

M1. (a) **M1** $\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Mn}^{2+} + 2\text{H}_2\text{O}$ 1

OR multiples

M2 An oxidising agent is an electron acceptor OR
receives / accepts / gains electrons

Ignore state symbols

M2 NOT an "electron pair acceptor"

1

M3 MnO_2 is the oxidising agent

Ignore "takes electrons" or "takes away electrons"

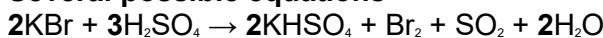
1

(b) **M1** Formation of SO_2 and Br_2 (could be in an equation)

1

M2 Balanced equation

Several possible equations



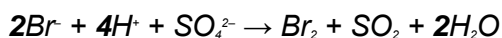
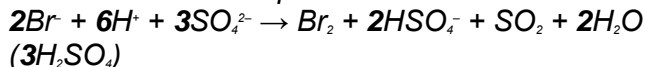
OR



1

M3 $2\text{KBr} + \text{Cl}_2 \rightarrow 2\text{KCl} + \text{Br}_2$

M2 Could be ionic equation with or without K^+

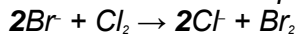


($2\text{HBr} + \text{H}_2\text{SO}_4$)

Accept HBr and H_2SO_4 in these equations as shown or mixed variants that balance.

Ignore equations for KBr reacting to produce HBr

M3 Could be ionic equation with or without K^+



1

M4 % atom economy of bromine

$$= \frac{\text{Br}_2}{2\text{KBr} + \text{Cl}_2} \times 100 = \frac{(2 \times 79.9)}{238 + 71} \times 100 = \frac{159.8}{309} \times 100$$

$$= 51.7\% \text{ OR } 52\%$$

M4 Ignore greater number of significant figures

1

M5 One from:

- High atom economy
- Less waste products
- Cl_2 is available on a large-scale
- No SO_2 produced
- Does not use concentrated H_2SO_4
- (Aqueous) KBr or bromide (ion) in seawater.
- Process 3 is simple(st) or easiest to carry out

*M5 Ignore reference to cost
Ignore reference to yield*

1

(c) **M1** HBr -1

1

M2 HBrO (+)1

1

M3 Equilibrium will shift to the right

OR

L to R

OR

Favours forward reaction

OR

Produces more HBrO

1

M4 Consequential on correct M3

OR

to oppose the loss of HBrO

OR

replaces (or implied) the HBrO (that has been used up)

1

[12]

M2. (a) Electronegativity increases

1

Proton number increases (increase in nuclear charge)

		1
	Same number of electron shells/levels <i>Or same radius or Shielding of outer electrons remains the same</i>	1
	Attraction of <u>bond pair</u> to nucleus increases <i>Allow 'electrons in bond' instead of 'bond pair'</i>	1
(b)	Big <u>difference</u> in electronegativity leads to ionic bonding, smaller covalent <i>Lose a mark if formula incorrect</i>	1
	Sodium oxide ionic lattice	1
	Strong forces of attraction <u>between ions</u>	1
	P ₄ O ₁₀ covalent molecular <i>Must have covalent and molecular (or molecules)</i>	1
	Weak (intermolecular) forces between molecules <i>Or weak vdW, or weak dipole–dipole between molecules</i>	1
	melting point Na ₂ O greater than for P ₄ O ₁₀ <i>Or argument relating mpt to strength of forces</i>	1
(c)	Moles NaOH = $0.0212 \times 0.5 = 0.0106$ <i>M1 moles of NaOH correct</i>	1
	Moles of H ₃ PO ₄ = 1/3 moles of NaOH (= 0.00353) <i>M2 is for 1/3</i>	1
	Moles of P in 25000 l = $0.00353 \times 10^6 = 3.53 \times 10^3$ <i>M3 is for factor of 1,000,000</i>	1
	Moles of P ₄ O ₁₀ = $3.53 \times 10^3/4$ <i>M4 is for factor of 1/4 (or 1/2 if P₂O₅)</i>	1
	Mass of P ₄ O ₁₀ = $3.53 \times 10^3/4 \times 284 = 0.251 \times 10^6$ g	

= 251 kg
(Or if P_2O_5 $3.53 \times 10^3/2 \times 142$)
M5 is for multiplying moles by M_r with correct units
allow conseq on incorrect M4
(allow 250-252)

1

[15]

M3.(a) percentage of oxygen is 58.33

1

correct calculation of ratios (C 3.125, H 4.17, O 3.645)

1

clearly relates ratios to formula eg
simplifies ratios (C 1, H 1.29, O 1.17) or for H then $3.125 \times 8 / 6 = 4.17\%$ etc

1

Notes

- * correct percentage of oxygen can be stated or shown clearly in a calculation
- * to score final mark must **clearly** show how ratios relate to $C_6H_8O_7$
- * allow full credit to candidate who correctly finds
percentage of oxygen
calculates M_r
shows percentage of H is 8 divided by M_r

(b) carbon dioxide / CO_2

1

(c) (i) suitable reaction vessel
eg sealed flask or test-tube with side arm or
eg tube in bung

1

suitable collection method
eg gas syringe / over water in measuring
eg cylinder

1

Notes

- * collection vessel must allow measurement of gas
- * if apparatus would leak lose second mark
- * ignore heating

- * can draw tubing as single line
- * accept 2D or 3D diagrams
- * do not need labels, and ignore mis-labelling

(ii) (1) mass on x -axis 1

Notes

* If axes unlabelled use data to decide that mass is on the x -axis

sensible scales 1

Notes

* lose this mark if the **plotted points** do not cover at least half of the paper

* lose this mark if the graph plot goes off the squared paper

plots points correctly \pm one square 1

(2) draws appropriate straight line of best fit, omitting point at 1.17g / 86 cm³

Notes

* lose this mark if the line deviates towards the point at 1.17g / 86 cm³

* candidates does not have to extrapolate the line to the origin to score this mark

* when checking for best fit, candidate's line **must** go through the origin \pm one square. Extend candidate's line if necessary 1

(3) 129 \pm 1 cm³

Notes

* accept this answer **only** 1

(d) CO₂ / gas formed distends stomach / produces wind / increases pressure in stomach 1

(e) molecular formula has to be a simple multiple of the empirical formula 1

so approximate M_r value will distinguish between the options or equivalent wording 1

(f) gas escapes before bung inserted any 2×1 for
syringe sticks
carbon dioxide soluble in water

Notes

* *do not accept 'operator error' / 'inaccurate equipment' / 'equipment leaks'* 2

(g) volume depends on pressure and temperature

Notes

* *do not accept 'to get a more accurate result' or equivalent wording without qualification* 1

(h) Tablets could vary between samples or equivalent wording

Notes

* *do not accept 'to get a more accurate / reliable result' or 'to make a fair test' without qualification* 1

(i) (i) NaHCO_3 **least** soluble 1

(ii) exhaust gases passed into mixture of NaCl and NH_3 1

(j) $2\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$

Notes

* *accept multiples*

1

(k) 106.0 divided by 217.1 \times 100 = 48.8%

Notes

* *ignore precision of answer*

1

[22]