OCR A-Level Chemistry A

Module 2: Foundations in chemistry mark scheme · goes with “Module 2: Foundations in chemistry” · whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/

Mark schemes

Acids and redox reactions, Amount of substance, Atomic structure and isotopes and Electrons, bonding and structure · 225 questions

Q1 · Acids and redox reactions · [1 mark]

Answer: **A**

$Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$

Q2 · Acids and redox reactions · [1 mark]

Answer: **C**

OCR MARK SCHEME

+5

EXAMINER GUIDANCE

ALLOW *+5* ***OR*** *5+ in box*

Q3 · Acids and redox reactions · [10 marks]

OCR MARK SCHEME

24(a)

(Acid) releases H^+ ions/ H^+ donor

AND

(weak acid) partially dissociates/ionises ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW *H^+* ***OR*** *proton*

IGNORE *vague responses that do not imply a number, e.g.*

- poor proton donor

IGNORE *‘doesn’t easily dissociate’*

IGNORE *‘a strong acid completely dissociates’*

Question is about a weak acid

24(b)(i)

$2Al(s) + 6CH_3COOH(aq) \rightarrow 2\ (CH_3COO)_3Al(aq) + 3H_2(g)$ ✓

[1 mark]

ALLOW *multiples, e.g.*

$Al(s) + 3CH_3COOH(aq) \rightarrow (CH_3COO)_3Al(aq) + 1½H_2(g)$

24(b)(ii)

Element oxidised: aluminium/Al 0 to +3 ✓

Element reduced: hydrogen/H +1 to 0 ✓

[2 marks]

ALLOW *3+ for +3 and 1+ for +1*

ALLOW *H_2 for hydrogen*

ALLOW *1 mark for elements* ***AND*** *all oxidation numbers correct, but H in oxidised line and Al in reduced line*

24(c)(i)

FIRST CHECK THE ANSWER ON THE ANSWER LINE

If answer = 2.21 (mol dm^{-3}) award 4 marks

TITRATION

M1 $n(Ba(OH)_2)$ in 25.0 cm^3

= = 1.125×10^{-3} (mol) ✓

M2 $n(CH_3COOH)$ in 25.45 cm^3 diluted vinegar

= $2 \times 1.125 \times 10^{-3} = 2.25 \times 10^{-3}$ (mol) ✓

SCALING **ALLOW ECF** from $n(CH_3COOH)$

M3 $[CH_3COOH]$ in diluted vinegar

$$= \frac{2.25 \times 10^{-3} \times 1000}{25.45} = 0.0884 \text{ (mol dm}^{-3}\text{)}$$ ✓

Calculator: 0.0884086

M4 $[CH_3COOH]$ in original vinegar

$$= \frac{0.0884 \times 250}{10.0} = 2.21 \text{ (mol dm}^{-3}\text{)}$$ ✓

[4 marks]

'+' is required in +3 and +1 oxidation numbers

IGNORE *numbers around equation*

(treat as rough working)

ALLOW 3 SF *or more correctly rounded throughout*

Apply ***ECF*** *where appropriate*

ALLOW ECF *from* $n(Ba(OH)_2)$

ALTERNATIVE APPROACHES FOR M3 AND M4:

M3 $n(CH_3COOH)$ in 25.45 cm^3 original vinegar

$$= \frac{2.25 \times 10^{-3} \times 250}{10.0} =$$ 0.05625 (mol) ✓

M4 $[CH_3COOH]$ in original vinegar

$$= \frac{0.05625 \times 1000}{25.45} = 2.21 \text{ (mol dm}^{-3}\text{)}$$ ✓

M3 $n(CH_3COOH)$ in 250 cm^3 diluted vinegar

$$= \frac{2.25 \times 10^{-3} \times 250}{25.45} =$$ 0.0221 (mol) ✓

M4 $[CH_3COOH]$ in original vinegar

$$= 0.0221 \times \frac{1000}{250} \times \frac{250}{10.0} = 2.21 \text{ (mol dm}^{-3}\text{)}$$ ✓

24(c)(ii)

Assumption:

Vinegar contains (ethanoic acid and) no other acids ✓

Prediction:

For credit, the response must refer to other acids

IGNORE *impurities, solution is pure, etc*

Experimental result is greater than conc of CH_3COOH

OR conc of CH_3COOH is less than experimental result ✓

[2 marks]

ONLY award the 'prediction' mark if 'assumption' mark is correct

Q4 · Acids and redox reactions · [1 mark]

Answer: **D**

0.50%

Q5 · Acids and redox reactions · [1 mark]

Answer: **C**

OCR MARK SCHEME

+6

EXAMINER GUIDANCE

ALLOW *+6 in the box*

Q6 · Acids and redox reactions · [1 mark]

Answer: **C**

calcium hydroxide

Q7 · Acids and redox reactions · [1 mark]

Answer: **A**

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Q8 · Acids and redox reactions · [1 mark]

Answer: **C**

OCR MARK SCHEME

+6

EXAMINER GUIDANCE

ALLOW *+6*

Q9 · Acids and redox reactions · [1 mark]

Answer: **D**

$H_2S + Cl_2 \rightarrow 2HCl + S$

Q10 · Acids and redox reactions · [13 marks]

OCR MARK SCHEME

1(a)

A solution of known concentration ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW *description of concentration*

1(b)

Releases OH^- (ions in aqueous solution) ✓

ALLOW *containing OH^- ions*

[1 mark]

IGNORE *mention of pH*

1(c)(i)

Final reading/cm^3	27.30	27.00	27.75
Initial reading/cm^3	0.45	0.60	1.25
Titre/cm^3	26.85	26.4**0**	26.5**0**

Initial and final readings

All burette readings (×6) correct ✓

Titres recorded to two decimal places with the last figure either 0 or 5

Correct subtractions to obtain final titre values ✓

Mean titre calculated from concordant results

Correct mean titre = 26.45 (cm^3) ✓

Mean titre recorded to accuracy of burette

Final answer recorded to two decimal places with the last figure either 0 or 5 ✓

ALLOW *missing zeroes for burette readings*

i.e. 0.6 for 0.60

27 OR 27.0 for 27.00

ALLOW ECF from incorrect burette readings

IF *MEAN IS CALCULATED FROM* ***ECF****, IT MUST BE FROM CLOSEST TITRES*

ALLOW *ecf from incorrect mean*

DO NOT ALLOW *26.5* cm^3

Question asks for nearest 0.05 cm^3

[4 marks]

1(c)(ii)

$$\frac{2 \times 0.05}{26.85} \times 100 = 0.37(2)\ (\%)$$ ✓

ALLOW *0.4 up to full calculation display of 0.372439478*

ALLOW ECF FOR CORRECT CALCULATION FROM 1 (c) (i) OR USE OF ANY TITRE

[1 mark]

1(c)(iii)

Use a (250 cm^3) volumetric flask (instead of a beaker) ✓

IGNORE *graduated flask*

[1 mark]

1(d)(i)

FIRST CHECK ANSWER ON ANSWER LINE

If answer = 118 (g mol^{-1}*) award 4 marks*

If answer = 108 (g mol^{-1}*) award 3 marks*

n(NaOH)

$$= 0.112 \times \frac{25.0}{1000} = 0.00280\ (\text{mol})$$ ✓

Throughout: **IGNORE** trailing zeroes in intermediate working,

e.g. For *n*(NaOH) **ALLOW** 0.0028 for 0.00280

ALLOW ECF from incorrect n(NaOH)

ALLOW ECF from incorrect n(A) OR n(NaOH)

n(A) in 25.0 cm^3

$= \frac{0.00280}{2} = 0.00140$ (mol) ✓

n(A) in 250 cm^3

$= 0.00140 \times \frac{250.0}{27.30} = 0.0128$ (mol) ✓

Molar mass, M(A) to nearest whole number.

$= \frac{1.513}{0.0128} = 118$ (g mol^{-1}) ✓

[4 marks]

ALLOW *3 sig fig up to full calculator display correctly rounded (0.012820512)*

ALLOW ECF from incorrect n(NaOH)

Possible ECFs for 3 marks

$0.00140 \times \frac{250}{\frac{1.513}{25}} = 108$

$\frac{1.513}{0.00140} = 1081$

No ÷2 for n(A)

- Molar mass A = 59 (g mol^{-1})

Using mean titre of 26.45 cm^3 from 1c(i)

- Molar mass A = 114 (g mol^{-1})

Using 27.3 × 0.112 in M1 and then 25.0 in M3

- Molar mass A = 99 (g mol^{-1})

1(d)(ii)

Structure of dicarboxylic acid

$HOOCCH_2CH_2COOH$ OR $HOOCCH(CH_3)COOH$ ✓

STRUCTURE MUST MATCH M_r from answer to 1 d) i) (within 10 AMU)

[1 mark]

ALLOW *correct structural OR skeletal OR displayed formulae OR a combination*

ALLOW *incorrect connectivity e.g –HO*

ALLOW ECF from incorrect molar mass in (d)(i) but only if 2 × COOH possible and M_r is a close match to (d) (i) within 10 AMU

Q11 · Acids and redox reactions · [1 mark]

Answer: **C**

I: +3 · Sb: +5

Q12 · Acids and redox reactions · [1 mark]

Answer: **D**

0.0964

Q13 · Acids and redox reactions · [1 mark]

Answer: **D**

It has the formula NH_4CO_3.

Q14 · Acids and redox reactions · [7 marks]

OCR MARK SCHEME EXAMINER GUIDANCE

22(a)(i)

Titre/cm^3	24.20	23.85	24.30	✓

Correct subtractions to obtain titres to 2 DP

[1 mark]

DO NOT ALLOW *24.2* ***OR*** *24.3*

22(a)(ii)

mean titre = $\frac{24.20 + 24.30}{2}$ = 24.25 (cm^3) ✓

i.e. using concordant (consistent) titres

[1 mark]

DO NOT ALLOW *mean of all three titres,*

i.e.

$\frac{24.20 + 23.85 + 24.30}{3}$ =

24.10/24.12

ALLOW ECF *from incorrect concordant titres from 22a(i)*

22(b)

FIRST CHECK THE ANSWER ON ANSWER LINE

IF answer = 0.309 (mol dm^{-3}) award 3 marks

$n(Na_2CO_3)$

= 0.150 × $\frac{25.00}{1000}$ = 3.75×10^{-3} (mol) ✓

n(HCl)

= 2 × $n(Na_2CO_3)$ = 7.50×10^{-3} (mol) ✓

[HCl] to 3 SF

= n(HCl) × $\frac{1000}{\text{mean titre from b(i)}}$

= $7.50 \times 10^{-3} \times \frac{1000}{24.25}$ = 0.309 (mol dm^{-3}) ✓

3 SF required

[3 marks]

ALLOW 3SF *or more throughout*

IGNORE *trailing zeroes,*

e.g. **ALLOW** 0.075 for 0.00750

ALLOW ECF *from 2 × incorrect $n(Na_2CO_3)$*

ALLOW ECF *from incorrect n(HCl),*

OR from $n(Na_2CO_3)$ if n(HCl) stage omitted

ALLOW ECF *from incorrect mean titre in b(ii)*

COMMON ERROR for 3 marks

From 24.10 cm^3 (mean of all 3 titres in b(ii)), [HCl] = 0.311 (mol dm^{-3})

22(c)

Pipette:

$\frac{0.04}{25.0}$ × 100 = 0.16 **OR** 0.2 (%) ✓

Burette: (using any of 3 titres or mean titre), e.g.

$\frac{0.05 \times 2}{24.20}$ × 100 = 0.41 **OR** 0.4 (%) ✓

ALLOW *% uncertainties to 1 SF or more, rounded correctly*

Other burette volumes:

$\frac{0.05 \times 2}{23.85}$ × 100 = 0.42 **OR** 0.4 (%)

Response does **NOT** need a statement of whether pipette or burette has greater % uncertainty.

[2 marks]

$\frac{0.05 \times 2}{24.30} \times 100 = 0.41$ **OR** 0.4 (%)

$\frac{0.05 \times 2}{24.25} \times 100 = 0.41$ **OR** 0.4 (%)

ALLOW burette volume of 50 cm^3, i.e.

$\frac{0.05 \times 2}{50} \times 100 = 0.2\%$

ALLOW ECF *from incorrect titre in 22(a)*

IF BOTH *calculations are 'correct' but ×100 is omitted BOTH times,* ***ALLOW*** *1 mark*

Q15 · Acids and redox reactions · [1 mark]

Answer: **D**

$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

Q16 · Acids and redox reactions · [11 marks]

OCR MARK SCHEME

2(a)

Level 3 (5–6 marks)

Calculates the correct mass of $Mg(NO_3)_2 \cdot 6H_2O$ or $Mg(NO_3)_2$.

AND

Explains the preparation steps, with most fine detail.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Attempts a calculation which is partly correct.

AND

Outlines the preparation steps, with some fine detail.

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Attempts the calculation but makes little progress or makes errors.

OR

EXAMINER GUIDANCE

Indicative scientific points may include:

Calculation:

$n = \frac{250.0}{1000} \times 0.4000 =$ 0.1(000) (mol)

$M(Mg(NO_3)_2 \cdot 6H_2O) = 256.3$

Mass = 0.1000 × 256.3 = 25.63 g

OR $M(Mg(NO_3)_2) = 148.3$

Mass = 14.83 g

ALLOW *small slip/rounding errors such as errors on M_r (e.g. use of 24 instead of 24.3 for Mg A_r)*

Preparation steps (apparatus and method):

- Weigh mass of crystals
- Dissolve in (distilled/deionised) water

Briefly outlines the preparation steps, which may be incomplete

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

- Transfer to 250 cm^3 volumetric flask
- Make up to the mark with more water so that bottom of meniscus is on the mark

IGNORE *removing the water of crystallisation*

Fine detail:

- 2 or more decimal place balance
- Rinse beaker and transfer washings to flask
- Use of dropping pipette when filling to mark
- Stopper, invert several times to mix

2(b)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 38.5 cm^3 award 3 marks

$n(Mg(NO_3)_2) = \frac{5.00}{148.3}$ = 0.0337 ..... (mol) ✓

$n(HNO_3)$ = 2 × 0.0337 ..... = 0.0674 .....(mol) ✓

volume = 0.0674..... × $\frac{1000}{1.75}$ = 38.5 (cm^3) ✓

3 SF required

[3 marks]

Calculator: 0.03371544167

ALLOW ECF *from $n(Mg(NO_3)_2)$*

Calculator: 0.06743088334

ALLOW ECF *from $n(HNO_3)$*

2(c)

Element oxidised: Oxygen/O

Change from: –2 to 0 ✓

Element reduced: Nitrogen/N:

Change form + 5 to +4 ✓

[2 marks]

MAX 1 mark if no '+' sign for oxidation number

ALLOW *2–*

ALLOW *5+* ***AND*** *4+*

ALLOW *O_2 for oxygen*

ALLOW *1 mark for all oxidation numbers correct, but oxidised and reduced the wrong way around*

IGNORE *numbers around equation*

i.e. treat as rough working

Q17 · Acids and redox reactions · [1 mark]

Answer: **B**

+3

Q18 · Acids and redox reactions · [1 mark]

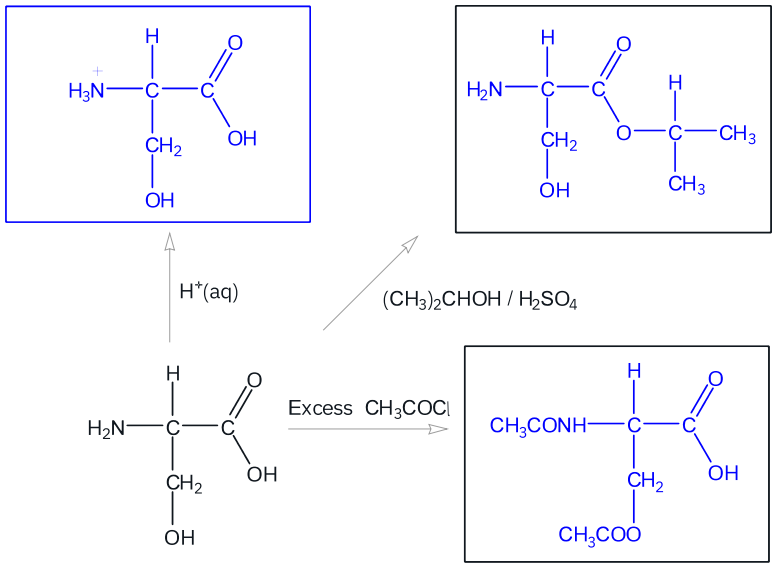
Answer: **D**

$3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2$

Q19 · Acids and redox reactions · [11 marks]

OCR MARK SCHEME

17(a)(i)



✓✓✓✓

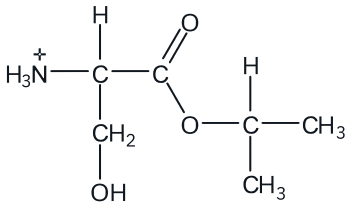
[4 marks]

EXAMINER GUIDANCE

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW *protonation of* NH_2 *group in reaction with* $(CH_3)_2CHOH$

i.e.

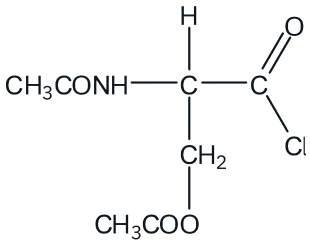


ALL structures must be based on serine

For reaction with excess CH_3COCl,

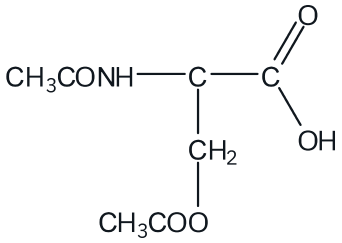
IGNORE *reaction of COOH to form an acid anhydride*

ALLOW *1 mark for*



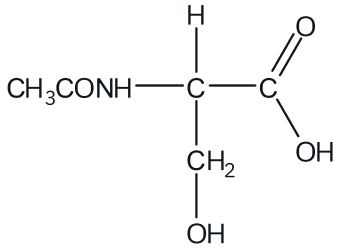
(both NH and OH groups reacted but acyl chloride instead of COOH)

OR



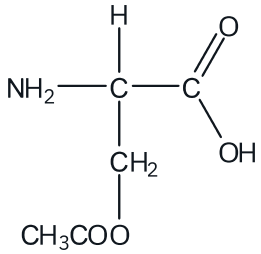
(both NH and OH groups reacted but H missing from α C atom)

OR



(NH group reacted correctly but rest of serine unchanged)

OR



(OH group reacted correctly but rest of serine unchanged)

17(a)(ii)

IF M_r(amino acid) = 131 from titration analysis AWARD *first 3 marks*

ALLOW 3SF *or more throughout*

IGNORE *trailing zeroes, e.g.* ***ALLOW*** *0.044 for 0.0440*

$n(\text{HCl}) = \dfrac{0.150 \times 25.0}{1000}$ **OR** 3.75×10^{-3} (mol) ✓

n(amino acid) in 250 cm^3

$= \dfrac{3.75 \times 10^{-3} \times 250.0}{21.30}$ **OR** 0.0440 (mol) ✓

$M(\text{amino acid}) = \dfrac{5.766}{0.0440} = 131\ (\text{g mol}^{-1})$ ✓

ALLOW *alternative approaches*

Calculator: 0.04401408451

ALLOW ECF *from incorrect n(HCl)*

ALLOW ECF *from incorrect n(amino acid)*

ALLOW ECF *from incorrect M(amino acid)*

i.e. ECF for alkyl group closest to calculated *M*(alkyl group),

e.g. for *M*(alkyl group) = 15, **ALLOW** $CH_3CH(NH_2)COOH$

Note: evidence may be shown with table

Amino acid = $(CH_3)_2CHCH_2CH(NH_2)COOH$/leucine

AND working to show R = 57 to justify choice

OR evidence to show M_r leucine = 131 to justify choice ✓

[4 marks]

17(b)(i)

R_f value in range 0.33 – 0.35 ✓

[1 mark]

ALLOW *2 SF or more. But ignore digits after second sig fig*

ALLOW *0.3 for 0.33.....*

17(b)(ii)

gly(cine) ✓

Amino acid matches (leu(cine) and) glycine in Solvent W

AND

Amino acid matches (ala(nine) and) glycine in Solvent X ✓

[2 marks]

ALLOW *glycine has the same/similar R_f as the unknown in both solvents/chromatograms*

ALLOW *suitable alternatives for R_f*

e.g. moves same distance

Q20 · Acids and redox reactions · [1 mark]

Answer: **D**

NH_3

Q21 · Acids and redox reactions · [15 marks]

OCR MARK SCHEME

1(a)(i)

(Acid) releases H^+ ions/ H^+ donor ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW *H^+* ***OR*** *proton*

1(a)(ii)

(weak acid) partially dissociates/ionises ✓

[1 mark]

IGNORE *vague responses that do not imply a number, e.g.*

- poor proton donor

IGNORE *'doesn't easily dissociate'*

IGNORE *'strong acid completely dissociates'*

1(b)(i)

	Titration 1	**Titration 2**	**Titration 3**
Final reading/cm^3	27.35	27.65	27.85
Initial reading/cm^3	0.05	0.10	0.45
Titre/cm^3	27.30	27.55	27.40

Initial and final readings

All titration readings (×6) correct ✓

Titres

Correct subtractions to obtain final titre values ✓

Mean titre calculated from concordant results

Correct mean titre = 27.35 (cm^3) ✓

Reading recorded to accuracy of burette

All values including mean titre recorded to two decimal places with the last figure either 0 or 5 ✓

