 10^{-2}$)
[Accept answers via 4 separate mole calculations] 1

= 0.316 – 0.317 mol [answer to 3 + sf]
[Mark conseq on errors in M1/M2] (1) 1

(iii) Moles of nitroglycerine = $4 \times 1.09 \times 10^{-2}$ (= 0.0438 mol)
[Mark conseq on their moles of O₂] 1

M_r of nitroglycerine = 227 or number string 1

Moles of nitroglycerine = $227 \times 0.0438 = 9.90 - 9.93(\underline{g})$
[answer to 3+ sf]
[If string OK but final answer wrong then allow M6 but AE for M7]
[Mark conseq on error in M_r] [Penalise wrong units]
[Penalise sig. fig. errors once only in whole question]

(b) $pV = nRT$ or $pV = \frac{mRT}{V}$ or $p = \frac{mRT}{V}$ 1

$$p = \frac{mRT}{V} = \frac{0.873 \times 8.31 \times 1100}{1.00 \times 10^{-3}}$$
 1

= 7980093 or 7980 or 7.98
[ignore s.f.] 1

units = Pa or kPa or MPa (as appropriate) 1
 [If error in conversion from Pa, treat as a contradiction of the units mark]
 [If transfer error, mark conseq but penalise M2]
 [If data from outside of above used, penalise M2 and M3]
 [If pV expression incorrectly rearranged, penalise M2 and M3]
 [if T = 1373 K used, penalise M2]

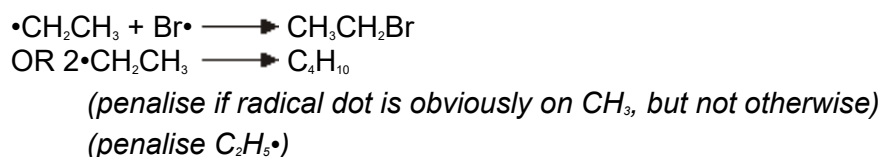
[11]

M8. (a) (i) (free-)radical substitution
(both words required for the mark) 1

(ii) uv light OR sunlight OR high temperature OR 150 °C to 500 °C 1

(iii) Propagation
(ignore "chain", "first", "second" in front of the word propagation) 1

(iv) Termination 1



(credit $2Br \longrightarrow Br_2$)
(ignore "chain" in front of the word termination)

1

(b) (i) Fractional distillation OR fractionation
(credit gas-liquid chromatography, GLC)

1

(ii) $CH_3CH_3 + 6Br_2 \longrightarrow C_2Br_6 + 6HBr$
(credit C_2H_6 for ethane)

1

(c) Correct structure for CF_2BrCF_2Br drawn out
(penalise "Fl" for fluorine)

1

(d) (i) 2-bromo-2-chloro-1,1,1-trifluoroethane
OR 1-bromo-1-chloro-2,2,2-trifluoroethane
(insist on all numbers, but do not penalise failure to
use alphabet)
(accept "flourine" and "cloro" in this instance)

1

(ii) 197.4 only
(ignore units)

1

(iii) $(57/197.4 \times 100) = 28.9\%$ OR 28.88%
(credit the correct answer independently in part (d)(iii), even
if (d)(ii) is blank or incorrectly calculated, but mark
consequential on part (d)(ii), if part (d)(ii) is incorrectly
calculated, accepting answers to 3sf or 4sf only)
(penalise 29% if it appears alone, but not if it follows a
correct answer)
(do not insist on the % sign being given)
(the percentage sign is not essential here, but penalise the
use of units e.g. grams)

1

[11]