[4 marks]

ALLOW *missing zeroes throughout except for last marking point*

e.g. 0.1 for 0.10

ALLOW ECF *from incorrect burette readings*

IF MEAN IS CALCULATED FROM ECF, IT MUST BE FROM CLOSEST TITRES

ALLOW any number of decimal places for mean titre for this mark

Note: Question asks for mean titre to nearest 0.05 cm^3

1(b)(ii)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 7.(00) award 5 marks

ALLOW ECF from incorrect titre calculated in 1(b)(i)

Throughout:

$n(\text{NaOH}) = \dfrac{27.35 \times 0.800}{1000} = 0.02188$ ✓

$n(\text{A})$ in 25.0 $\text{cm}^3 = \dfrac{0.02188}{3} = 0.00729(33)$ ✓

$n(\text{A})$ in 250 $\text{cm}^3 = 10 \times 0.00729(33) = 0.0729(33)$ ✓

mass citric acid in 250 $\text{cm}^3 = 0.0729 \times 192 = 14(.0032)$ (g) ✓

mass citric acid in one lime $= \dfrac{14.0}{2} = 7.(00)$ (g) ✓

[5 marks]

ALLOW *3 SF or more, correctly rounded*

e.g. $n(\text{NaOH}) = 0.0219$ for 0.02188

ALLOW ECF *from incorrect n(NaOH)*

ALLOW ECF *for all subsequent steps*

From $n(\text{NaOH}) = 0.0219$,

$n(\text{A}) = 0.073(0)$

mass citric acid = 14(.016)

mass in 1 lime = 7(.008)

1(c)

Action taken to modify method

Use half a lime

OR

Make up lime juice (solution) in 1 dm^3 volumetric flask ✓

Dilution ratio to justify

4 times less citric acid/lime juice

OR

NaOH is 4 times more dilute (giving same titre)

OR

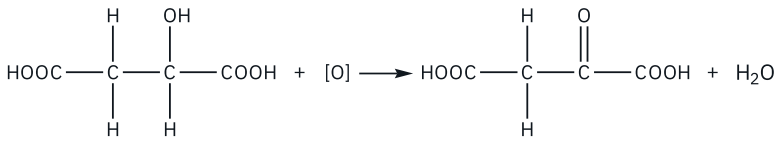
1:4 ratio for NaOH concentration ✓

[2 marks]

ALLOW *any feasible method that would give a dilution factor of 4*

ALLOW *quartered*

1(d)



Correct structure of product ✓

Correctly balanced equation ✓

[2 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

Q22 · Acids and redox reactions · [1 mark]

Answer: **B**

3 Fe^{2+} and 4 Fe^{3+}

Q23 · Acids and redox reactions · [11 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

22(a)

(Strong acid) completely/fully dissociates/ionises ✓

[1 mark]

DO NOT ALLOW *easily dissociates*

ALLOW ALL H^+ ions are released

22(b)(i)

$CuO + 2HCl \rightarrow CuCl_2 + H_2O$ ✓

[1 mark]

ALLOW multiples

IGNORE *state symbols*

IGNORE *charges, even if wrong*

22(b)(ii)

$(NH_4)_2CO_3 + 2HNO_3 \rightarrow 2NH_4NO_3 + CO_2 + H_2O$

Any 4 formulae correct ✓

All 5 formulae correct and balanced ✓

[2 marks]

ALLOW multiples

IGNORE *state symbols*

IGNORE *charges, even if wrong*

ALLOW H_2CO_3 for $CO_2 + H_2O$

Counts as 2 formulae for marking criteria

22(c)(i)

Volumetric flask ✓

[1 mark]

ALLOW graduated flask

22(c)(ii)

Shaded cells were given in the question.

Final reading/cm^3	20.25	40.85	25.85
Initial reading/cm^3	0.00	20.25	5.50
Titre/cm^3	**20.25**	**20.60**	**20.35**

All 3 titres correct to 2 DP ✓

[1 mark]

DO NOT ALLOW *1 DP, e.g. 20.6 instead of 20.60*

22(c)(iii)

mean titre = $\frac{20.25 + 20.35}{2}$ = 20.30 (cm^3) ✓

i.e. using concordant (consistent) titres

[1 mark]

ALLOW 20.3

Missing '0' already penalised in c(ii)

DO NOT ALLOW *mean of all three titres,*

i.e. $\frac{20.25 + 20.60 + 20.35}{3}$ = 20.40

22(c)(iv)

$n(H_2SO_4) = 0.165 \times \frac{20.30}{1000} = 3.35 \times 10^{-3}$ (mol) ✓

ALLOW ECF *throughout and from incorrect concordant titres from 22c(iii)*

n(MOH) in 25.0 cm^3 = $2 \times 3.35 \times 10^{-3}$

$= 6.70 \times 10^{-3}$ (mol) ✓

n(MOH) in 250.0 cm^3 = $10 \times 6.70 \times 10^{-3}$

$= 6.70 \times 10^{-2}$ (mol) ✓

A_r of M = $\dfrac{2.62}{6.70 \times 10^{-2}}$ = 39.1 AND M = potassium/K ✓

COMMON ERRORS

Use of 20.4 from mean of all 3 titres ALL 4 MARKS

$n(H_2SO_4) = 0.165 \times \dfrac{20.4}{1000} = 3.366 \times 10^{-3}$ (mol) ✓ from (c)

(iii)

n(MOH) in 25.0 cm^3 = $2 \times 3.366 \times 10^{-3}$

$= 6.732 \times 10^{-3}$ (mol) ✓

n(MOH) in 250.0 cm^3 = $10 \times 6.732 \times 10^{-3}$

$= 6.732 \times 10^{-2}$ (mol) ✓

A_r of M = $\dfrac{2.62}{6.732 \times 10^{-2}}$ = 38.9.... **OR** 39 AND M = K ✓

IF *×10 is absent,* A_r *= 389 AND M = Cs* ***OR*** *Fr*

Use of 25.0 (wrong volume) for $n(H_2SO_4)$

$n(H_2SO_4) = 0.165 \times \dfrac{25}{1000} = 4.125 \times 10^{-3}$ (mol) ✗

n(MOH) in 25.0 cm^3 = $2 \times 4.125 \times 10^{-3}$

$= 8.25 \times 10^{-3}$ (mol) ✓

n(MOH) in 250.0 cm^3 = $10 \times 8.25 \times 10^{-3}$

$= 8.25 \times 10^{-2}$ (mol) ✓

A_r of M = $\dfrac{2.62}{8.25 \times 10^{-2}}$ = 31.75..... AND M = K ✓

IF *×10 is absent,* A_r *= 317.5 AND M = Cs* ***OR*** *Fr*

Calculator value = 3.3495×10^{-3}

Calculator value = 6.699×10^{-3}

Calculator value = 6.699×10^{-2}

By **ECF**, ALLOW Group 1 metal nearest to calculated value of A_r

[4 marks]

Q24 · Acids and redox reactions · [1 mark]

Answer: **B**

S_8

Q25 · Acids and redox reactions · [11 marks]

OCR MARK SCHEME EXAMINER GUIDANCE

5(a)

FIRST CHECK THE ANSWER ON ANSWER LINE

If Mass = 318 (mg) award 6 marks

Mean titre 1 mark

$= \frac{(22.30 + 22.40)}{2} = 22.35(0)$ (cm^3) ✓

Analysis of results 5 marks

$n(HCl) = \frac{0.200 \times 22.35}{1000} = 4.47 \times 10^{-3}$ (mol) ✓

n(NaOH) remaining in 25.0 cm^3 = n(HCl)

n(NaOH) remaining in 250 cm^3

$= 4.47 \times 10^{-3} \times 10 = 4.47 \times 10^{-2}$ **OR** 0.0447 (mol) ✓

n(NaOH) that reacted with aspirin

$= 0.0500 - 4.47 \times 10^{-2} = 5.30 \times 10^{-3}$ (mol) ✓

mass in 3 tablets $= 5.30 \times 10^{-3} \times 180 = 0.954$ g ✓

Mass in 1 tablet = 318 mg ✓

COMMON ERRORS:

No scaling × 10

$0.05 - 4.47 \times 10^{-3} \rightarrow 4.553 \times 10^{-2}$ ✓

$4.553 \times 10^{-2} \times 180 \rightarrow 8.1954$ g in 3 tablets ✓

→ 2731.8/2732/2730 mg in 1 tablet ✓ 5 marks

No scaling × 10 before subtraction but scaling after

4 marks

$0.05 - 4.47 \times 10^{-3} \rightarrow 4.553 \times 10^{-2}$ ✓

$4.553 \times 10^{-2} \times 10 \times 180 \rightarrow 81954$ g in 3 tablets ✗

→ 27318 / 27320 / 27300 mg in 1 tablet ✓

[6 marks]

Common error:

Incorrect mean from all 3 titres = 22.6 cm^3

CHECK BELOW TITRATION TABLE

Use **ECF** throughout

Intermediate values for working to at least 3 SF.

ALLOW scaling for 1 aspirin tablet early in calc, e.g. for final 2 marks:

n(aspirin) in 1 tablet

$= \frac{5.30 \times 10^{-3}}{3} = 1.77..... \times 10^{-3}$ (mol) ✓

Mass in 1 tablet = $1.77..... \times 10^{-3} \times 180 = 0.318$ g

= 318 mg ✓

No subtraction from 0.05 5 marks

$\rightarrow 4.47 \times 10^{-2} \times 180 \rightarrow 8.046 \rightarrow$ 2682/2680 mg in 1 tablet

---

Omitting initial titration calculation 2 marks

$0.05 \times 180 \rightarrow 9$ g in 3 tablets ✓ → 3000 mg in 1 tablet ✓

Mean of 22.60 (use of all 3 titres) 5 marks

Mean $= \frac{67.8}{3} = 22.60$ ✗→

4.52×10^{-3} ✓ $\times 10 \rightarrow 4.52 \times 10^{-2}$ ✓

$0.05 - 4.52 \times 10^{-2} \rightarrow 4.80 \times 10^{-3}$ ✓

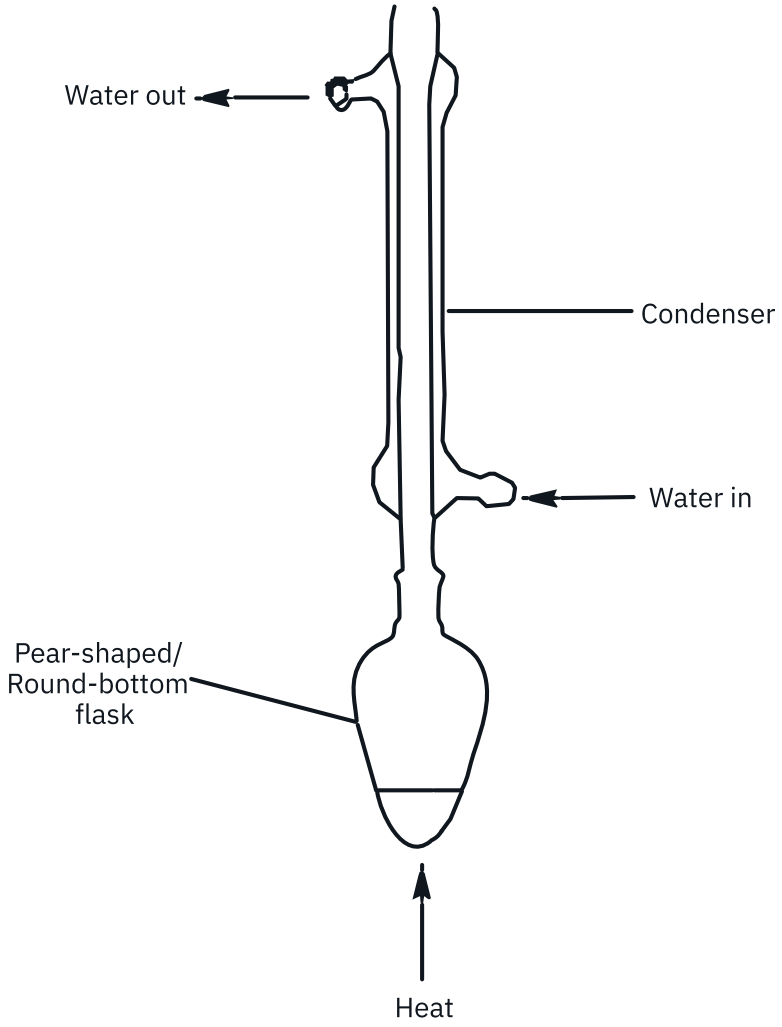
$4.80 \times 10^{-3} \times 180 \rightarrow 0.864$ g in 3 tablets ✓

→ 288 mg in 1 tablet ✓

5(b)(i)

For open system,

DO NOT ALLOW



Reaction apparatus (Labels **NOT** required)

flask

AND upright condenser

AND open system at top ✓ *(Could be labelled)*

Labels **AND** direction of water flow

Pear-shaped/round-bottom flask

AND condenser

AND water in at bottom and out at top ✓

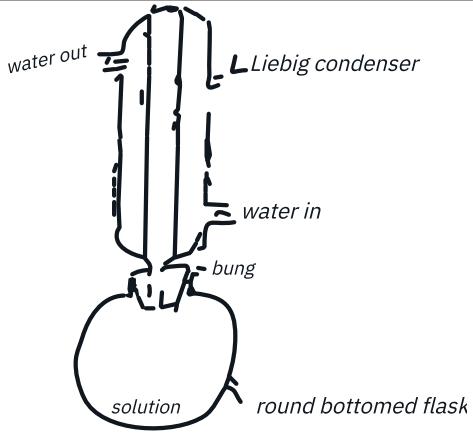
Heat **NOT** required

DO NOT ALLOW *flask, conical flask, volumetric flask*

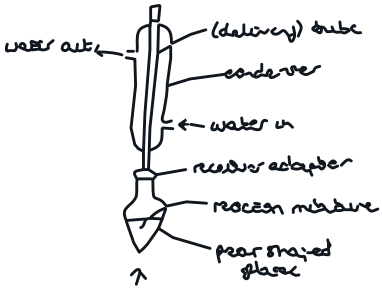
DO NOT ALLOW *thermometer*

DO NOT ALLOW *condensing tube as label*

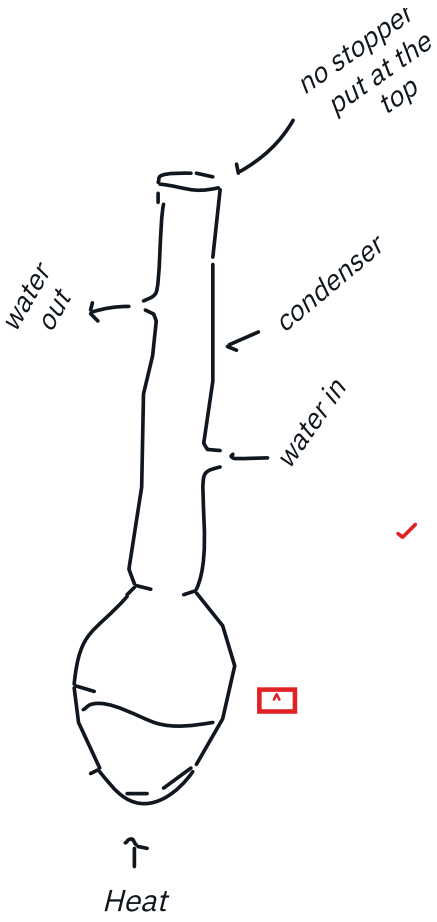
[2 marks]

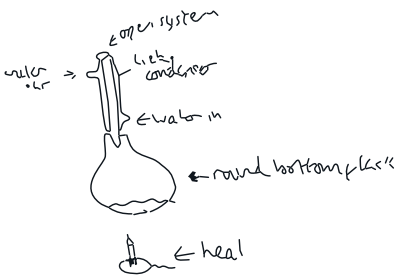


✓



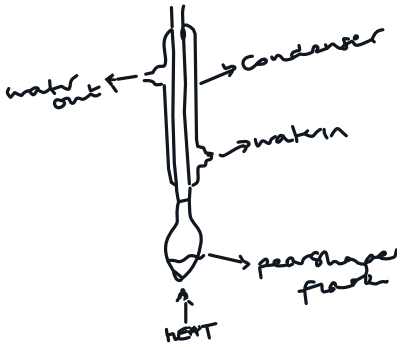
For open system, ALLOW label. e.g. 'open at top'

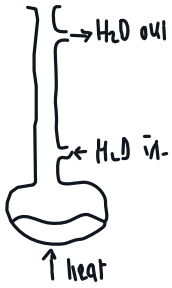


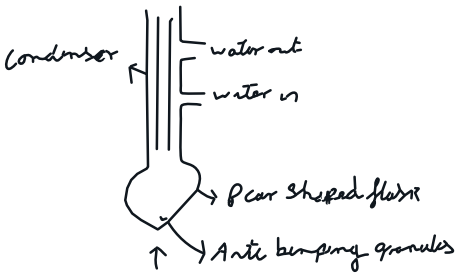


BOD ✓ ✓

ALLOW line across flask

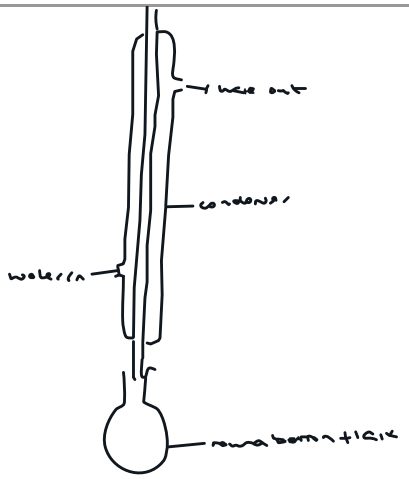






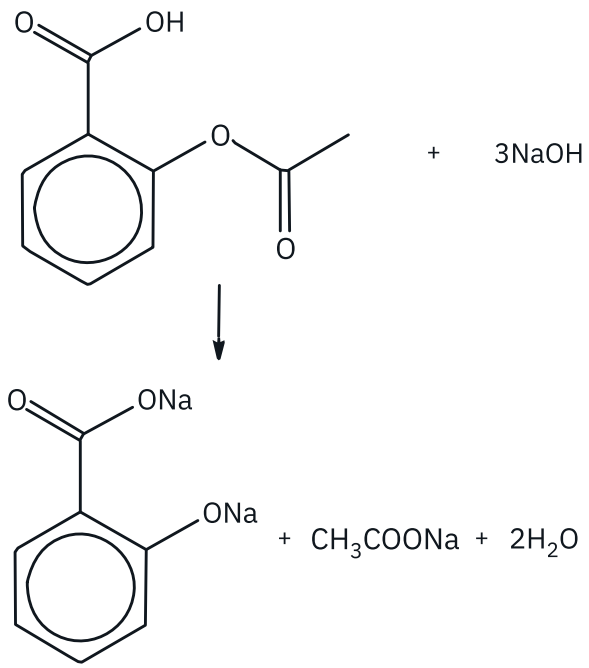
✓ ✓

ALLOW small gap between flask and condenser BOD, e.g.



✓

5(b)(ii)



Organic products ✓ ✓ 2 marks

3NaOH **AND** $2H_2O$ ✓ 1 mark

***NOTE**: ALLOW O^-Na^+ for ONa throughout*

SCROLL DOWN FOR PRODUCTS

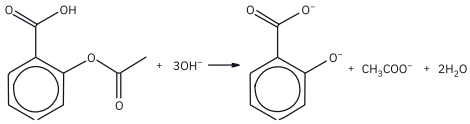
[3 marks]

*ALLOW any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous*

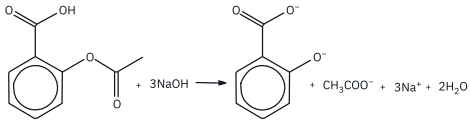
IGNORE annotations of provided structure of aspirin at top left

*ALLOW equation with $3OH^-$ **OR** 3NaOH giving anions for organic products, i.e.*

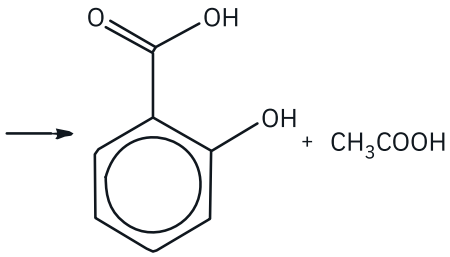
i.e.

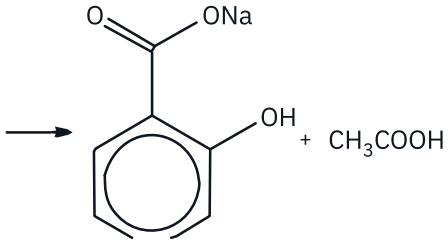


OR



ALLOW 1 of the 2 organic products mark for BOTH structures as COOH and OH (or mixture) e.g





Q26 · Acids and redox reactions · [8 marks]

OCR MARK SCHEME

22(a)

strong acid: fully dissociates/ionises

AND

weak acid: partially dissociates/ionises ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW strong acid fully dissociates

weak acid dissociates/ionises less

ALLOW strong acid releases all H^+ ions

weak acid partially releases H^+ ions

IGNORE strong acid dissociates more

strong acid dissociates quicker

DO NOT ALLOW

strong acid fully dissociates

weak acid does not fully dissociate

Response does not state that weak acid dissociates

IGNORE breaks down for dissociate/ionise

***DO NOT ALLOW** comparison of concentrations*

22(b)(i)

Titre/cm^3	24.40	24.15	24.25	✓

Correct subtractions to obtain titres to 2 DP

[1 mark]

***DO NOT ALLOW** 24.4*

22(b)(ii)

mean titre = $\frac{24.15 + 24.25}{2}$ = 24.20 (cm^3) ✓

i.e. using concordant (consistent) titres

[1 mark]

ALLOW 24.2 DP already assessed in b(i)

***DO NOT ALLOW** mean of all three titres,*

22(b)(iii)

FIRST CHECK ANSWER ON ANSWER LINE

IF answer = 89.4 (%) award 5 marks

CHECK mean titre from 22b(ii) first.

THEN apply **ECF** throughout using THIS mean titre

First 3 mark must come from the titration

$n(Na_2CO_3) = 0.200 \times \frac{24.20}{1000} = 4.84 \times 10^{-3}$ (mol) ✓

$n(CH_3COOH)$ in 25.0 $cm^3 = 2 \times 4.84 \times 10^{-3} =$

9.68×10^{-3} (mol) ✓

$n(CH_3COOH)$ in 250 $cm^3 = 10 \times 9.68 \times 10^{-3} =$

9.68×10^{-2} (mol) ✓

mass of CH_3COOH) in 250 $cm^3 = 60 \times 9.68 \times 10^{-2} = 5.808$ (g) ✓

% composition to 3 SF = $\frac{5.808}{6.50} \times 100 = 89.4$ (%) ✓ 3 SF

Calculator: 89.35384615

COMMON ERRORS

Omitting ÷ 1000 for $n(Na_2CO_3)$

Up to 3 marks are possible

$n(Na_2CO_3) = 0.200 \times 24.20 = 4.84$ (mol) ✗

$n(CH_3COOH)$ in 25.0 $cm^3 = 2 \times 4.84 = 9.68$ (mol) ✓

$n(CH_3COOH)$ in 250 $cm^3 = 10 \times 9.68 = 96.8$ (mol) ✓

mass of CH_3COOH) in 250 $cm^3 = 60 \times 96.8 = 5808$ (g) ✓

% composition to 3 SF = $\frac{5808}{6.50} \times 100 = 89400$ (%) ✗

Impossible value

[5 marks]

i.e.

$\frac{24.40 + 24.15 + 24.25}{3} =$

24.26/24.27

ALLOW ECF *from incorrect concordant titres from 22b(i)*

ALLOW 3SF or more throughout

IGNORE trailing zeroes,

e.g. ALLOW 24.2 for 24.20

ALLOW ECF *from incorrect mean titre in b(ii)*

ALLOW ECF *from 2 × incorrect* $n(Na_2CO_3)$

ALLOW ECF *from incorrect* $n(CH_3COOH)$,

OR

from $n(Na_2CO_3)$ if $n(CH_3COOH)$ stage omitted

ALLOW 5.81 (3 SF)

IF mass is rounded to 5.81, Answer is still 89.4%

Calculator = 89.38461538

8.94% is 4 marks (omission of × 10 stage)

IF incorrect mean titre of 24.26/24.27 cm^3 *used:*

(mean of all 3 titres in b(ii)),

% composition = 89.6% to 3 SF for ALL 5 marks by **ECF**

NOTE*: Some candidates are calculating* $n(CH_3COOH)$ *based on the 6.50 g sample being pure*

DO NOT ALLOW *0.108(3.....*

$n(CH_3COOH) = \frac{6.50}{60} = 0.108(3.....$

COMMON ERRORS

Using 25.0 cm^3 (pipette volume) instead of 24.20 cm^3

Up to 4 marks are possible

$n(Na_2CO_3) = 0.200 \times \frac{25.00}{1000} = 5.00 \times 10^{-3}$ (mol) ✗

$n(CH_3COOH)$ in 25.0 $cm^3 = 2 \times 5.00 \times 10^{-3} = 1 \times 10^{-2}$ (mol) ✓

$n(CH_3COOH)$ in 250 $cm^3 = 10 \times 1 \times 10^{-2} = 1 \times 10^{-1}$ (mol) ✓

mass of $CH_3COOH)$ in 250 $cm^3 = 60 \times 1 \times 10^{-1} = 6.00$ (g) ✓

% composition to 3 SF

$= \frac{6.00}{6.50} \times 100 = 92.3$ (%) ✓

Calculator: 92.30769231

Q27 · Acids and redox reactions · [1 mark]

Answer: **D**

0.55%

Q28 · Acids and redox reactions · [1 mark]

Answer: **C**

OCR MARK SCHEME

+2

EXAMINER GUIDANCE

ALLOW +2

Q29 · Acids and redox reactions · [1 mark]

Answer: **B**

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

Q30 · Acids and redox reactions · [11 marks]

OCR MARK SCHEME

3(a)(i)

23.30	**23.05**	**23.15**

✓

[1 mark]

3(a)(ii)

Mean titre = $\frac{23.05 + 23.15}{2}$ = 23.1(0) ✓

[1 mark]

3(a)(iii)

FIRST CHECK THE ANSWER ON THE ANSWER LINE

If answer = 413 (mg) award 5 marks

n(NaOH) = $\frac{23.1 \times 0.08}{1000}$ = 1.848×10^{-3} ✓

n(acid) in 25 cm^3 = $\frac{1.848 \times 10^{-3}}{2}$ = 9.24×10^{-4} ✓

n(acid) in 250 cm^3 for 3 tablets = $9.24 \times 10^{-4} \times 10$

$= 9.24 \times 10^{-3}$ ✓

mass of acid in 3 tablets = $9.24 \times 10^{-3} \times 134$

= 1.23(816) g ✓

mass of acid in one tablet = $\frac{1.23816 \times 1000}{3}$ = 413 (mg) ✓

[5 marks]

EXAMINER GUIDANCE

DO NOT ALLOW *23.3*

ALLOW ECF *from incorrect titres from 3a(i) but values must be concordant (i.e. within 0.1 cm^3 of each other)*

ALLOW ECF *from incorrect mean titre in a(ii) and throughout*

ALLOW *3SF up to calculator value throughout*

TAKE CARE: values shown may be truncated calculator values.

IGNORE *rounding errors past 3SF*

Steps can be calculated in any order which will change the intermediate answers. Marks are for the processing of the data.

Alternative Approach

n(acid) in one tablet

= $\frac{9.24 \times 10^{-3}}{3}$ = 3.08×10^{-3} ✓

mass of acid in one tablet =

$3.08 \times 10^{-3} \times 134 \times 1000$

= 413 (mg) ✓

Final answer must be to 3 SF **AND** mg

COMMON ERRORS

0.413, 4.13, 41.3	4 marks	Incorrect conversion to mg **(check for x 10 in method)**
1240 / 1238	4 marks	Not divided by 3 for 1 tablet

3(b)

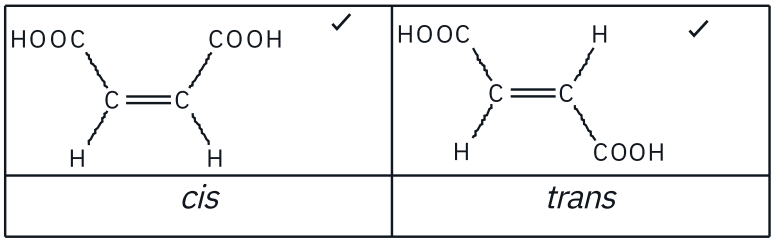
The titre would be greater ✓

(NaOH) would be more dilute / less concentrated (so a bigger volume would be needed to neutralise the acid). ✓

[2 marks]

ALLOW *AW*

3(c)



[2 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW *one mark if both stereoisomers of are shown but in the incorrect columns*

DO NOT ALLOW *incorrect connectivity e.g.*



or - HOOC on first occasion but allow **ECF** in second structure.

Q31 · Acids and redox reactions · [1 mark]

Answer: **A**

5.75

Q32 · Acids and redox reactions · [1 mark]

Answer: **D**

0.37%

Q33 · Acids and redox reactions · [1 mark]

Answer: **C**

Ag_2CO_3

Q34 · Acids and redox reactions · [11 marks]

OCR MARK SCHEME

23(a)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 0.454 (mol dm^{-3}) award 3 marks

If answer = 0.227 (mol dm^{-3}) award first 2 marks

$n(Ba(OH)_2)$ in 100 cm^3 1 mark

$= \frac{3.89}{171.3}$ = 0.0227.... (mol) ✓

3 SF or more

Concentration of OH^- 2 marks

$n(Ba(OH)_2)$ ×2 = 2 × 0.0227

= 0.0454.... (mol) ✓

Use of ×10 = 10 × 0.0454

Concentration of OH^- = 0.454 (mol dm^{-3}) ✓

3 SF required

[3 marks]

EXAMINER GUIDANCE

***ALLOW ECF** throughout*

***ALLOW** use of 171 within working*

(Use of A_r: Ba 137 rather than 137.3)

Calculator: 0.02270869819

***IGNORE** figures after 7 in 0.0227*

ALLOW working with ×10 before ×2

Use of ×10 = 10 × 0.0227

= 0.227.... (mol) ✓

Use of ×2 = 2 × 0.227

Concentration of OH^- = 0.454 (mol dm^{-3}) ✓

3 SF required

Common error

0.227 no × 2 2 marks

23(b)(i)

(Titres that agree) within 0.1 cm^3 ✓

[1 mark]

***ALLOW** within 0.05 cm^3*

***ALLOW** ml for cm^3*

If cm^3 units are absent, ASSUME cm^3

BUT

***DO NOT ALLOW** incorrect units,*

e.g. dm^3; mol dm^{-3}

23(b)(ii)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 0.0856 (mol dm^{-3}) award 3 marks

$n(HNO_3) = 0.160 \times \frac{26.75}{1000} = 4.28 \times 10^{-3}$ (mol) ✓

$n(Ba(OH)_2)$ in 25.0 $cm^3 = \frac{4.28 \times 10^{-3}}{2}$

$= 2.14 \times 10^{-3}$ (mol) ✓

Use ECF throughout

***DO NOT ALLOW** 4.3×10^{-3}*

BUT remaining marks available by **ECF**

e.g.

$\frac{4.3 \times 10^{-3}}{2} = 2.15 \times 10^{-3}$ ✓ **ECF**

Concentration = $2.14 \times 10^{-3} \times \frac{1000}{25}$

= 0.0856 (mol dm^{-3}) ✓

$2.15 \times 10^{-3} \times \frac{1000}{25}$ = 0.086 ✓ **ECF**

[3 marks]

23(c)

Route 1

Reactant:

Add water (to Ba) **OR** H_2O in equation ✓

Balanced equation:

$Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$ ✓

Route 2

Balanced equation with O_2

$2Ba + O_2 \rightarrow 2BaO$ ✓

Balanced equation with H_2O

$BaO + H_2O \rightarrow Ba(OH)_2$ ✓

ALLOW *multiples in equations*

Balanced equation automatically collects 2 marks for Route 1

ALLOW *1 mark for BOTH reactants in route 2:*

i.e. React with O_2 **AND** then with H_2O

NOTE

3 correct balanced equations → 4 marks

[4 marks]

Q35 · Acids and redox reactions · [1 mark]

Answer: **A**

Cl is both oxidised and reduced.

Q36 · Acids and redox reactions · [1 mark]

Answer: **B**

FeO_4^{2-}

Q37 · Acids and redox reactions · [1 mark]

Answer: **D**

The pipette is rinsed with water before filling with NaOH(aq).

Q38 · Acids and redox reactions · [1 mark]

Answer: **D**

NH_3

Q39 · Acids and redox reactions · [1 mark]

Answer: **B**

Leave the droplet in the tip.

Q40 · Acids and redox reactions · [12 marks]

OCR MARK SCHEME

3(a)

From colourless to pink ✓

[1 mark]

3(b)(i)

Titre: 18.50, 18.05, 18.20, 18.30 ✓

All titres with 2 DP and ending with '0' **OR** '5'

[1 mark]

3(b)(ii)

To estimate the titre ✓

[1 mark]

3(b)(iii)

18.25 cm^3 ✓

[1 mark]

3(b)(iv)

% uncertainty = $\frac{0.1}{18.05} \times 100 = 0.55$ % ✓

[1 mark]

3(c)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 3 AND M = 132(,0).... award 5 marks

$n(NaOH) = \frac{18.25 \times 0.240}{1000} = 4.38 \times 10^{-3}$ ✓

n(acid) in 25 $cm^3 = \frac{4.38 \times 10^{-3}}{2} = 2.19 \times 10^{-3}$ (mol) ✓

n(acid) in 250 $cm^3 = 2.19 \times 10^{-2}$ (mol) ✓

M(acid)

$= \frac{2.891}{2.19 \times 10^{-2}} = 132(.0)\ldots\ldots$ (g mol^{-1}) ✓

$M(CH_2)_n$

= 132 – 90 **OR** (132.0.... – 90) **OR** 42

(seen anywhere)

EXAMINER GUIDANCE

DO NOT ALLOW *responses given to only 1 decimal place*

ALLOW *'getting a rough idea of the titre' (or similar wording)*

ALLOW *ECF from incorrect subtraction in (b)(i) or incorrect mean*

ALLOW *calculation from other titre values*

ALLOW ECF throughout

ALLOW ECF *from (b)(iii)*

Answers should be to at least 3 significant figures for first 4 marks.

AND $n = \frac{42}{14} = 3$ ✓ whole number required

[5 marks]

3(d)

The titre would be less ✓

Glutaric acid would be less concentrated/more dilute ✓

[2 marks]

Q41 · Acids and redox reactions · [12 marks]

OCR MARK SCHEME

18(a)

Formula: $CuCO_3$ ✓

$CuCO_3 + 2HNO_3 \rightarrow Cu(NO_3)_2 + CO_2 + H_2O$ ✓

[2 marks]

EXAMINER GUIDANCE

IGNORE state symbols

ALLOW *formula within equation.*

ALLOW *other copper(II) compounds which can react with nitric acid to form a gas e.g. CuS, $CuSO_3$ for mark 1, with correct equation for mark 2.*

e.g.$CuSO_3 + 2HNO_3 \rightarrow Cu(NO_3)_2 + SO_2 + H_2O$

18(b)

$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$ ✓

[1 mark]

ALLOW *multiples*

State symbols are required

18(c)

starch (solution)

AND

blue-black to colourless ✓

[1 mark]

ALLOW *blue* ***OR*** *black* ***OR*** *purple for colour of mixture*

ALLOW *blue colour disappears (to colourless)*

IGNORE *'clear'*

IGNORE *'colorimetry*

18(d)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 1.35 award 4 marks

$n(S_2O_3^{2-}) = \frac{0.0200 \times 26.55}{1000}$

$= 5.31 \times 10^{-4}$ (mol) ✓

$n(I_2) = 2.655 \times 10^{-4}$ **OR**

$n(Cu^{2+}) = 5.31 \times 10^{-4}$ (mol) ✓

ALLOW ECF *throughout*

If 1:2 ratio for I_2:Cu^{2+} not used check ratio in b) and allow ***ECF***

IGNORE *rounding errors after 3 SF*

Calculator: 0.0337185

ALLOW *3 SF (0.0337) up to calculator value*

$m(Cu/Cu^{2+})$ in ore = $63.5 \times 5.31 \times 10^{-4}$

= 0.0337..... (g) ✓

$$\text{percentage} = \frac{0.0337....}{2.50} \times 100$$

= 1.35 (%) ✓ (3SF required)

[4 marks]

***ECF** dependent on the use of a calculated mass of Cu/Cu^{2+}*

18(e)(i)

Lower **AND** smaller titre ✓

[1 mark]

***ALLOW** less I_2 produced / less Cu^{2+} reacts*

18(e)(ii)

The same **AND** burette measures by difference ✓

[1 mark]

ALLOW AW

18(f)

Any two of the following:

Make up a (standard solution) from Step 2 to a stated volume (e.g. 250 cm^3)

OR

Repeat titrations

AND

Take mean of concordant/closest titres/ identify anomalies

OR

lower $[S_2O_3]^{2-}$ to increase titre volume (to reduce the percentage error).

OR

higher $[S_2O_3]^{2-}$ so not to refill the burette.

OR

Use a 3 dec place balance (to reduce the percentage error).

[2 marks]

Q42 · Acids and redox reactions · [1 mark]

Answer: **D**

Ag(s): 3 · H_2O(l): 2

Q43 · Acids and redox reactions · [12 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

3(a)

$n(Ba(OH)_2) = \frac{0.150 \times 250}{1000}$ **OR** 0.0375 (mol) ✓

Mass $Ba(OH)_2 = 0.0375 \times 171.3 = 6.42375$ (g) ✓

Dissolve solid in (distilled) water (less than 250 cm^3) in beaker ✓

Transfer (solution) to volumetric flask

AND

Transfer washings (from beaker) to flask ✓

Make up to mark/up to 250 cm^3 with (distilled) water

AND

Invert flask (several times to ensure mixing) ✓

[5 marks]

ALLOW ECF *from incorrect* $n(Ba(OH)_2)$

ALLOW *6.42 up to 6.42375 correctly rounded*

6.42 g subsumes 1st mark

ALLOW *conical flask for beaker*

ALLOW *graduated flask*

DO NOT ALLOW *round-bottom or conical flask*

3(b)

$n(Ba(OH)_2) = \frac{0.150 \times 23.50}{1000}$

$= 3.525 \times 10^{-3}$ (mol) ✓

n(D) in 25.0 $cm^3 = 2 \times 3.525 \times 10^{-3}$

$= 7.05 \times 10^{-3}$ (mol) ✓

n(D) in 100 $cm^3 = \frac{7.05 \times 10^{-3} \times 100}{25.0}$

= 0.0282 (mol) ✓

Molar mass (D) = $\frac{3.215}{0.0282}$ = 114 ($g\ mol^{-1}$) ✓

Formula: = C_5H_9COOH

OR C_nH_{2n-1}: $M(C_5H_9) = 114 - 45 = 69$ ✓

If not stated, could be credited from structure

cis stereoisomers.

The drawn stereoisomers must have

- Different groups attached to each C atom of C=C
- Each C of C=C has the same group on the same side

Any 2 *cis* isomers ✓✓

Many possibilities, e.g.

Use ECF throughout

Intermediate values for working to at least 3 SF.

TAKE CARE as value written down may be truncated value stored in calculator.

Depending on rounding, either can be credited.

ALLOW *Mass D in 25.0* cm^3

$= \frac{3.215}{4} = 0.80375\ g$

Molar mass (D)

$= \frac{0.80375}{7.05 \times 10^{-3}} = 114$

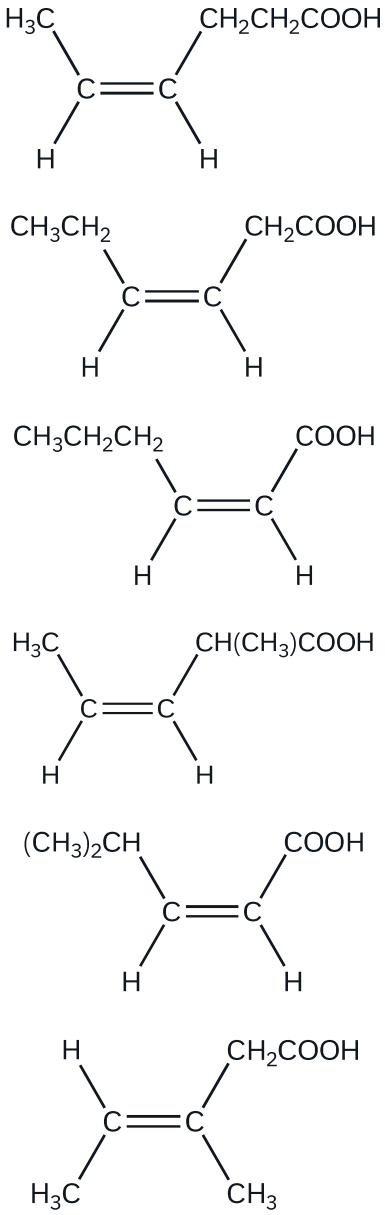
COMMON ERRORS:

Up to Molar mass = 114 (1st 4 marks)

M = 456 → 3/4 marks (mol in 100 cm^3 omitted)

$M = \frac{3.215}{7.05 \times 10^{-3}} = 456$

M = 228 → 3/4 marks (No × 2 for n(D))



ALLOW *correct structural, with 'cis' part displayed*

OR skeletal

OR displayed formula

OR mixture of above as long as non-ambiguous

ALLOW *side chains as molecular formula,*

e.g. C_3H_7 for $(CH_3)_2CH$ **OR** $CH_3CH_2CH_2$

e.g. $C_3H_5O_2$ for CH_2CH_2COOH

IGNORE *poor connectivity to all groups*

[7 marks]

$$\frac{3.525 \times 10^{-3} \times 100}{25.0} = 0.0141$$

$$M = \frac{3.215}{0.0141} = 228$$

M = 100.8 → 3/4 marks

23.50 instead of 25.00 and scaling by × 100 / 23.50

$$\frac{25.0 \times 0.150}{1000} = 3.75 \times 10^{-3}$$ ✗

→ $2 \times 3.75 \times 10^{-3} = 7.5 \times 10^{-3}$ ✓

→ $\frac{7.5 \times 10^{-3} \times 100}{23.50} = 0.0319$ ✓

→ $\frac{3.215}{0.0319}$ → 100.8 ✓

THEN ALLOW ECF for carboxylic acid closest to calculated M(alkyl group) but must be C_nH_{2n-1}

e.g. For M(alkyl) = 100, **ALLOW** C_4H_7 (55)

For M(alkyl) = 411, **ALLOW** $C_{29}H_{57}$ (405) **OR** $C_{30}H_{59}$ (419)

THEN judge *cis* isomers with closest match

ALLOW *1 mark for 2 trans isomers shown instead of 2 cis isomers*

ECF *for Same error made twice.*

Q44 · Amount of substance · [1 mark]

Answer: **C**

$(NH_4)_2S$

Q45 · Amount of substance · [11 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

22(a)

Initial ratios

Cr, $\frac{19.51}{52.0}$; Cl, $\frac{39.96}{35.5}$; H, $\frac{4.51}{1.0}$; O, $\frac{36.02}{16.0}$

OR

Cr, 0.375; Cl,1.126; H,4.51; O, 2.25 ✓

Whole number ratios

Cr, 1; Cl, 3; H, 12; O, 6 ✓

Formula with water of crystallisation

$CrCl_3 \cdot 6H_2O$ ✓

[3 marks]

***NOTE**: If only the correct answer of $CrCl_3 \cdot 6H_2O$ is seen with no working, award 1 mark only*

***IF** there is no whole number ratio,*

***ALLOW** empirical formula: $CrCl_3H_{12}O_6$*

***ALLOW ECF** from incorrect whole number ratio, provided **ONLY Cl incorrect AND** $6H_2O$,*

e.g. $CrCl_2 \cdot 6H_2O$

22(b)(i)

$\frac{2 \times 0.005}{0.58} \times 100 = 1.72\%$ ✓

[1 mark]

***ALLOW** 2% **OR** 1.7% up to calculator value of 1.724137931*

22(b)(ii)

Use balance weighing to 3/more decimal places

OR

Use a larger mass/amount ✓

[1 mark]

***ALLOW** more precise/more accurate/ more sensitive/higher resolution/smaller division*

***IGNORE** 'less error/smaller interval balance'*

***IGNORE** any reference to lid on crucible (water can't escape)*

***IGNORE** 'weigh straight after heating'*

***IGNORE** idea of repeating the experiment/ taking an average/ getting concordant results /larger sample size, etc.*

22(b)(iii)

Heat to constant mass ✓

[1 mark]

***ALLOW** response that implies heating to constant mass,*

e.g. Heat again until the mass does not change

***IGNORE** 'heat for longer'*

Needs link to constant mass

22(c)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 24.8 (cm^3) award 3 marks

***ALLOW ECF** from* $\frac{n(NaOH)}{2}$

$n(NaOH) = 0.124 \times \frac{25.0}{1000} = 3.1(0) \times 10^{-3}$ (mol) ✓

$n(H_2SO_4) = \frac{3.10 \times 10^{-3}}{2} = 1.55 \times 10^{-3}$ (mol) ✓

$V(H_2SO_4) = 1.55 \times 10^{-3} \times \frac{1000}{6.25 \times 10^{-2}} = 24.8\ (cm^3)$ ✓

[3 marks]

ALLOW ECF *from* $n(H_2SO_4) \times \frac{1000}{6.25 \times 10^{-2}}$

22(d)

Element oxidised: aluminium/Al 0 to +3 ✓

Element reduced: hydrogen/H/H^+ +1 to 0 ✓

[2 marks]

MAX 1 mark if no '+' sign for oxidation number

ALLOW *3+*

ALLOW *1+*

ALLOW *H_2 for hydrogen*

ALLOW *1 mark for all oxidation numbers correct, but oxidised and reduced the wrong way around*

IGNORE *numbers around equation*

i.e. treat as rough working

Q46 · Amount of substance · [1 mark]

Answer: **D**

300 cm^3

Q47 · Amount of substance · [9 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

4(a)(i)

More energy is required for bond breaking than is released by bond making ✓

[1 mark]

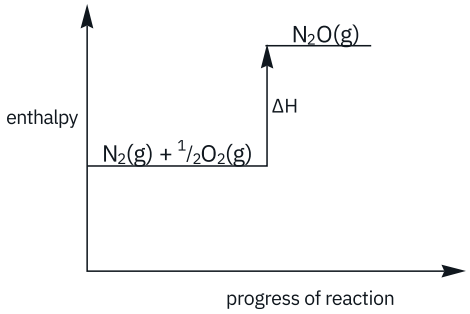
4(a)(ii)

Enthalpy profile diagram

- Δ*H* labelled **OR** 82 on vertical arrow
- Products above reactants (either chemical symbols or the words products and reactants)
- Arrow upwards ✓

Formulae **AND** state symbols

$N_2(g) + ½O_2(g) \rightarrow N_2O(g)$ ✓



IGNORE *activation energy*

[2 marks]

DO NOT ALLOW *multiples of equation: 1 mole of N_2O is formed*

4(b)

FIRST CHECK ANSWER ON THE ANSWER LINE

IF *answer = 4.46 × 10^6 (Pa) award 4 marks*

Amount of N_2O

$n(N_2O) = \frac{187}{44}$ **OR** 4.25 (mol) ✓

Unit conversion

Volume conversion to m^3 = 2.32 × 10^{-3} (m^3) ✓

Ideal gas equation / temperature conversion

$p = \frac{nRT}{V}$ **OR** $p = \frac{4.25 \times 8.314 \times 293}{2.32 \times 10^{-3}}$

AND

Use of T = 293 K ✓

Final answer

p = 4.46 × 10^6 (Pa) ✓

Must be calculated in standard form **AND** to 3 SF

If there is an alternative answer, check to see if there is any ***ECF*** *credit possible*

ALLOW ECF *from incorrect amount of N_2O*

e.g. use of incorrect M_r for N_2O could still score 3 marks

Common Errors (3 marks)

No temperature conversion

$p = \frac{4.25 \times 8.314 \times 20}{2.32 \times 10^{-3}} = 3.05 \times 10^5$

Incorrect volume conversion

$p = \frac{4.25 \times 8.314 \times 293}{2.32 \times 10^{-6}} = 4.46 \times 10^9$

No volume conversion

$p = \frac{4.25 \times 8.314 \times 293}{2.32} = 4.46 \times 10^3$

No standard form = 4460000

[4 marks]

4(c)

Propagation step 1

$NO\bullet + O_3 \rightarrow NO_2\bullet + O_2$ ✓

Propagation step 2

$NO_2\bullet + O \rightarrow NO\bullet + O_2$ ✓

ALLOW *one mark for both correct symbol equations with (any or all) dots missing or extra dots*

e.g. $NO + O_3 \rightarrow NO_2\bullet + O_2$

$NO_2 + O \rightarrow NO + O_2\bullet$

[2 marks]

Q48 · Amount of substance · [1 mark]

Answer: **D**

C_2H_5O

Q49 · Amount of substance · [9 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

25(a)(i)

More energy is released by forming bonds than energy required when breaking bonds ✓

[1 mark]

ORA

Response needs link between energy, breaking and making bonds

ALLOW *'bond breaking is endothermic'* ***AND*** *'bond making is exothermic'*

ALLOW *within labelled energy diagram*

25(a)(ii)

FIRST, CHECK THE ANSWER ON ANSWER LINE

IF bond enthalpy = (+)612 (kJ mol^{-1}) award 3 marks

IF bond enthalpy = (–)316 (kJ mol^{-1}) award 2 marks

Energy for bonds made (4 × C=O + 4 × O–H)

4 × 805 + 4 × 464

OR 3220 + 1856

OR 5076 (kJ) ✓

Energy for bonds broken (4 × C–H + 3 × O=O)

4 × 413 + 3 × 498

OR 1652 + 1494

OR 3146 (kJ) ✓

C=C bond enthalpy correctly calculated

C=C bond enthalpy = –1318 – 3146 + 5076

= (+)612 kJ mol^{-1} ✓

Mark is for answer

[3 marks]

IGNORE *sign*

IGNORE *sign*

ALLOW ECF

DO NOT ALLOW *– sign*

COMMON ERRORS

+2106	omission of 3O=O	**2 marks**
–3248	–1318 + 3146 – 5076	**2 marks**

25(b)

FIRST check the molar mass on answer line

MUST be derived from $pV = nRT$,

Award 4 marks for calculation for:

- answer = 70
- **OR answer that rounds to 69.9 OR 70.0**

Rearranging ideal gas equation to make n subject

$n = \frac{pV}{RT}$ ✓

Substituting all values including conversion to Pa and m^3

If there is an alternative answer, check to see if there is any ECF credit possible using working *below*

1st mark may be implicit by direct substitution of correct values below into rearranged equation.

ONLY award this mark if n has been derived from correct rearranged ideal gas equation

ALLOW 3 SF up to calculator value, correctly *rounded*

$n = \frac{(101 \times 10^3) \times (82.5 \times 10^{-6})}{8.314 \times 373}$ ✓

$n = 2.68693073 \times 10^{-3} \rightarrow 2.69 \times 10^{-3}$ (mol) ✓

unrounded rounded to 3 SF

Calculation of molar mass, *M*

$M = \frac{m}{n} = \frac{0.1881}{2.68693073 \times 10^{-3}} = 70(.0)\ (g\ mol^{-1})$

$\rightarrow \frac{0.1881}{2.69 \times 10^{-3}} = 69.9\ (g\ mol^{-1})$ ✓

Molecular formula of D

C_5H_{10} ✓

IF *candidate has failed to derive suitable value of n,* ***ALLOW*** *value of M from 0.1881* ***AND*** *24000 with alkene closest to calculated value for last 2 marks*

See Guidance column.

NOTE: ALLOW *69.9 → 70.0* ***AND*** *70 (2SF)*

Calculator from unrounded:

70.00552634

ALLOW *any unambiguous structure*

ALLOW ECF *provided that formula given is an alkene and matches M calculated from 0.1881* ***AND*** *pV = nRT*

$M = \frac{0.1881}{\frac{82.5}{24000}}$ **OR** $\frac{0.1881}{3.4375 \times 10^{-3}}$

= 54.72 **OR** 54.7 **OR** 55 ✓

ALLOW *54.68 from use of* 3.44×10^{-3}

From **54.72, ONLY ALLOW** = C_4H_8 ✓

[5 marks]

Q50 · Amount of substance · [1 mark]

Answer: **B**

0.3 mol C_3H_8

Q51 · Amount of substance · [1 mark]

Answer: **C**

$BaCO_3 + 2HCl \rightarrow BaCl_2 + CO_2 + H_2O$

Q52 · Amount of substance · [1 mark]

Answer: **C**

OCR MARK SCHEME

4.1

EXAMINER GUIDANCE

ALLOW *4.1 in the box*

Q53 · Amount of substance · [10 marks]

OCR MARK SCHEME

19(a)

$n(H_2O_2) = \frac{2.30 \times 25.0}{1000}$ **OR** = 0.0575 (mol) ✓

vol $O_2 = \frac{0.0575}{2} \times 24000 = 690\ cm^3$ ✓

EXAMINER GUIDANCE

ALLOW *0.69(0) dm³*

2nd mark subsumes 1st mark

ALLOW *1000 cm³/1 dm³ syringe*

Collect in 1000 cm^3/1 dm^3 measuring cylinder ✓

[3 marks]

Needs a name of actual apparatus, not just 'container'

'measuring cylinder' without volume is insufficient

DO NOT ALLOW *burette*

ALLOW *volumes from 700–1000 cm^3 but should be realistic apparatus, e.g. 700, 750, 800, 850, 900, 950.*

19(b)

Measure mass (loss) ✓

[1 mark]

ALLOW *weight for mass*

ALLOW *take samples and titrate (remaining H_2O_2)*

19(c)

Level 3 (5–6 marks)

A comprehensive conclusion using quantitative data from the graph to correctly determine initial rate **AND** half lives/gradient with 1st order conclusion for H_2O_2 **AND** determination of *k*.

There is a well-developed line of reasoning which is clear and logically structured.

Clear working for initial rate, half life/gradient and order and *k*.

Units mostly correct throughout.

Level 2 (3–4 marks)

Attempts to describe all three scientific points but explanations may be incomplete.

OR Explains two scientific points thoroughly with few omissions.

There is a line of reasoning with some structure and supported by some evidence. The scientific points are supported by evidence from the graph.

Level 1 (1–2 marks)

Reaches a simple conclusion using at least one piece of quantitative data from the graph.

Attempts to calculate initial rate **OR** half life.

There is an attempt at a logical structure with a reasoned conclusion from the evidence.

0 marks No response worthy of credit.

Indicative scientific points may include:

Initial rate

- Tangent shown on graph as line at t = 0 s
- Gradient determined in range: $1.5 – 2.0 \times 10^{-3}$

e.g. $\frac{2.3}{1300} = 1.77 \times 10^{-3}$

- initial rate as gradient value with units: mol dm^{-3} s^{-1},

Evidence for 1st order 2 methods

- 1st order clearly linked to half-life **OR** 2 gradients:

1. Half life

- Half life shown on graph
- Half life range 800–1000 s
- Two 'constant' half lives ±50 s

2. Two gradients → two rates

- 2 tangents shown on graph at *c* and *c*/2
- Gradient at *c*/2 is half gradient at *c*

[6 marks]

e.g. $c = 2.3$ mol dm^{-3}, gradient = 1.6×10^{-3}

AND $c = 1.15$ mol dm^{-3}, gradient = 0.8×10^{-3}

- For chosen method, conclusion: H_2O_2 is 1st order

Determination of k 2 methods

- k clearly linked to rate **OR** half-life:

$k = \frac{\text{rate}}{[H_2O_2]}$ e.g. $k = \frac{1.6 \times 10^{-3}}{2.3} = 7 \times 10^{-4}$ s^{-1}

OR $k = \frac{\ln 2}{t_{1/2}}$ e.g. $k = \frac{0.693}{950} = 7.3 \times 10^{-4}$ s^{-1}

Q54 · Amount of substance · [1 mark]

Answer: **B**

OCR MARK SCHEME

20

EXAMINER GUIDANCE

ALLOW *20 in the box*

Q55 · Amount of substance · [1 mark]

Answer: **C**

6.02×10^{20}

Q56 · Amount of substance · [1 mark]

Answer: **A**

1.26 g

Q57 · Amount of substance · [1 mark]

Answer: **A**

6.02×10^{22}

Q58 · Amount of substance · [1 mark]

Answer: **C**

C_2H_4O

Q59 · Amount of substance · [1 mark]

Answer: **D**

Addition

Q60 · Amount of substance · [11 marks]

OCR MARK SCHEME

1(a)

Throughout

- **ALLOW** bonding regions for bonded pairs
- **ALLOW** diagrams for communicating two bonds, two lone pairs and hydrogen bonding in ice
- **IGNORE** responses about open lattice/tetrahedral structure in ice

Ice

Ice has hydrogen bonds/bonding ✓

$H_2O(g)$

2 bonded pairs **AND** 2 lone pairs ✓

Repulsion

Lone pairs repel more (than bonded pairs) ✓

[3 marks]

EXAMINER GUIDANCE

ALLOW *more hydrogen bonding/H bonds*

For $H_2O(g)$,

- **ALLOW** water
- **IGNORE** hydrogen bonding

1(b)

It increases/causes/contributes to global warming

OR C–H bonds vibrate **OR** absorb IR ✓

[1 mark]

ALLOW *it is a greenhouse gas/increases temp*

IGNORE *ozone, radicals* ***OR*** *acid rain*

1(c)

FIRST CHECK THE ANSWER ON THE ANSWER LINE

IF answer = $CH_4 \cdot 5.74H_2O$ ***OR*** *5.74 award 2 marks*

Mole ratio

$n(CH_4) : n(H_2O) = \frac{13.4}{16.0} : \frac{86.6}{18.0}$

OR 0.8375 : 4.811 ✓

Formula

$CH_4 \cdot 5.74H_2O$ **OR** 5.74 ✓

[2 marks]

Working to at least 3 SF but **IGNORE** 'trailing zeroes', e.g. **ALLOW** 16 for 16.0

ALLOW *algebraic approach, e.g.*

$n(CH_4) = n(CH_4 \cdot xH_2O)$

$\frac{13.4}{16.0} = \frac{100}{16.0 + 18x}$

x = 5.74

ALLOW ECF from incorrect mole ratio

For 1 mark, **ALLOW** x with < 2 DP:

- x = 5.7

- x = 6
- x = 5.73 from 0.8375 and 4.8

from 0.84 and 4.811

- x = 5.71 from 0.84 and 4.8

1(d)

FIRST CHECK THE ANSWER ON THE ANSWER LINE

IF answer = 188 (dm^3) ***AND*** *use of ideal gas equation*

Award 4 marks for calculation

$n(CH_4)$ in 1 kg

$n(CH_4) = \frac{1 \times 10^3}{16.0} \times \frac{13.4}{100} = 8.375$ **OR** 8.38 (mol) ✓

Rearranging ideal gas equation

$V = \frac{nRT}{p}$ ✓

Substitution of values into $V = \frac{nRT}{p}$:

- Calculated value of $n(CH_4)$ (Use ECF)
- R = 8.314 **OR** 8.31
- T in K: 273 K
- p in Pa **OR** kPa 101 **OR** 101×10^3 **OR** 1.01×10^5

e.g. $\frac{8.375 \times 8.314 \times 273}{(101 \times 10^3)}$ **OR** $\frac{8.375 \times 8.314 \times 273}{101}$ ✓

Final volume in dm^3 to 3 SF

$V = 188$ (dm^3) ✓

COMMON ERRORS

ALLOW *use of M(answer to (c)* ***OR*** *119.32*

Examples

From $n(CH_4 \cdot 5.74H_2O)$

$\frac{1 \times 10^3}{119.32} = 8.38(1) \rightarrow 188$ (dm^3)

From $n(CH_4 \cdot 5.7H_2O)$

$\frac{1 \times 10^3}{118.6} = 8.43(2) \rightarrow 189$ (dm^3)

From $n(CH_4 \cdot 6H_2O)$

$\frac{1 \times 10^3}{124.0} = 8.06$ (mol) → 181 (dm^3)

IF $V = \frac{nRT}{p}$ *is omitted,* ***ALLOW*** *when values are substituted into rearranged ideal gas equation.*

Use of 298 K	**ALLOW ECF**	**3 marks max**
Example	$n(CH_4 \cdot 5.74H_2O)$ = 8.375 ✓	$V = \frac{8.375 \times 8.314 \times 298}{101 \times 10^3}$ → 205 (dm^3) ✓✓
Use of 24.0 dm^3 OR 22.4 dm^3	**ALLOW ECF** from $n(CH_4)$	**2 marks max for $n(CH_4)$ and V in dm^3**
24.0 dm^3	$n(CH_4 \cdot 5.74H_2O)$ = 8.375 ✓	$V = 8.375 \times 24.0$ = 201 (dm^3) ✓
22.4 dm^3	$n(CH_4 \cdot 5.74H_2O)$ = 8.375 ✓	$V = 8.375 \times 22.4$ = 188 (dm^3) ✓
13.4% (13.4/100) omitted		**3 marks**
	$n = \frac{1 \times 10^3}{16} =$ 62.5 (mol) ✗	$V = \frac{62.5 \times 8.314 \times 273}{101 \times 10^3}$ → 1400 (dm^3) ✓✓✓

[4 marks]

1(e)

For fuel **OR** energy ✓

[1 mark]

ALLOW *responses linked with energy. e.g.*

- to generate electricity
- for burning/heat

ALLOW *(chemical) feedstock*

IGNORE *cooking*

Q61 · Amount of substance · [19 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

4(a)(i)

Burette readings

Final (reading)/cm^3	23.15	45.95	32.45	✓
Initial (reading)/cm^3	0.60	23.15	10.00	

- Correct titration results recorded with initial and final readings, clearly labeled **AND** all readings recorded to two decimal places with last figure either 0 or 5

Titres

Titre/cm^3	22.55	22.80	22.45	✓

- Correct subtractions to obtain final titres to 2 DP

Units

- Units of cm^3 for initial, final and titres ✓

Mean titre

- mean titre = $\frac{22.55 + 22.45}{2}$ = 22.50 OR 22.5 cm^3 ✓

i.e. using concordant (consistent) titres

[4 marks]

Table not required

ALLOW *initial reading before final reading*

ALLOW ECF

ALLOW *units with each value*

ALLOW *brackets for units, i.e. (cm^3)*

ALLOW ECF *from incorrect concordant titres*

4(a)(ii)

ALLOW *3SF or more throughout*

IGNORE trailing zeroes, e.g. ***ALLOW*** *0.084 for 0.0840*

$n(NaOH) = \frac{0.0840 \times 22.50}{1000} = 1.89 \times 10^{-3}$ (mol) ✓

$n(A)$ in 250 $cm^3 = 10 \times 1.89 \times 10^{-3} = 1.89 \times 10^{-2}$ (mol) ✓

$M(A) = \frac{2.495}{1.89 \times 10^{-2}} = 132$ (g mol^{-1}) ✓

M(alkyl group) (= 132 – 75) = 57 ✓

R = C_4H_9 ✓

ALLOW *alkyl group in drawn structure with straight chain or branch(es) in wrong position,*

e.g. for R = C_4H_9, $CH_3CH_2CH_2CH_2$ OR $(CH_3)_3C$

ALLOW ECF *from incorrect mean titre in 4a(i)*

e.g. From 22.60 cm^3 (mean of all 3 titres in (i),

$n(NaOH) = 1.8984 \times 10^{-3}$ (mol)

ALLOW ECF *from incorrect n(NaOH)*

ALLOW ECF *from incorrect n(A)*

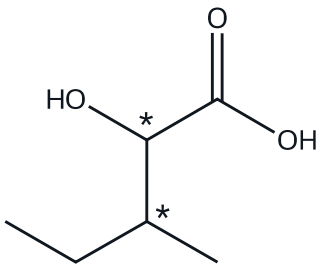
ALLOW ECF *from incorrect M(A) – 75*

ALLOW ECF *for alkyl group closest to calculated M(alkyl group),*

e.g. for M = 45, **ALLOW** C_3H_7 (43)

ALLOW *correct structural OR skeletal OR displayed formula OR mixture of the above as long as non-*

Structure with chiral carbon atoms identified (see * below)



✓

[6 marks]

ambiguous

IGNORE poor connectivity to OH groups

Given in question

Common error for 4 marks max

25.00 instead of 22.50 and scaling by × 10

2.10×10^{-3} ✗ → 2.10×10^{-2} ✓

→ 118.81 ✓ → 43.81 ✓ → C_3H_7 ✓

25.00 instead of 22.50 and scaling by × 250 / 22.50

2.10×10^{-3} ✗ → 2.33×10^{-2} ✓

→ 106.93 ✓ → 31.93 ✓ → C_2H_5 ✓

No structure with 2 chiral centres possible ✗

4(b)(i)

Equation

$2HOCH(R)COOH + Mg \rightarrow (HOCH(R)COO)_2Mg + H_2$

Organic product ✓

Balance ✓

Type of reaction

Redox ✓

[3 marks]

ALLOW *correct structural OR skeletal OR displayed formula OR mixture of the above as long as non-ambiguous*

ALLOW

$2HOCH(R)COOH + Mg \rightarrow$

$2HOCH(R)COO^- + Mg^{2+} + H_2$

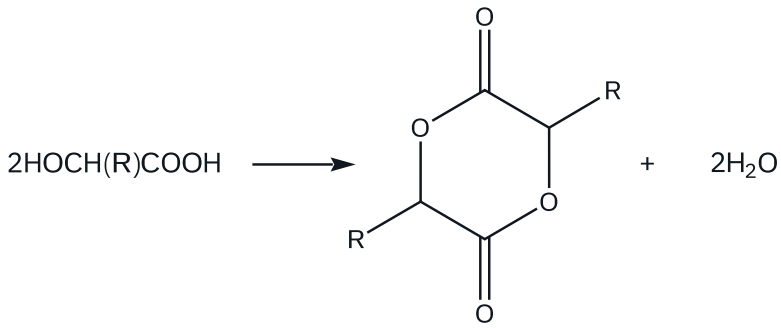
ALLOW *multiples*

IGNORE poor connectivity to OH groups

Given in question

4(b)(ii)

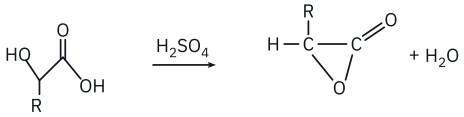
Equation



Organic product ✓

ALLOW *correct structural OR skeletal OR displayed formula OR mixture of the above as long as non-ambiguous*

ALLOW *1 mark of the 2 equation marks for formation of '3 ring' with balanced equation:*



✓

Balance ✓

Type of reaction

Condensation OR esterification ✓

[3 marks]

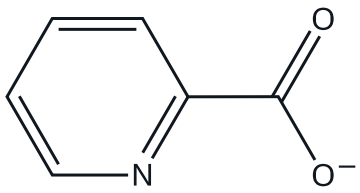
ALLOW *condensation polymerisation*

ALLOW *addition–elimination*

IGNORE elimination

IGNORE dehydration

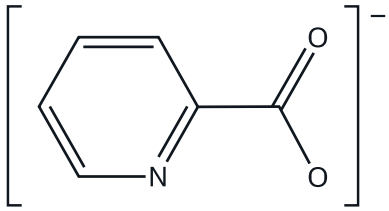
4(c)(i)



✓

[1 mark]

ALLOW *brackets around structure with negative charge outside, i.e.*



ALLOW *ring (Kekulé structure)*

4(c)(ii)

FIRST CHECK THE ANSWER ON THE ANSWER LINE

If answer = 1.61 × 10^{-3} award 2 marks

M = 418(.0) (g mol^{-1}) OR n(Cr) = 3.85 × 10^{-6} (mol) ✓

Mass = 3.85 × 10^{-6} × 418.0 = 1.61 × 10^{-3} g ✓

[2 marks]

Note: $\frac{(200 \times 10^{-6})}{52.0} = 3.85 \times 10^{-6}$ *(at least 3 SF)*

ALLOW ECF *from incorrect M OR n(Cr)*

ALLOW *3 SF up to calculator value correctly rounded*

Q62 · Amount of substance · [1 mark]

Answer: **C**

2.41 × 10^{24}

Q63 · Amount of substance · [13 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

22(a)(i)

Oxidised

AND

(Mg) transfers/loses/donates 2 electrons ✓

2 essential

[1 mark]

ALLOW *Mg loses 6 electrons: 3 Mg in equation*

ALLOW *Mg → Mg^{2+} + $2e^-$*

IGNORE *oxidation numbers (even if wrong)*

22(a)(ii)

FIRST CHECK ANSWER ON THE ANSWER LINE

IF answer = 2.26 (3 SF) award 3 marks

At least 3SF needed throughout BUT

ALLOW *no trailing zeroes (e.g. 0.062 for 0.0620)*

ALLOW ECF *from n(H_3PO_4)*

$n(H_3PO_4) = \frac{1.24 \times 50.0}{1000} = 0.062(0)$ (mol) ✓

$n(Mg) = \frac{3}{2} \times 0.062(0) = 0.093(0)$ (mol) ✓

mass of Mg = 0.0930 × 24.3 = 2.26 (g) ✓

3 SF required

[3 marks]

***ALLOW ECF** from n(Mg)*

COMMON ERRORS for 2 marks

3:2 ratio omitted → $n(Mg) = 0.062(0)$ → 1.51 (g)

Inverted 2:3 ratio → $n(Mg) = 0.0413$ → 1.00 (g)

22(a)(iii)

Separation of solid

Filter to obtain solid/precipitate ✓

Requires realisation that solid is filtered off.

Solid may be stated within 'removal of water'

Removal of water

Dry (solid)

OR Evaporate (water/solution/liquid) ✓

[2 marks]

ALLOW

Removal of water

Evaporate/ distil water/solution/liquid ✓

***IGNORE** 'distil' if product **OR** H_2 is distilled*

Collection of remaining solid ✓

Requires realisation that solid remains

***IGNORE** 'Leave to crystallise' (already solid)*

22(a)(iv)

Formula

MgO **OR** $Mg(OH)_2$ **OR** $MgCO_3$ **OR** soluble Mg salt ✓

Equation

$3MgO + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 3H_2O$

OR

$3Mg(OH)_2 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6H_2O$

OR

$3MgCO_3 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 3CO_2 + 3H_2O$ ✓

[2 marks]

In equation:

NO ECF from incorrect formula

***ALLOW** multiples*

***IGNORE** state symbols (even if incorrect)*

Soluble Mg salts include

$MgCl_2$, $MgSO_4$, $Mg(NO_3)_2$, $MgBr_2$, MgI_2

e.g. $3MgCl_2 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6HCl$

22(b)(i)

FIRST CHECK ANSWER ON THE ANSWER LINE

IF answer = 315 (cm^3) award 4 marks

Amount of PH_3

$n(PH_3) = \frac{3.20 \times 10^{-2}}{4}$ **OR** $8(.00) \times 10^{-3}$ (mol) ✓

Unit conversions

If there is an alternative answer, check to see if there is any ECF credit possible

***ALLOW ECF** throughout*

Common Errors (3 marks)

Use of $n(H_3PO_4) = 3.20 \times 10^{-2}$ (Very common)

p conversion → Pa = 100×10^3 (Pa)

AND

T conversion → K = 473 (K) ✓

Evidence of use of rearranged gas equation

OR $V = \frac{nRT}{p}$

OR $V = \frac{8(.00) \times 10^{-3} \times 8.314 \times 473}{100 \times 10^3}$

OR $V = 3.15 \times 10^{-4}$ ✓

Calculator: = 3.1460176×10^{-4}

V conversion of m^3 → cm^3

$V = 3.15 \times 10^{-4} \times 10^6 = 315\ cm^3$ ✓

Calculator from unrounded cm^3: 314.60176 cm^3

Requires 3 OR MORE SF, correctly rounded

ALLOW use of R = 8.31 → 314.4504 → 314 to 3SF

[4 marks]

$V = \frac{3.2(0) \times 10^{-2} \times 8.314 \times 473}{100 \times 10^3} \times 10^6$

$= 1258.40704\ cm^3$ (1260 to 3 SF)

No temperature conversion from °C to K

$V = \frac{8(.00) \times 10^{-3} \times 8.314 \times 200}{100 \times 10^3} \times 10^6$

$= 133\ cm^3$

No p conversion from kPa to Pa

$V = \frac{8(.00) \times 10^{-3} \times 8.314 \times 473}{100} \times 10^6$

$= 315000\ cm^3$

No volume conversion from m^3 to cm^3

$V = 3.15 \times 10^{-4}$

***IGNORE** use of 24/24000 for molar volume e.g.*

$3.2(0) \times 10^{-2} \times 24000 = 768$ scores zero

$8(.00) \times 10^{-3} \times 24000 = 192$ scores 1st mark only

***ALLOW** multiples*

22(b)(ii)

$4PH_3 + 8O_2 \rightarrow P_4O_{10} + 6H_2O$ ✓

[1 mark]

Q64 · Amount of substance · [1 mark]

Answer: **B**

NH_4NO_3

Q65 · Amount of substance · [1 mark]

Answer: **C**

1.84 g

Q66 · Amount of substance · [1 mark]

Answer: **B**

4.515×10^{23}

Q67 · Amount of substance · [1 mark]

Answer: **C**

$C_2H_5Br + H_2O \rightarrow C_2H_5OH + HBr$

Q68 · Amount of substance · [1 mark]

Answer: **C**

29.17%

Q69 · Amount of substance · [1 mark]

Answer: **D**

$CH_3CH_2CH_2CH_2OH \rightarrow CH_3CH_2CH{=}CH_2 + H_2O$

Q70 · Amount of substance · [1 mark]

Answer: **B**

10.0 dm^3

Q71 · Amount of substance · [1 mark]

Answer: **B**

259 cm^3

Q72 · Amount of substance · [1 mark]

Answer: **B**

magnesium

Q73 · Amount of substance · [1 mark]

Answer: **D**

Cu_3PO_4

Q74 · Amount of substance · [18 marks]

OCR MARK SCHEME

1(a)(i)

(Weighted) mean/average mass of an atom ✓

compared with 1/12th mass of carbon-12

OR compared with mass of carbon-12 which is 12 ✓

EXAMINER GUIDANCE

DO NOT ALLOW *mean mass of an element*

i.e. ‘atom’ essential

[2 marks]

Both marks available based on mole:

ALLOW mass of 1 mole of atoms ✓

compared to 1/12th 1 mole/12 g of carbon-12 ✓

ALLOW mass of one mole of atoms ✓

1/12th mass of one mole/12 g of carbon-12 ✓

1(a)(ii)

Use of isotope data

Use of 87 × 6.9 **AND** 88 × 82.9 **AND** 10.2 anywhere ✓

Calculation of isotopic mass

$$\frac{(100 \times 87.73) - (87 \times 6.9) - (88 \times 82.9)}{10.2} = 86 \text{ OR } 86.03$$ ✓

[2 marks]

ALLOW *877.5 = 10.2A*

ALLOW *87.73*

$$= \frac{(A \times 10.2) + 600.3 + 7295.2}{100}$$

ALLOW

$$\frac{8773 - 600.3 - 7295.2}{10.2} = 86.03$$

ALLOW $\frac{87.73 - 78.955}{0.102}$ *OR*

$\frac{8.775}{0.102}$ *= 86 OR 86.03*

DO NOT ALLOW *Sr-86 with no working/justification*

ALLOW *any unambiguous representation*

1(b)

Bonding and structure

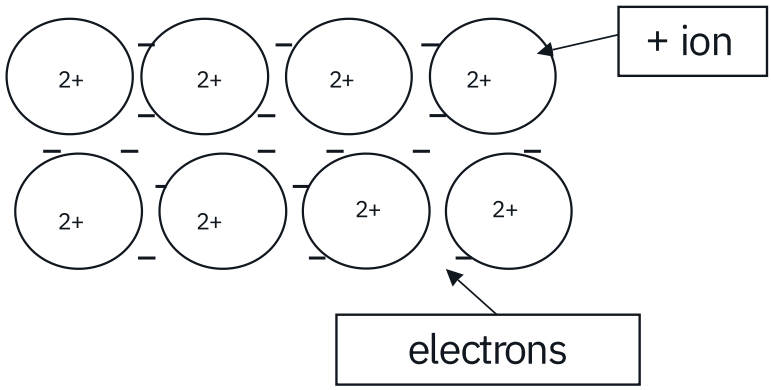


Diagram must have at least two rows and a minimum of two ions per row (allow Sr^{+} or Sr^{2+})

ALLOW *for labels: + ions, positive ions, cations*

ALLOW *e^{-} OR e as label for electron*

DO NOT ALLOW *intermolecular forces*

ALLOW *mobile electrons*

Metallic bonding diagram

Regular arrangement of labelled + ions ✓

scattering of labelled electrons between other species ✓

Properties linked to explanation

metallic bond or attraction between the electrons and the positive ions/cations ✓

bonds are strong/require a lot of energy to break

AND high melting point ✓

Delocalised electrons move

AND good conductivity ✓

[5 marks]

1(c)(i)

$Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$ ✓

[1 mark]

ALLOW *correct multiples including fractions*

IGNORE *state symbols*

1(c)(ii)

Two points (✓✓) from

With calcium:

1. less vigorous fizzing/bubbling/effervescence
2. dissolves more slowly/slower reaction
3. solution has a lower pH/less alkaline
4. precipitate forms/less soluble

[2 marks]

IGNORE *gives out less/more heat, less reactive, less gas*

1(d)(i)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 5.8 award 3 marks

$n(SrCl_2) = \dfrac{1.62}{158.6} = 0.0102\ldots\ldots$ (mol) ✓

$n(H_2O) = \dfrac{1.07}{18} = 0.0594\ldots\ldots\ldots$ (mol) ✓

$x = SrCl_2 : H_2O = \dfrac{0.0594\ldots\ldots}{0.0102\ldots\ldots}$

= 5.8 ✓

[3 marks]

Calculator: 0.01021437579

Calculator: 0.05944444444

ALLOW ECF *from $n(SrCl_2)$ and/or $n(H_2O)$*

Answer must be to TWO significant figures

ALLOW *2 marks for 5.83 (answer must be to 2 SF)*

1(d)(ii)

To make sure all the water had been removed ✓

[1 mark]

IGNORE *just 'to weigh to constant mass'*

1(d)(iii)

Use balance that weighs to 3/more decimal places ✓

Use a larger mass (of hydrated strontium chloride) ✓

[2 marks]

ALLOW *more precise/more accurate/ more sensitive/higher resolution/smaller division/weigh to 0.001*

IGNORE *'less error/smaller interval balance'*

IGNORE *any reference to lid on crucible (water can't escape)*

IGNORE *'weigh straight after heating'*

IGNORE *idea of repeating the experiment/ taking an average/ getting concordant results /larger sample size, etc.*

Q75 · Amount of substance · [1 mark]

Answer: **A**

CH_4

Q76 · Amount of substance · [1 mark]

Answer: **B**

5.30 g

Q77 · Amount of substance · [1 mark]

Answer: **A**

49.8

Q78 · Amount of substance · [9 marks]

OCR MARK SCHEME

1(a)

Polar bonds

F (atom) is more electronegative (than C atom)

OR F is very/the most electronegative ✓

No overall dipole

(CF_4 is) symmetrical **OR** tetrahedral

OR dipoles cancel

OR dipoles act in opposite directions ✓

[2 marks]

EXAMINER GUIDANCE

Mark independently

ALLOW

C and F have different electronegativities

OR the atoms have different electronegativities

.....BUT

DO NOT ALLOW *C is more electronegative*

ALLOW *C–F shown with correct dipole, i.e.* $C^{\delta+}–F^{\delta-}$.

IGNORE *square planar*

IGNORE *polar bonds cancel*

BUT ALLOW polarities cancel

IGNORE *charges cancel*

1(b)

(Molecules) contain

- ^{2}H **OR** deuterium/D
- ^{3}H **OR** tritium/T

OR O/H atoms have more neutrons (than ^{1}H)

OR (different) O/H isotopes are present

OR (Molecules are) D_2O ✓

[1 mark]

ALLOW *Molecules contain* ^{18}O

Idea of isotopes is critical

.....BUT

DO NOT ALLOW *isotopes of elements different from H and O (e.g. C)*

1(c)

$p(O_2) = 0.21 \times 1.00 \times 10^5$

$= 21{,}000 / 2.1 \times 10^4$ (Pa) ✓

[1 mark]

1(d)

FIRST, CHECK ANSWER

IF *answer = 231 000, award 2 marks*

$n(C_3H_8)$

$n(C_3H_8) = \frac{42.0 \times 10^3}{24.0}$ **OR** $\frac{42.0 \times 10^6}{24\,000}$ **OR** 1750 (mol) ✓

Mass of CO_2

mass $CO_2 = 3 \times 1750 \times 44$

$= 231\,000 / 2.31 \times 10^5$ (g) ✓

ALLOW *2 SF, e.g. 230 000*

[2 marks]

ALLOW *use of ideal gas equation with a sensible temperature (20–25°C) and pressure (100/101 kPa)*

At 20°C and 100 kPa,

$n(C_3H_8)$

$= \frac{100 \times 10^3 \times 42.0}{(8.314 \times 293)} = 1724...$ (mol)

→ ~ 227586 (g) (dependent on roundings)

At 25°C and 100 kPa,

$n(C_3H_8)$

$= \frac{100 \times 10^3 \times 42.0}{(8.314 \times 298)} = 1695...$ (mol)

→ ~ 223767 (g) (dependent on roundings)

ALLOW *use of 8.31 for R*

ALLOW ECF *from* $n(C_3H_8)$

Common errors from 24.0 dm^3

231	→ 1 mark	No conversion of m^3 to dm^3
0.231	→ 1 mark	Confusion of cm^3 and dm^3
77 000	→ 1 mark	No 3 × for CO_2

1(e)

Initial rate = $10^{-2} \times 2.4 \times 10^{-3}$ s^{-1}

= 2.4×10^{-5} (mol dm^{-3} s^{-1}) ✓

[1 mark]

1(f)

FIRST, CHECK ANSWER

***IF** answer = 9.03×10^{22}, award 2 marks*

$n(P_2O_5) = \frac{4.26}{142.0}$ **OR** 0.03(00) (mol) ✓

O atoms = $5 \times 0.0300 \times 6.02 \times 10^{23}$

= 9.03×10^{22} ✓

Minimum 3 SF required

[2 marks]

Alternative approach

n(O atoms) = $\frac{4.26}{142.0} \times 5 = 0.15$ ✓

O atoms = $0.15 \times 6.02 \times 10^{23}$ = 9.03×10^{22} ✓

***ALLOW ECF** from incorrect $n(P_2O_5)$*

***ALLOW** use of 6.022×10^{23}*

Common error

1.806×10^{22} **OR** 1.81×10^{22} → 1 mark No × 5

Q79 · Amount of substance · [8 marks]

OCR MARK SCHEME

2(a)

$CO_3^{2-} + H_2O \rightarrow OH^- + HCO_3^-$

OR

$CO_3^{2-} + H_2O \rightarrow 2OH^- + CO_2$ ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW

$CO_3^{2-} + 2H_2O \rightarrow 2OH^- + H_2CO_3$

***IGNORE** state symbols*

***ALLOW** inclusion of Na^+ as spectator ion, e.g.*

$2Na^+ + CO_3^{2-} + H_2O \rightarrow 2OH^- + 2Na^+ + CO_2$

IGNORE

$Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$

Ionic equation required

IGNORE *equation with* H^+ *or* H_3O^+

e.g. $CO_3^{2-} + H^+ \rightarrow OH^- + CO_2$

Question asks for reaction with H_2O

2(b)

Acid/H^+/HCl reacts with **OR** protonates

- benzoate / $C_6H_5COO^-$
- carboxylate / salt

(to form benzoic acid) ✓

[1 mark]

ALLOW *suitable equation, e.g.*

$C_6H_5COO^- + H^+ \rightarrow C_6H_5COOH$

IGNORE *responses purely in terms of neutralisation of alkali, e.g.*

Acid/H^+/HCl neutralises / reacts with/removes alkali / OH^- / CO_3^{2-} / Na_2CO_3

2(c)

$C_6H_5CH_2OH + 2[O] \rightarrow C_6H_5COOH + H_2O$ ✓

[1 mark]

ALLOW *molecular, structural, displayed formulae, etc*

e.g. molecular:

$C_7H_8O + 2[O] \rightarrow C_7H_6O_2 + H_2O$

2(d)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 33.8 OR 33.9 (%) award 3 marks

Theoretical moles

$n(C_6H_5COOH)$ **OR** $n(C_6H_5CH_2OH)$

$= \frac{4.00 \times 1.04}{108.0}$ **OR** 0.0385..... (mol) ✓

Actual moles

$n(C_6H_5COOH) = \frac{1.59}{122.0}$ **OR** 0.013(0).... (mol) ✓

% yield = $\frac{0.0130...}{0.0385....} \times 100 = 33.8\%$ **OR** 33.9 (3 sig fig) ✓

Answer depends on some intermediate roundings to 3SF

[3 marks]

ALLOW ECF *for each step*

Calculator = 0.03851851852

Calculator = 0.01303278689

Alternative method using mass

1. Theoretical moles = 0.0385 mol
2. Mass = 0.0385 × 122.0 = 4.70 g
3. % yield = $\frac{1.59}{4.70} \times 100 = 33.8\%$

Common errors

35.2% → 2 marks

- From $\frac{4.00}{108} = 0.0370$

(no use of density)

36.5 **OR** 36.6% → 2 marks

$$\frac{4.00/1.04}{108} = \frac{3.846}{108} =$$

- 0.0356

(÷ density instead of × density)

2(e)

Dissolve in the minimum quantity of hot water/solvent ✓

Cool

AND

Filter

AND

(leave to) dry ✓

All three needed

ALLOW *any solvent*

DO NOT ALLOW *use of drying agent (e.g. $MgSO_4$)*

IGNORE

- Initial filtering
- hot filtration to remove insoluble impurities

[2 marks]

Q80 · Amount of substance · [10 marks]

OCR MARK SCHEME

3(a)(i)

$4Pb_2O_3 + 3CH_4 \rightarrow 8Pb + 3CO_2 + 6H_2O$

OR

$Pb_2O_3 + CH_4 \rightarrow 2Pb + CO + 2H_2O$

OR

$2Pb_2O_3 + 3CH_4 \rightarrow 4Pb + 3C + 6H_2O$ ✓

EXAMINER GUIDANCE

ALLOW *multiples*

IGNORE *state symbols*

[1 mark]

3(a)(ii)

ONE Safety issue AND precaution ✓

From:

Safety issue:

Compounds may be toxic/poisonous/flammable

AND

Precaution:

Use a fume cupboard/good ventilation

Safety issue:

Lead (compounds) is/are toxic/poisonous

AND

Precaution:

IGNORE *use safety glasses, lab coat (in question) and tying hair back, safety screen*

Definite safety issue needed.

*Not just 'harmful' **OR** dangerous (Too vague).*

Wear gloves

Safety issue:

Methane is flammable

AND

Precaution:

Keep away from flame

[1 mark]

3(a)(iii)

Any 2 modifications ✓ ✓

from

1. Heat to constant mass

(Ensures all lead oxide has reacted)

2. Spread/stir/break up lead oxide

OR increase surface area

OR use powder rather than lumps

(Ensures all lead oxide has reacted)

3. Pass methane/inert gas/N_2 through tube as it cools

OR don't pass cold air

(Prevents O_2 reacting with Pb)

4. Use excess methane **OR** more methane

(Ensures all lead oxide has reacted)

5. Bubble (escaping) gas through lime water

(Ensures all lead oxide has reacted

OR ensures all CO_2 has been produced)

ALLOW *response that implies heating to constant mass, e.g.*

Heat again until the mass does not change

IGNORE *'heat for longer'*

Needs link to constant mass

IGNORE *'weigh straight after heating'*

IGNORE *idea of repeating the experiment/ taking an average/ getting concordant results / larger sample size, etc.*

[2 marks]

3(a)(iv)

Pb : O

Masses(/g): 3.132 **AND** 0.322

OR Mole ratios: $\frac{3.132}{207.2} : \frac{0.322}{16.0}$

OR Mole ratios: 0.0151: 0.020125 ✓

Empirical formula Pb_3O_4

(must come from masses) ✓

NO ECF from incorrect masses

[2 marks]

3(b)

Type of lattice 2 marks

- SiO_2: Giant (covalent lattice) ✓
- CO_2: Simple molecular/covalent (lattice) ✓

Explanation 2 marks

1. Forces in CO_2

- Induced dipole–dipole interactions / London forces ✓

2. Comparison of forces with strength / melting point

- (Covalent) bonds in SiO_2 are stronger THAN intermolecular forces in CO_2

OR

- More energy to break (covalent) bonds in SiO_2 THAN intermolecular forces in CO_2 ✓

ORA

[4 marks]

Throughout, IGNORE 'ionic' for SiO_2

FOR SiO_2, IGNORE macromolecular

DO NOT ALLOW *giant metallic*

Mark explanation independently on type of lattice i.e. no **ECF** from incorrect lattice

For CO_2

IGNORE

- covalent bonds
- van der Waals' forces
- idid
- LDF

DO NOT ALLOW *hydrogen bonds*

OR permanent dipole interactions

For SiO_2,

comparison needs just 'bonds' **OR** 'forces'

For intermolecular, **ALLOW** 'between molecules'

For comparison,

ALLOW *strong in SiO_2* ***AND*** *weak in CO_2*

DO NOT ALLOW *responses containing intermolecular forces in SiO_2*

IGNORE *'More bonds'*

Q81 · Amount of substance · [12 marks]

OCR MARK SCHEME

6(a)(i)

A: $Fe(OH)_3(s)$ ✓

B: $Ag_2S(s)$ ✓

[2 marks]

EXAMINER GUIDANCE

ALLOW *$Fe(OH)_3(H_2O)_3$*

IGNORE *state symbols*

6(a)(ii)

Student is incorrect

AND

ALLOW *no electron transfer*

No oxidation numbers change

OR example, e,g, Fe stays as +2 ✓

[1 mark]

6(a)(iii)

$2[Fe(H_2O)_6]^{2+} + Cl_2 \rightarrow 2[Fe(H_2O)_6]^{3+} + 2Cl^-$ ✓

[1 mark]

ALLOW multiples

e.g. $[Fe(H_2O)_6]^{2+} + ½Cl_2 \rightarrow [Fe(H_2O)_6]^{3+} + Cl^-$

ALLOW

$2[Fe(H_2O)_6]^{2+} + Cl_2 \rightarrow 2[Fe(H_2O)_5OH]^{2+} + 2HCl$

OR

$2[Fe(H_2O)_6]^{2+} + Cl_2 \rightarrow 2[Fe(H_2O)_5Cl]^{2+} + 2H_2O$

***NOTE**: equation MUST be balanced by charge and oxidation number*

***IGNORE** state symbols*

6(a)(iv)

$5H_2S + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 5S + 8H_2O$ ✓✓

1st mark

ALL Correct species (SIX)

OR

Equation containing Mn and S species correctly balanced

i.e. $5H_2S + 2MnO_4^-$ ..... $\rightarrow 2Mn^{2+} + 5S$ .....

2nd mark

Complete correct balanced equation

[2 marks]

***ALLOW** multiples, e.g.*

$2½\ H_2S + MnO_4^- + 3H^+ \rightarrow Mn^{2+} + 2½\ S + 4H_2O$

***ALLOW** equation with S^{2--}, e.g.*

$5S^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 5S + 8H_2O$

***IGNORE** extra electrons for 1st mark*

6(b)

Level 3 (5–6 marks)

Reaches a comprehensive conclusion to determine the correct formulae of almost all of C, D, E, F, **G AND $9H_2O$**

There is a well-developed line of reasoning which is clear and logically structured.

The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Indicative scientific points may include:

Formula of C, D, E, F and G

- C: $Fe(NO_3)_3 \cdot 9H_2O$ **OR** $FeN_3O_9 \cdot 9H_2O$
- D: FeN_3O_9 **OR** $Fe(NO_3)_3$
- E: Fe_2O_3
- F: NO_2

Reaches a sound conclusion to determine the correct formulae of at least half of C, D, E, **F, G AND $9H_2O$**.

There is a line of reasoning presented with some structure.

The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Reaches a simple conclusion to determine the correct formulae of some of C, D, E, F, **G AND $9H_2O$**.

There is an attempt at a logical structure with a line of reasoning.

The information is in the most part relevant.

0 marks No response or no response worthy of credit.

[6 marks]

- G: O_2
- $9H_2O$

Examples of evidence

$n(H_2O) = \frac{0.486}{18.0} = 0.027$ (mol)

$0.027 : 0.003 = 1 : 9 \rightarrow 9H_2O$

n(F)

$= \frac{(270 - 54)}{24000} = \frac{216}{24000} =$ 0.009(00) (mol)

$M(E) = 55.8 \times 2 + 16.0 \times 3 = 159.6$

$M(F) = \frac{0.414}{0.009(00)} = 46$ (g mol^{-1})

G: oxygen linked to relighting glowing split

***NOTE**: Equations could include evidence*

e.g

$Fe(NO_3)_3 \cdot 9H_2O \rightarrow Fe(NO_3)_3 + 9H_2O$

$FeN_3O_9 \cdot 9H_2O \rightarrow FeN_3O_9 + 9H_2O$

$2Fe(NO_3)_3 \rightarrow Fe_2O_3 + 6NO_2 + 1½O_2$

Q82 · Amount of substance · [8 marks]

OCR MARK SCHEME

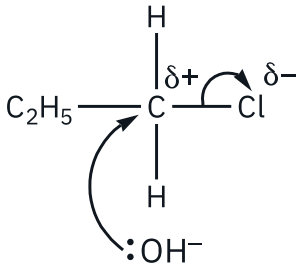
26(a)

Curly arrow from HO^- to C atom of C–Cl bond ✓

Dipole shown on C–Cl bond, $C^{\delta+}$ and $Cl^{\delta-}$

AND

curly arrow from C–Cl bond to Cl atom ✓



***IGNORE** presence of Na^+ but OH^- needed*

i.e. Na^+OH^-can be allowed if criteria met

EXAMINER GUIDANCE

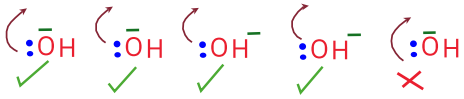
***NOTE**: curly arrows can be straight, snake-like, etc. but **NOT** double headed or half headed arrows*

1st curly arrow must

- go to C of C–Cl

AND

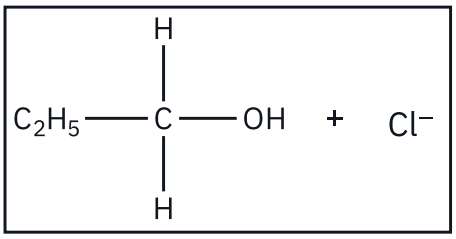
- start from, OR be traced back to any point across width of lone pair on O of OH^-



- OR start from – charge on O of ^-OH ion

DO NOT ALLOW *H_2O instead of OH^-*

Correct organic product AND Cl^- ✓

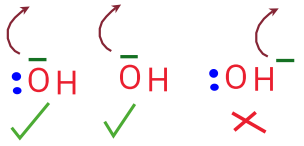


IGNORE *presence of Na^+ but Cl^- needed*

i.e. Na^+Cl^- can be allowed

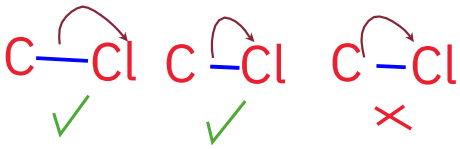
BUT NaCl does **NOT** show Cl^-

[3 marks]



(Lone pair **NOT** needed if curly arrow shown from O^-)

2nd curly arrow must start from, OR be traced back to, any part of C–Cl bond and go to Cl



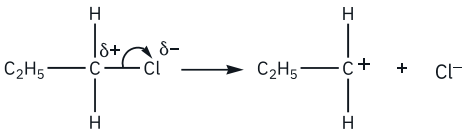
ALLOW ECF $NaCl^-$ ONLY from $NaOH^-$

ALLOW *S_N1 mechanism*

First mark

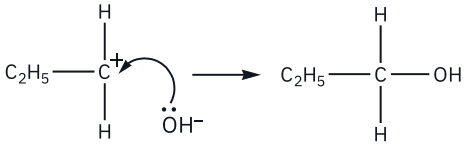
Dipole shown on C–Cl bond, $C^{\delta+}$ and $Cl^{\delta-}$,

AND curly arrow from C–Cl bond to Cl atom ✓



Second mark

Correct carbocation AND curly arrow from HO^- to carbocation



Curly arrow must come from lone pair on O of HO^-

OR OH^-

OR from minus on O of HO^- ion (no need to show lone pair if curly came from negative charge) ✓

Third mark

26(b)

FIRST check the molar mass on answer line

MUST be derived from $pV = nRT$,

Award 4 marks for calculation for:

- answer = 136.9 OR 137

Rearranging ideal gas equation to make *n* subject

$n = \frac{pV}{RT}$ ✓

Substituting all values including conversion to m^3 and K

$n = \frac{(1.01 \times 10^5) \times (74.0 \times 10^{-6})}{8.314 \times 373}$ ✓

$n = 2.410095443 \times 10^{-3}$	→	2.41×10^{-3} (mol) ✓
unrounded		rounded to 3 SF

Calculation of molar mass, *M*

$M = \frac{m}{n} = \frac{0.330}{2.410095443 \times 10^{-3}} = 136.9..\ (g\ mol^{-1})$

$\rightarrow \frac{0.330}{2.41 \times 10^{-3}} = 136.9\ (g\ mol^{-1})$ ✓

ALLOW *calculated M in range 136.9 – 137*

Molecular formula of D

C_4H_9Br ✓

IF *candidate has failed to derive suitable value of n,* ***ALLOW*** *value of M from 0.330 AND 24000 with haloalkane closest to calculated value for last 2 marks*

See Guidance column.

[5 marks]

Correct organic product AND Cl^- ✓

If there is an alternative answer, check to see if there is any ***ECF*** *credit possible using working below*

1st mark may be implicit by direct substitution of correct values below into rearranged equation.

ALLOW *use of 8.31 for R →* 2.411×10^{-3}

ONLY award this mark if *n* has been derived from correct rearranged ideal gas equation

ALLOW *3 SF up to calculator value, correctly rounded*

2.41×10^{-3} OR 0.002411255537 → first 3 marks

→ 136.868581616 → C_4H_9Br

NOTE: ALLOW *137 (i.e. to 3 SF)*

ALLOW *any unambiguous structure*

ALLOW ECF provided that formula given is a haloalkane and matches M calculated from 0.330 g AND pV = nRT

$M = \frac{0.330}{74.0/24000}$ OR $\frac{0.330}{3.0833.. \times 10^{-3}}$

= 107 to 3 SF ✓

From 107, ONLY **ALLOW** = C_2H_5Br (108.9) ✓

Q83 · Amount of substance · [1 mark]

Answer: **C**

45.5 g

Q84 · Amount of substance · [1 mark]

Answer: **B**

6.25 cm^3

Q85 · Amount of substance · [1 mark]

Answer: **D**

7.22×10^{24}

Q86 · Amount of substance · [1 mark]

Answer: **C**

$2N_2(g) + O_2(g) \rightarrow 2N_2O(g)$

Q87 · Amount of substance · [1 mark]

Answer: **B**

Cr

Q88 · Amount of substance · [1 mark]

Answer: **C**

0.275

Q89 · Amount of substance · [1 mark]

Answer: **B**

O_2

Q90 · Amount of substance · [6 marks]

OCR MARK SCHEME

17

FIRST CHECK ANSWER LINES

If M=168(.0) Award 4 marks for calculation providing unit conversions are correct

Use of ideal gas equation

$pV = nRT$ **OR** $n = \frac{pV}{RT}$ ✓

SI Unit conversions AND substitution into $n = \frac{pV}{RT}$:

- R = 8.314 **OR** 8.31
- $V = 186 \times 10^{-6}$
- T in K: 303 K

EXAMINER GUIDANCE

ALLOW ECF throughout

ALLOW *calculator value of 167.968115 (using 8.314) for M*

ALLOW *calculator value of 167.8873033 (using 8.31) for M*

Calculator value of *n*:

from 8.314 = $7.900308915 \times 10^{-3}$

from 8.31 = $7.904111711 \times 10^{-3}$

ALLOW *ECF that matches M but the formula MUST contain F_6O*

Use of 24 dm^3:

e.g. $\frac{1.07 \times 10^5 \times 186 \times 10^{-6}}{8.314 \times 303}$ ✓

Calculation of n

$n = 7.90 \times 10^{-3}$ (mol) ✓

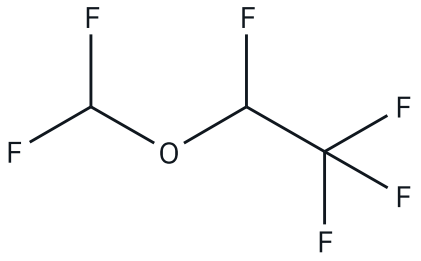
Calculation of M

$M = \frac{1.327}{7.90 \times 10^{-3}} = 168(.0)$ ✓

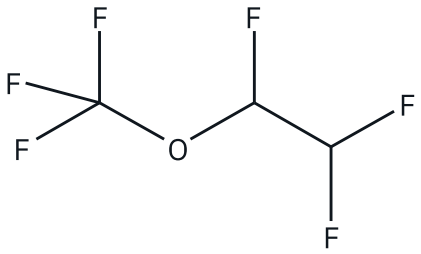
Molecular formula

$C_3H_2F_6O$ ✓

Structure



OR



✓

e.g. $n = \frac{186.0}{24000} = 7.75 \times 10^{-3}$ No mark

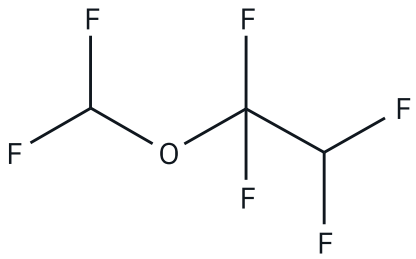
(calculation much simpler)

$M = \frac{1.327}{7.75 \times 10^{-3}} = 171(.2)$ ✓ **ECF**

$C_3H_5F_6O$ ✓ **ECF**

ALLOW *ECF for a feasibile chemical structure that matches M* ***AND*** *contains F_6O* ***AND*** *has a chiral carbon*

DO NOT ALLOW



no chiral carbon

[6 marks]

Q91 · Amount of substance · [1 mark]

Answer: **B**

$C_6H_{14} \rightarrow 2C_2H_4 + C_2H_6$

Q92 · Amount of substance · [1 mark]

Answer: **C**

OCR MARK SCHEME

500 mg

EXAMINER GUIDANCE

ALLOW *500 (This is the correct mass)*

Q93 · Amount of substance · [1 mark]

Answer: **C**

OCR MARK SCHEME

EXAMINER GUIDANCE

4.80 dm^3

ALLOW *4.8 (This is the correct volume)*

Q94 · Amount of substance · [13 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

6(a)

Number of optical isomers = 4 ✓

[1 mark]

6(b)(i)

Hydrogen bonding

AND

Many OH/hydroxyl / hydroxy / alcohol ✓

ALLOW *4 OH*

DO NOT ALLOW *OH^-*

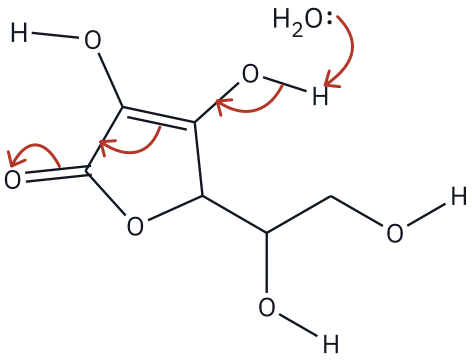
[1 mark]

6(b)(ii)

x = 15 ✓ y = 31 ✓

[2 marks]

6(c)(i)



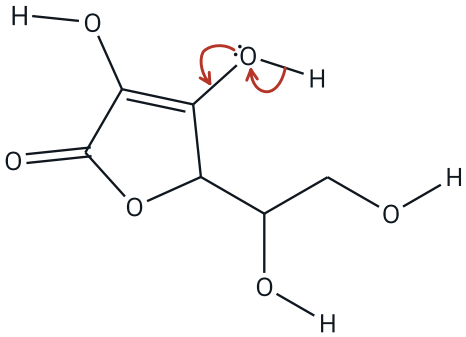
3 **OR** 4 curly arrows correct → 2 marks ✓✓

1 curly arrow correct → 1 mark ✓

[2 marks]

IGNORE incorrect curly arrows

IGNORE *'double' curly arrows such as:*



H_2O Curly arrow must

- start from, **OR** be traced back to any point across width of lone pair on H_2O:

6(c)(ii)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 2.16 award 3 marks

[Vitamin C] = 0.150 × 4 = 0.600 (mol dm^{-3}) ✓

For $[H^+]$

ALLOW ECF *from incorrect [vitamin C]*

for pH

0.6 seen anywhere

$[H^+] = \sqrt{(K_a \times [\text{Vitamin C}])}$

$= \sqrt{(7.94 \times 10^{-5} \times 0.600)}$

$= 6.90 \times 10^{-3}$ (mol dm^{-3}) ✓

pH = –log $[H^+]$

$= -\log 6.90 \times 10^{-3}$

= 2.16 ✓

2 DP required

[3 marks]

ALLOW ECF ONLY *if $[H^+]$ has been derived from K_a* ***AND*** *[vitamin C]*

COMMON ERRORS

pH = 4.32 2/3 calculation marks

No square root of $(7.94 \times 10^{-5} \times 0.600)$

pH = 2.46 2/3 calculation marks

No × 4 $(7.94 \times 10^{-5} \times 0.150)$

pH = 2.76 2/3 calculation marks

÷ 4 $(7.94 \times 10^{-5} \times 0.0375)$

pH = 4.92 1/3 calculation mark

No square root AND 0.150

pH = 5.53 1/3 calculation mark

No square root AND 0.0375

6(d)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 38 (mg) award 4 marks

$n(I_2) = \dfrac{22.50 \times 9.60 \times 10^{-4}}{1000} = 2.16 \times 10^{-5}$ (mol) ✓

n(vitamin C) in 250 cm^3 volumetric flask

$= 10 \times 2.16 \times 10^{-5} = 2.16 \times 10^{-4}$ (mol) ✓

M(Vitamin C: $C_6H_8O_6$) = 176 **OR** (12 × 6) + (1 × 8) + (16 × 6)

Seen anywhere

Mass vitamin C in 150 cm^3 of orange

$= 2.16 \times 10^{-4} \times 176.0 = 0.038016$ g

= 38 (mg) ✓

2 SF or more

[4 marks]

Use ECF throughout

Intermediate values for working to at least 3 SF.

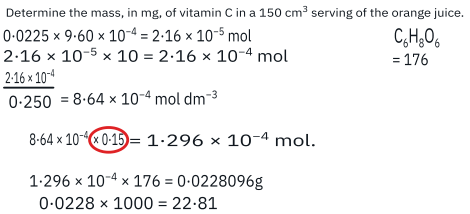
TAKE CARE as value written down may be truncated value stored in calculator.

Depending on rounding, either can be credited.

COMMON ERRORS:

22.81 mg scaling by 150/250 → 3 marks

FINAL MARK LOST BY SCALING



✓ ✓ ✓ ✗

42.24 mg using 25.0 cm^3 instead of 22.50

→ 3 marks

25.34 mg using 25.0 cm^3 **AND** scaling by 150/250 instead of 22.50

→ 2 marks

63.36 mg scaling by 250/150 → 3 marks

Q95 · Amount of substance · [1 mark]

Answer: **D**

1.08

Q96 · Amount of substance · [1 mark]

Answer: **B**

CH_2

Q97 · Amount of substance · [1 mark]

Answer: **C**

15.4%

Q98 · Amount of substance · [1 mark]

Answer: **C**

2.41×10^{24}

Q99 · Amount of substance · [1 mark]

Answer: **D**

150 cm^3

Q100 · Amount of substance · [1 mark]

Answer: **C**

0.33 g

Q101 · Amount of substance · [19 marks]

OCR MARK SCHEME

2(a)(i)

Equation

$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

All formulae and balancing correct ✓

Observation

Effervescence/fizzing/bubbles

OR

EXAMINER GUIDANCE

ALLOW *correct multiples including fractions*

IGNORE *state symbols, even if wrong*

IGNORE *temperature change, pH change or gas formed i.e. must be an observable change.*

IGNORE *turns cloudy*

Ca/solid disappears/dissolves

OR

Forms a white ppt/solid ✓

[2 marks]

DO NOT ALLOW *Colour change*

2(a)(ii)

More vigorous effervescence/fizzing/bubbling

OR

Ba/solid disappears/dissolves faster

OR

White ppt formed less rapidly ✓

[1 mark]

ORA *if clearly references Ca*

ALLOW *AW such as stronger/ rapid/ quicker/ more quickly/ more violent*

ALLOW *less or no ppt (as barium hydroxide is more soluble)*

Note: Must reference observation not just reaction e.g. more vigorous reaction.

IGNORE *finishes first*

IGNORE *more bubbles (need idea of rate)*

IGNORE *exothermic*

2(b)(i)

$Ba(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)$

Balanced equation ✓

State symbols ✓

[2 marks]

ALLOW *ionic equation*

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

M2 dependent on M1

IGNORE *NaCl balanced on both sides*

2(b)(ii)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 26.6 % award 4 marks

$n(BaSO_4) = \frac{3.28}{233.4}$ **OR** 0.014053... (mol) ✓

mass $Ba(NO_3)_2$ = 0.014053... × 261.3

OR 3.672.....(g) ✓

mass NaCl = 5.00 – 3.672.. **OR** 1.3279... (g) ✓

$\% \text{ NaCl} = \frac{1.3279 \times 100}{5.00}$ = 26.6(%) 3 SF ✓

[4 marks]

ALLOW ECF from incorrect equation in 2(b)(i) and throughout

ALLOW *3SF up to calculated value throughout*

IGNORE *rounding errors past 3SF*

Calculator: 0.01405312768

Calculator: 3.672082262

Calculator: 1.327917738

ALLOW ECF for use of calculated mass NaCl e.g. 0.014053...x 58.5 = 0.8221.... to give final % 16.4 to 3SF

Alternative approach for last 2 marks

$\% Ba(NO_3)_2 = \frac{3.672 \times 100}{5.00}$ = 73.44 ... ✓

% NaCl = 100 – 73.44 = 26.6 % ✓

2(b)(iii)

Silver chloride/AgCl would be produced (as a precipitate) ✓

(Mass of NaCl) can be calculated from the mass/moles of AgCl ✓

[2 marks]

ALLOW *Chloride reacts to give (white) ppt*

IGNORE *incorrect formula of silver chloride*

ALLOW *equation showing formation of AgCl(s)*

ALLOW *Weigh AgCl and use to calculate %/mass/moles*

2(c)(i)

Shaded cells don't need filling in.

Substance	**Magnesium sulfide**	**Aluminium**	**Silicon**	**Phosphorus trichloride**
Melting point/°C	2000	660	1414	–94
Electrical conductivity		Good	Poor	
Type of lattice structure	Giant **Ionic** ✓	**Giant Metallic** ✓	**Giant Covalent** ✓	**Simple Molecular** ✓

[4 marks]

ALLOW *Simple covalent instead of simple molecular*

2(c)(ii)

Melting points

MgS: ionic bonds (between oppositely charged ions) ✓

PCl_3: intermolecular forces ✓

More energy needed (to separate ions in MgS)

OR

Strong ionic bonds **AND** weak intermolecular forces ✓

Conductivity

Al: mobile/delocalised electrons

AND

Si: no mobile/delocalised electrons **OR** no charge carriers **OR** no mobile ions

ALLOW *London forces or permanent dipole dipole interactions*

ORA *answer must be comparative*

ALLOW ECF from incorrect type of bonding i.e. stronger attraction/more energy

IGNORE *'free electrons' for mobile/delocalised electrons*

[4 marks]

Q102 · Amount of substance · [1 mark]

Answer: **B**

45.0 g of C_2H_6

Q103 · Amount of substance · [1 mark]

Answer: **D**

10.3%

Q104 · Amount of substance · [13 marks]

OCR MARK SCHEME

19(a)(i)

$(K_p) = \dfrac{p(N_2O_4(g))}{p(NO_2(g))^2}$ ✓

Units atm^{-1} ✓

CHECK THE ANSWER ON ANSWER LINE

*if answer = 1.17 × **10^{-2}** **OR 1.18** × 10^{-2} award 3 calculation marks*

Calculation

- nN_2O_4 = 0.3(00) (mol) **AND** ntotal = 5.7(0) (mol) ✓
- pNO_2 = ($\dfrac{5.4(0)}{5.7(0)}$ × 5.00 =) 4.74 (atm) **AND** pN_2O_4 = ($\dfrac{0.3(00)}{5.7(0)}$ × 5.00 =) 0.263 (atm) ✓
- K_p to 3 SF ($K_p = \dfrac{0.263}{4.74^2}$ =) 1.17 × 10^{-2} ✓

[5 marks]

EXAMINER GUIDANCE

***ALLOW** species without state symbols and without brackets.*

e.g., pSO_3^2 , $ppSO_3^2$, PSO_3^2, $p(SO_3)^2$ $(pSO_3)^2$ etc.

***DO NOT ALLOW** square brackets*

***ALLOW** atm as **ECF** if K_p is upside down*

***ALLOW ECF** throughout*

***ALLOW** 3 SF up to the calculated value.*

***IGNORE** RE after 3SF*

Calculator value

pNO_2 = 4.7368.....

pN_2O_4 = 0.26315....

Mark use of 2SF in working as incorrect once and then allow ECF

Answer MUST be 3 SF

Common error for 2 calculation marks:

2.47 x 10^{-2} (using 0.6 mol N_2O_4)

19(a)(ii)

Higher temperature

Δ*H* is negative / exothermic (for forward reaction)

AND equilibrium shifts to left/to LHS/decreases yield ✓

Higher pressure

ORA

***ALLOW** correct equilibrium shifts without explanations for 1 mark*

***ALLOW** opposing effects may not be the same size*

2 (gaseous) moles form 1 (gaseous) mole/ to side with fewer moles

AND Equilibrium shifts to right /RHS/increases yield ✓

Comparison

Difficult to predict relative contributions of two opposing factors ✓

[3 marks]

__ALLOW__ effects could cancel each other out

__ALLOW__ effects oppose one another

__DO NOT ALLOW__ if both equilibrium shifts are in the same direction

__DO NOT ALLOW__ just 'it is difficult to predict equilibrium position' (in question) For the 3rd mark, we are assessing the idea that we don't know which factor is dominant

19(b)

Rearranging ideal gas equation

$n = \frac{pV}{RT}$ ✓

Unit conversion AND substitution into $n = \frac{pV}{RT}$:

- R = 8.314 **OR** 8.31
- V in $m^3 = 74 \times 10^{-6}$
- T in $K = 348$
- P in Pa = 101×10^3

e.g. $\frac{101 \times 10^3 \times 74.0 \times 10^{-6}}{8.314 \times 348}$ ✓

Calculation of n

$n = 2.58..... \times 10^{-3}$ (mol) ✓

Calculation of M

$M = \frac{0.28}{2.58.... \times 10^{-3}} = 108(.....)$ ✓

Molecular formula that is the closest to the calculated M_r value.

e.g. M_r 108 = N_2O_5 ✓

[5 marks]

__ALLOW ECF__ throughout if all values have been used to calculate n

__IF__ $n = \frac{pV}{RT}$ is omitted, __ALLOW__ when values are substituted into rearranged ideal gas equation

CARE:

Correct n value subsumes first marking point only as two incorrect unit conversions can lead to correct n

Calculator value:

from 8.314 $n = 2.583234483 \times 10^{-3}$

from 8.31 $n = 2.584477917 \times 10^{-3}$

Calculator value:

M from 8.314 = 108.3912443

M from 8.31 = 108.3390955

M from $\frac{0.28}{2.58 \times 10^{-3}} = 108.5$ **OR** 109

__ALLOW ECF__ from calculation of n provided formula of oxide contains at least one N i.e. NO ($M_r = 30$)

Use of 24 dm^3: Final 2 marks possible by **ECF**

e.g. $n = \frac{74.0}{24000} = 3.08 \times 10^{-3}$

No mark (calculation much simpler)

$M = \frac{0.28}{3.08 \times 10^{-3}} = 90(.8)$ **ECF**

N_3O_3 **ECF**

DO NOT ALLOW *N_2O_4 (in question)*

ALLOW ECF *matching calculated M*

Q105 · Amount of substance · [1 mark]

Answer: **C**

Mn_2O_3

Q106 · Amount of substance · [10 marks]

OCR MARK SCHEME

21(a)(i)

Colourless to (pale) pink

[1 mark]

EXAMINER GUIDANCE

ALLOW <u>Pale</u> *purple*

DO NOT ALLOW *purple*

21(a)(ii)

12.65	12.95	12.75

✓

$\frac{12.65+12.75}{2}$ = 12.7(0) cm^3 ✓

[2 marks]

21(a)(iii)

FIRST CHECK THE ANSWER ON ANSWER LINE

if answer = 6.35 × 10^{-3} award 3 marks

$n(MnO_4^-)$ in titration = $(\frac{0.00250 \times 12.7}{1000})$ = 3.175×10^{-5} ✓

$n(Fe^{2+})$ in 25.0 cm^3 = $(3.175 \times 10^{-5} \times 5)$ =

1.5875×10^{-4} (mol) ✓

$[Fe^{2+}] = \frac{1.5875 \times 10^{-4}}{0.025}$ **OR** $(1.5875 \times 10^{-4} \times 40)$ =

6.35×10^{-3} ($mol\ dm^{-3}$) ✓

[3 marks]

ALLOW ECF *from incorrect titre in 21 a ii) for 3 marks*

e.g. Titre of 12.78 cm^3 gives

6.39×10^{-3}

ALLOW 3 SF or more throughout

ALLOW ECF *throughout*

ALLOW

$n(Fe^{2+})$ in 250 cm^3 =

1.5875×10^{-3} (mol)

so $[Fe^{2+}]$ in 25 cm^3

= $\frac{1.5875 \times 10^{-3}}{0.25}$ = 6.35×10^{-3}

Common errors for 2 marks

2.46×10^{-2} (volumes transposed)

21(b)

System 1/$E^{\ominus}$(Zn) is more negative/less positive than system 2/ $E^{\ominus}(Fe^{3+})$ ✓

Eqm 2 shifts to right **AND** Eqm 1 shifts to left

OR

Zinc reduces iron(III) ions (to iron(II))

OR

$Zn + 2Fe^{3+} \rightarrow Zn^{2+} + 2Fe^{2+}$ ✓

System 1/$E^{\ominus}$(Zn) is more negative than system 3/ $E^{\ominus}(MnO_4^-)$ ✓

Eqm 3 shifts to right **AND** Eqm 1 shifts to left

OR

(If unfiltered), MnO_4^- oxidise zinc

OR

$2MnO_4^- + 5Zn + 16H^+ \rightarrow 2Mn^{2+} + 5Zn^{2+} + 8H_2O$ ✓

[4 marks]

1.25×10^{-2} (same volume used twice)

1.27×10^{-3} (no x 5)

2.54×10^{-4} (÷5)

ALLOW ORA *throughout*

IGNORE *larger/smaller/greater/less throughout*

ALLOW *$E^{\ominus}$ = (+)1.53(V)*

ALLOW *comparison if Fe system is identified*

ALLOW *$E^{\ominus}$ = (+) 2.27(V)*

ALLOW *comparison if MnO_4^- is identified*

Q107 · Amount of substance · [1 mark]

Answer: **D**

3.48×10^{22}

Q108 · Amount of substance · [1 mark]

Answer: **C**

0.0200 mol dm^{-3} HCl and 0.0600 mol dm^{-3} NaCl

Q109 · Amount of substance · [1 mark]

Answer: **D**

16 minutes

Q110 · Amount of substance · [1 mark]

Answer: **D**

MgO

Q111 · Amount of substance · [1 mark]

Answer: **D**

N_2O_3

Q112 · Amount of substance · [1 mark]

Answer: **B**

Chlorine may form toxic chlorinated hydrocarbons.

Q113 · Amount of substance · [1 mark]

Answer: **C**

$2Fe_2O_3 \rightarrow 4Fe + 3O_2$

Q114 · Amount of substance · [1 mark]

Answer: **C**

OCR MARK SCHEME

1.50

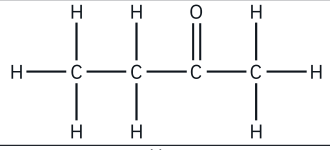
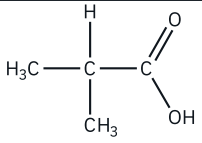
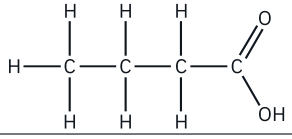
EXAMINER GUIDANCE

ALLOW *1.5(0)*

Q115 · Amount of substance · [9 marks]

OCR MARK SCHEME

25(a)

Alcohol	Organic product
D	
E	
F	No reaction
G	

ALL 4 responses correct → 3 marks ✓✓✓

3 responses correct → 2 marks ✓✓

2 responses correct → 1 marks ✓

[3 marks]

25(b)

D ✓

[1 mark]

25(c)

For CALCULATION, check the volume of CO_2 on answer line MUST be derived from pV = *nRT*,

Award 5 marks for calculation for:

- **answer = 2.89 × 10^4 (cm^3) OR 28900 (cm^3)**

Calculation of number of moles, *n* of CO_2 produced

$n(\text{Alcohol F}) = \frac{g}{M} = \frac{25.9}{74.0} = 0.35(0)\ (\text{g mol}^{-1})$ ✓

$n(CO_2) = 4 \times 0.35(0) = 1.4(0)$ mol ✓

Rearranging ideal gas equation to make *V* subject

$V = \frac{nRT}{p}$ ✓

Conversion of 100°C to 373K, and substituting all values into rearranged ideal gas equation

EXAMINER GUIDANCE

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

DO NOT ALLOW *structure if H(s) are missing from ONE structural formula*

……. BUT ALLOW any further omissions as ECF

Take care with numbers of carbons, the branches and the position of branching …. especially for E

IGNORE *connectivity for methyl groups*

BUT penalise incorrect connectivity for OH once

e.g. –HO

ALLOW *structure of alcohol F for 'no reaction'*

Check entire response for credit worthy working

If there is an alternative answer, check to see if there is any ECF credit possible using working

Marking point 3 can be awarded by direct substitution of values.

ALLOW *150 (kPa) for 1.50 × 10^5 (conversion is assessed in marking point 4)*

ALLOW *use of 8.31 for R → 0.02892988*

DO NOT ALLOW *use of 150 (kPa)*

ALLOW *3 SF up to calculator value, correctly rounded*

$V = \frac{1.40 \times 8.314 \times 373}{1.50 \times 10^5}$ **OR** 0.02894380... (m^3) ✓

V conversion of $m^3 \rightarrow cm^3$ **AND** 3 SF (most appropriate)

$V = 0.02894 \times 10^6 = 2.89 \times 10^4\ cm^3$ **OR** 28900 cm^3 ✓

[5 marks]

(use of 8.31 for R gives same answer)

Note use of 373.15 → 29000

Fine for all 5 marks

Common errors:

No use of ratio x4

7240 → 4 marks

Not appropriate SF

28943.8 → 4 marks

No temp conversion

7760 → 4 marks

Use of 25.9 as n in pV=nRT

535000 → 3 marks

Q116 · Amount of substance · [1 mark]

Answer: **C**

7.224×10^{23}

Q117 · Amount of substance · [1 mark]

Answer: **D**

$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

Q118 · Amount of substance · [1 mark]

Answer: **A**

PO_2

Q119 · Amount of substance · [12 marks]

OCR MARK SCHEME

2(a)(i)

$Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$

[1 mark]

EXAMINER GUIDANCE

ALLOW *$Ca^+(g) - e^- \rightarrow Ca^{2+}(g)$*

ALLOW *e for electron (i.e. charge omitted)*

IGNORE *states on the electron*

2(a)(ii)

Level 3 (5-6 marks)

Covers all 3 areas A, B and C in detail with very few omissions or errors

Indicative scientific points may include:

A Difference in Reactivity and Explanation

ORA *is allowed for the following:*

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Covers at least 2 areas in detail with very few omissions or errors

OR

Covers all 3 areas in some detail

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Covers 1 area in detail with very few omissions or errors

OR

Covers 2 areas in some detail

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks No response or no response worthy of credit

[6 marks]

- Ca more reactive than Mg.
- Atomic radius of Ca is greater or more shells/shielding.
- Attraction of outer electrons to the nucleus is less.
- Ionisation energies of Ca are less.

OR Easier to remove Ca outer electrons.

B Observations and equation

- Effervescence/fizzing/bubbles
- Ca/solid disappears/dissolves

OR

Forms a white ppt/solid

- $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ (**IGNORE** state symbols)

C Redox

- Both oxidation and reduction take place.
- Ca is oxidised
- Oxidation number of Ca increases from 0 to +2

OR

Ca loses 2 electrons (to form Ca^{2+} ions)

- H is reduced
- Oxidation number of H decreases from +1 to 0

OR

H gains 1 electron (per H atom)

Aspects of the communication statement might typically have been met for all levels when:

- All information given is correct using appropriate scientific language, for example (in A) comparison of Mg and Ca not

just trend down group and (in C) directly links redox to oxidation and reduction.

- There are no errors, for example incorrect balancing, using +2 as initial oxidation state for H.

2(b)(i)

FIRST CHECK THE ANSWER ON ANSWER LINE

IF *vol = 184 cm^3 award 2 marks*

$n(BaCO_3) = \frac{1.51}{197.3}$ **OR** $7.6533.... \times 10^{-3}$ ✓

$vCO_2 = 7.6533.... \times 10^{-3} \times 24000 = 184\ cm^3$ ✓

[2 marks]

ALLOW *3SF up to calculator value $7.653319818 \times 10^{-3}$*

IGNORE *rounding errors past 3SF*

ALLOW ECF *from incorrect $n(BaCO_3)$*

Answer must be 3 SF and in cm^3

ALLOW *use of ideal gas equation with an appropriate temperature (290–298K) and pressure (100/101/101325 kPa)*

e.g.

e.g. At 293K and 100 kPa,

$V = (7.65... \times 10^{-3} \times 8.314 \times 293) / 100 \times 10^3$

$V = 186\ cm^3$

2(b)(ii)

Any two from ✓✓

- (Gas lost /escapes) when the bung is replaced
- Some CO_2 / gas dissolves (in the water)
- Conditions / T/ P not at RTP

[2 marks]

IGNORE *Incomplete reaction*

IGNORE *human errors e.g. unsealed apparatus, gas escaping the measuring cylinder*

ALLOW *'when $BaCO_3$ is added to flask'*

ALLOW *not standard conditions*

2(b)(iii)

Use a gas syringe (in place of the upturned measuring cylinder)

OR

Place the barium carbonate inside a small tube and release it into the acid without removing the stopper OWTTE ✓

[1 mark]

IGNORE *gas cylinder*

ALLOW *use a water bath set at room temperature*

Q120 · Amount of substance · [1 mark]

Answer: **C**

6

Q121 · Amount of substance · [1 mark]

Answer: **B**

6.39

Q122 · Amount of substance · [1 mark]

Answer: **C**

OCR MARK SCHEME

17

EXAMINER GUIDANCE

ALLOW *17*

Q123 · Amount of substance · [1 mark]

Answer: **B**

1.806×10^{23}

Q124 · Amount of substance · [1 mark]

Answer: **A**

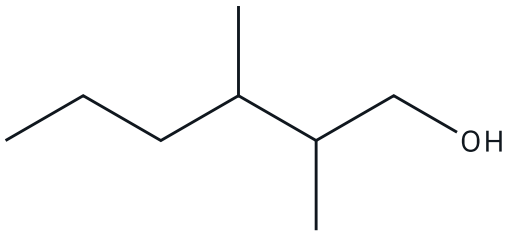
$C_3H_7Br \rightarrow C_3H_6 + HBr$

Q125 · Amount of substance · [14 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

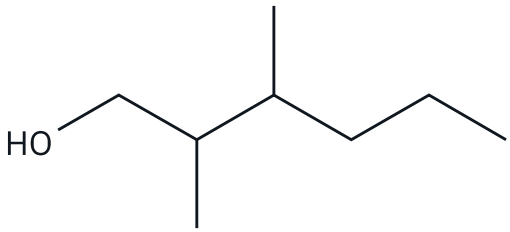
2(a)(i)



✓

Count main carbon chain first (watch for only 5 or 7 Cs)

Watch for correct reversed orientation:



[1 mark]

Structure MUST be skeletal (NO CH_3).

BUT

ALLOW *O–H*

DO NOT ALLOW *OH–*

ALLOW *any vertical bond to the OH group*

i.e. **ALLOW**



OR



IGNORE *any structural formulae, etc*

Treat as working

2(a)(ii)

FIRST, CHECK ANSWER

IF *answer =* ***7.04 × 10^{23} OR 7.05 × 10^{23},*** *award 3 marks*

$n(C_8H_{18}O) = \frac{8.45}{130.0}$ **OR** 0.065(0) (mol) ✓

n(H atoms) = 18 × 0.0650 **OR** 1.17 ✓

H atoms = 1.17 × 6.02 × 10^{23}

= 7.04 × 10^{23} ✓

3 SF and standard form required

ALLOW *use of 6.022 × 10^{23} → 7.05 × 10^{23}*

[3 marks]

ALLOW ECF *throughout*

Alternative working

18 and 6.02 × 10^{23} in different order

0.0650 × 6.02 × **10^{23} OR**
3.913 × 10^{22} ✓

3.913 × 10^{22} × 18 = 7.04 × 10^{23} ✓

Common errors		
3.91 × 10^{22}	→ 2 marks	No × 18
2.17 × 10^{21}	→ 2 marks	÷18
7.0434 × 10^{23}	→ 2 marks	Not 3 SF
5.42 × 10^{21}	→ 2 marks	÷130 twice

ALLOW *5.40–5.42 × 10^{21} (intermediate rounding)*

2(b)(i)

Assume that 'It' means paracetamol

It is a phenol

OR

It is not a carboxylic acid/no carboxyl group/no carboxylic

OR

It does not contain COOH ✓

A correct functional group must be in answer

[1 mark]

IGNORE

It is too weak an acid/not strong enough

It is a weak acid *So is COOH*

It does not react with Na_2CO_3 *In Q*

It contains amide **OR** benzene ring

IGNORE *reference to an alcohol/hydroxyl group*

DO NOT ALLOW *It is not acidic It is!*

It is a phenol which is not acidic is a CON

It contains ketone **OR** amine CON

2(b)(ii)

FIRST, CHECK ANSWER

IF *Mass ibuprofen = 206 mg*

AND mass paracetamol = 494 mg award 4 marks

$n(CO_2) = \frac{48.0}{24000} = 2 \times 10^{-3}$ (mol) ✓

n(ibuprofen) = $2 \times 2 \times 10^{-3} = 4 \times 10^{-3}$ (mol) ✓

In 4 tablets

Mass of ibuprofen = $4 \times 10^{-3} \times 206 = 0.824$ g ✓

In 1 tablet (÷4)

Mass ibuprofen = 206 mg

AND mass paracetamol = 494 mg ✓

NOTE*: Mass ibuprofen + mass paracetamol in 1 tablet = 700 mg*

Mass ibuprofen + mass paracetamol in 4 tablets = 2800 mg

[4 marks]

ECF throughout

Alternative order for 1st 3 marks:

$n(CO_2)$ from 1 tablet = 5×10^{-4} (mol) ✓

n(ibuprofen) in 1 tablet = 1×10^{-3} (mol) ✓

Mass of ibuprofen = $1 \times 10^{-3} \times 206 = 0.206$ g ✓

Common errors		
103 **AND** 597	3 marks	no ×2 for n(ibuprofen)
824 **AND** 1976	3 marks	no ÷4 for 1 tablet

824 + 1976 = 2800

***ALLOW** use of ideal gas equation with a sensible temperature (290–298K) and pressure (100/101/101325 kPa)*

e.g. At 298 K and 100 kPa,

$n(CO_2)$

$= \frac{100 \times 10^3 \times 48.0 \times 10^{-6}}{8.314 \times 298} =$ 1.937....

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

***ALLOW** use of 8.31 for R*

298K → = 1.938.... $\times 10^{-3}$ (mol)

2(c)

FIRST, CHECK ANSWER

IF pH = 13.04 award 5 marks

ALLOW ECF throughout

3SF minimum

***ALLOW** acceptable rounding written on scripts and take care as candidate may carry their calculator answer.*

$[Ba(OH)_2]$

$\frac{46.80}{171.3}$ **OR 0.273**..... mol dm^{-3} ✓

Calculator: 0.2732049037

Concentration of diluted $Ba(OH)_2$

$\frac{0.273.....}{5}$ = 0.0546..... (mol dm^{-3}) ✓

Calculator: 0.05464098074

$[OH^-]$

2 × 0.0546..... = 0.1092..... (mol dm^{-3}) ✓

Calculator 0.1092819615

pH

$[H^+] = \frac{1.00 \times 10^{-14}}{0.1092...}$ **OR 9.15**..... $\times 10^{-14}$ (mol dm^{-3}) ✓

Calculator 9.150641026 $\times 10^{-14}$

pH = –log(9.15..... $\times 10^{-14}$) = 13.04 to 2 DP ✓

No pH mark without use of K_w OR pOH

DO NOT ALLOW a pH value ≤ 7 for last mark

[5 marks]

Alternatives for 1st and 2nd marks:

mass in 20 cm^3 = 100 cm^3

= 46.80 × 0.02 = 0.936 g ✓

$[Ba(OH)_2] = \frac{0.936}{171.3} \times 10 =$ 0.0546.... ✓

$[Ba(OH)_2]$ in diluted solution

$= \frac{46.80}{5}$ = 9.36 (g dm^{-3}) ✓

$[Ba(OH)_2] = \frac{9.36}{171.3}$ = 0.0546.... ✓

For pH marks

ALLOW

pOH = –log 0.1092... = 0.96.... ✓

pH = 14 – 0.96 = 13.04 ✓

Common errors		
pH = 11.04	4 marks	÷10 instead of ×10 in alternative
pH = 12.44	4 marks	÷2 instead of ×2 for OH^-
pH = 12.74	4 marks	No ×2 for OH^-
pH = 13.74	4 marks	No ÷5
pH = 15.27	4 marks	No ÷171.3
pH = 13.44	3 marks	No ÷5 and no ×2
pH = 13.97	3 marks	No ÷171.3 and no ×2
pH = 14.27	3 marks	No ÷171.3 and ×10
pH = 14.44	2 marks	No ÷5 and no ×2 and ×10
pH = 15.67	2 marks	K_w and pH only

Q126 · Amount of substance · [1 mark]

Answer: **B**

2 g of nitrogen dioxide, NO_2

Q127 · Amount of substance · [1 mark]

Answer: **C**

OCR MARK SCHEME EXAMINER GUIDANCE

36.7%

ALLOW *36.7*

Q128 · Amount of substance · [9 marks]

OCR MARK SCHEME

22(a)(i)

$(1s^2)2s^22p^63s^23p^63d^{10}4s^24p^5$ ✓

Look carefully at $1s^22s^22p^63s^23p^6$ – there may be a mistake

[1 mark]

EXAMINER GUIDANCE

ALLOW *3d after* $4s^2$,

e.g. $1s^22s^22p^63s^23p^64s^23d^{10}4p^5$

ALLOW *upper case D, etc and subscripts,*

e.g. .....$4S_23D_1$

DO NOT ALLOW *[Ar] as shorthand for* $1s^22s^22p^63s^23p^6$

IGNORE $1s^2$ *repeated*

22(a)(ii)

$P_4 + 6Br_2 \rightarrow 4PBr_3$ ✓

[1 mark]

ALLOW *multiples*

22(b)

Giant ionic ✓

In solid state/lattice,

ions are fixed (in position) **OR** cannot move

AND

In liquid state,

ions are mobile **OR** can move ✓

[2 marks]

'Giant' is essential

Mark independently of 1st structure mark

IGNORE *comments about electrons for solid*

IGNORE *'free' ions*

22(c)

FIRST CHECK ANSWER LINES

If molecular formula = BrF_5 ***AND 174.6/175 AND working showing use of ideal gas equation***

Award 5 marks for calculation

Rearranging ideal gas equation

$n = \frac{pV}{RT}$ ✓

Unit conversion AND substitution into $n = \frac{pV}{RT}$:

- R = 8.314 **OR** 8.31

ALLOW ECF throughout

IF $n = \frac{pV}{RT}$ *is omitted,* ***ALLOW*** *when values are substituted into rearranged ideal gas equation.*

ALLOW *conversion of V into* dm^3 ***AND*** *p in kPa*

Gives same answer in powers of 10

Calculator value:

from 8.314 = $2.450725899 \times 10^{-3}$

from 8.31 = $2.45190555 \times 10^{-3}$

IGNORE *figures after 5 in 2.45*

- $V = 76(.0) \times 10^{-6}$ (m^3)
- T in K: 373 K

e.g. $\frac{1.00 \times 10^5 \times 76.0 \times 10^{-6}}{8.314 \times 373}$ ✓

***ALLOW ECF** from a value of n that has been derived from pV = nRT*

e.g. 0.174.6 **OR** 0.175 from 2.45

***ALLOW ECF** matching **ECF M** from pV = nRT*

Calculation of *n* using *p*, *V*, R AND T

$n = 2.45 \times 10^{-3}$ (mol) ✓

Calculation of *M*

$M = \frac{0.428}{2.45 \times 10^{-3}} = 174.6$ ✓

Molecular formula

BrF_5 **OR** F_5Br ✓

Use of 24 dm^3

Final 2 marks possible for use of 76.0 cm^3 **OR** 0.0760 dm^3 by **ECF**

e.g. $n = \frac{76.0}{24000} = 3.17 \times 10^{-3}$ No mark (calculation much simpler)

$M = \frac{0.428}{3.17 \times 10^{-3}} = 135$ ✓ **ECF**

BrF_3 ✓ **ECF**

[5 marks]

Q129 · Amount of substance · [1 mark]

Answer: **C**

OCR MARK SCHEME

4

EXAMINER GUIDANCE

***ALLOW** 4*

Q130 · Amount of substance · [1 mark]

Answer: **A**

ClF

Q131 · Amount of substance · [13 marks]

OCR MARK SCHEME

1(a)

Oxidised

AND

nickel has lost/donated two electrons ✓

EXAMINER GUIDANCE

***IGNORE** reference to oxidation numbers (even if incorrect)*

[1 mark]

1(b)(i)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 43.6 (cm^3) award 3 marks

$n(\text{Ni}) = \dfrac{0.192}{58.7} = 3.27... \times 10^{-3}$ (mol) ✓

$n(\text{HCl}) = 3.27 \times 10^{-3} \times 2 = 6.54... \times 10^{-3}$ (mol) ✓

$\text{Volume HCl} = \dfrac{6.54 \times 10^{-3}}{0.15} \times 1000 = 43.6\ (cm^3)$ ✓

3 SF required

[3 marks]

ALLOW *3.27×10^{-3} up to calculator value of $3.270868825 \times 10^{-3}$*

ALLOW *6.54×10^{-3} up to calculator value of $6.541737649 \times 10^{-3}$*

1(b)(ii)

$\text{Volume } H_2 = 3.27 \times 10^{-3} \times 24000 = 78.5\ (cm^3)$ ✓

[1 mark]

ALLOW *ECF from incorrect n(Ni) from (b)(i)*

ALLOW *78.48 (cm^3)*

1(b)(iii)

Volume is the same ✓

Mg is in excess

OR

Volume of H_2 depends on HCl/HCl is limiting reagent ✓

[2 marks]

1(c)

Level 3 (5–6 marks)

The candidate gives a clear description of all three tests with correct observations.

AND

Equations are mostly correct.

AND

Some fine detail included in answer.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

The candidate describes all three tests with correct observations.

OR

Indicative scientific points

Tests for anions

Carbonate test:

Add $HNO_3(aq)/HCl(aq)/H_2SO_4(aq)/H^+(aq)$

fizzing/ forms $CO_2(g)$ → Carbonate identified

Sulfate test:

Add $Ba(NO_3)_2(aq)$ **OR** $BaCl_2(aq)$

White precipitate → Sulfate identified

Bromide test

Add $AgNO_3$ (aq)

Cream precipitate → Bromide identified

Equations (ionic or full)

Describes two tests with a few omissions.

AND

Includes at least one correct equation.

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence

Level 1 (1–2 marks)

The candidate attempts to describe two tests and observations, but explanations are incomplete.

OR

Gives a thorough description and explanation of one of the tests and attempts one equation.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

***IGNORE** state symbols (even if wrong)*

Carbonate

$2H^+ + CO_3^{2-} \rightarrow CO_2 + H_2O$

OR $2H^+ + NiCO_3 \rightarrow Ni^{2+} + CO_2 + H_2O$

OR $2HNO_3 + NiCO_3 \rightarrow Ni(NO_3)_2 + H_2O + CO_2$

OR $2HCl + NiCO_3 \rightarrow NiCl_2 + H_2O + CO_2$

OR $H_2SO_4 + NiCO_3 \rightarrow NiSO_4 + H_2O + CO_2$

Sulfate

$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$

OR $Ba(NO_3)_2 + NiSO_4 \rightarrow BaSO_4 + Ni(NO_3)_2$

OR $BaCl_2 + NiSO_4 \rightarrow BaSO_4 + NiCl_2$

Bromide

$Ag^+ + Br^- \rightarrow AgBr$

OR $2AgNO_3 + NiBr_2 \rightarrow 2AgBr + Ni(NO_3)_2$

Fine Detail (NOT inclusive)

Sequence of tests on samples

Carbonate → Sulfate → Bromide

Solubility of AgBr

Soluble in concentrated ammonia

State symbols in ionic or full equations

e.g.

- $2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$

OR $2H^+(aq) + NiCO_3(s) \rightarrow Ni^{2+}(aq) + CO_2(g) + H_2O(l)$

- $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

- $Ag^{+}(aq) + Br^{-}(aq) \rightarrow AgBr(s)$

Q132 · Amount of substance · [1 mark]

Answer: **B**

The number of electrons lost by 20.05 g of calcium when it reacts with oxygen.

Q133 · Amount of substance · [1 mark]

Answer: **B**

Titanium

Q134 · Amount of substance · [1 mark]

Answer: **C**

1.11 g

Q135 · Amount of substance · [1 mark]

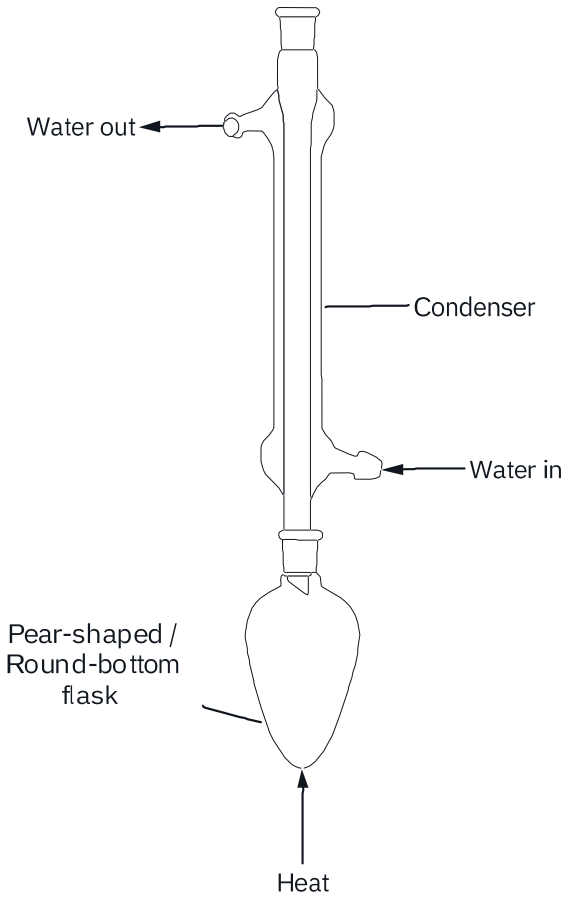
Answer: **A**

CH

Q136 · Amount of substance · [16 marks]

OCR MARK SCHEME

1(a)(i)



EXAMINER GUIDANCE

DO NOT ALLOW *conical flask, volumetric flask, beaker in place of round bottom/pear shaped flask*

Water flow AND condenser

Water in at bottom and out at top

AND condenser ✓

Flask and technique

Pear-shaped/round-bottom flask

AND reflux ✓

[2 marks]

1(a)(ii)

Diagram showing knowledge of filtration under reduced pressure

Diagram showing Buchner flask

must have ONE side arm

AND

Buchner/Hirsh funnel on top of flask ✓

Labels not required

Labels **NOT** required for diagram

ALLOW *diagram of a conical flask with a filtering setup above*

AND

Side arm either in conical flask **OR** between flask and filter paper of funnel

IGNORE *absence of seals*

Further details:

- Funnel sealed or stoppered to flask

AND

- Apparatus capable of filtering under reduced pressure

AND

- Label for setup from side arm to indicate reduced pressure

AND

- Label for Buchner flask **OR** Buchner/Hirsh funnel ✓

ALLOW slips in spelling of 'Buchner'

MUST imply some type of seal between filter setup and flask.

ALLOW small gaps

Examples of suitable labels (may have arrow from side arm or tube attached)

- to pump
- to vacuum
- air out
- suction
- reduced pressure
- etc.

For Buchner flask and Buchner funnel

DO NOT ALLOW *just 'flask* ***OR*** *'funnel'*

Flask and funnel used in normal filtration

[2 marks]

1(b)(i)

Comparison of branching and points of contact

ALLOW ORA *throughout*

e.g. $CH_3CH_2CH_2NH_2$ has longer chain / straight chain / no branches

AND

e.g. $CH_3CH_2CH_2NH_2$ has more points of contact / more surface interaction (between molecules) ✓

Relative strength of force

e.g. $CH_3CH_2CH_2NH_2$ has stronger/more induced dipole(–dipole) interactions

OR London forces ✓

ALLOW *'The straighter the chain, the more points of contact ....'*

IGNORE *comparison using 'primary', 'secondary' and 'tertiary'.*

Comparison of branching is required.

For London forces,

- **ALLOW** induced dipole(–dipole) interactions
- **IGNORE** IDID **OR** van der Waals' forces/VDW

Hydrogen bonds

$CH_3CH_2CH_2NH_2$ **OR** $(CH_3)_2CHNH_2$ have hydrogen/H bonds

OR

$(CH_3)_3N$ has no hydrogen/H bonds ✓

Relative strength of force

Hydrogen bonds are stronger than London forces /permanent dipole interactions ✓

DO NOT ALLOW *$CH_3CH_2CH_2NH_2$ has more electrons*

(number of electrons are the same)

DO NOT ALLOW *'more energy to break covalent bonds*

ALLOW *little energy is required to break London forces (compared with H bonds)*

Comparison of energy required to break force

e.g. More energy to break/overcome London forces/intermolecular forces in $CH_3CH_2CH_2NH_2$

OR

More energy is needed to break H bonds (than London forces) ✓

[4 marks]

1(b)(ii)

FIRST CHECK MOLECULAR FORMULA and STRUCTURE

IF *molecular formula = $C_5H_{13}N$* ***AND*** *correct structure* ***AND*** *evidence of ideal gas equation → 6 marks*

Correct up to 87 **AND** $C_5H_{13}N$ → 5 marks

Correct up to 87 → 4 marks

IF *$n = \frac{pV}{RT}$ is omitted,* ***ALLOW*** *when values are substituted into rearranged ideal gas equation.*

Calculator: $n = 2.321740325 \times 10^{-3}$ from 8.314

From 8.31, $n = 2.322857889 \times 10^{-3}$

ALLOW *elements in any order*

ALLOW *molecular formula = $C_3H_9N_3$*

ALLOW *other molecular formulae of an amine that has M = 87, e.g. C_4H_9NO*

Rearranging ideal gas equation

$n = \frac{pV}{RT}$ ✓

Unit conversion AND substitution into *n* = $\frac{pV}{RT}$:

- R = 8.314 **OR** 8.31

- $V = 72(.0) \times 10^{-6}$
- T in K: 373 K

e.g. $\dfrac{1.00 \times 10^{5} \times 72.0 \times 10^{-6}}{8.314 \times 373}$ ✓

Calculation of n

$n = 2.32 \times 10^{-3}$ (mol) ✓

Calculation of M

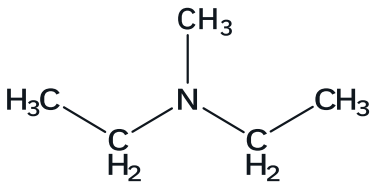
$M = \dfrac{0.202}{2.32 \times 10^{-3}} = 87$ ✓

Molecular formula

$C_5H_{13}N$ ✓

Molecular formula required

Structure of amine A from $C_5H_{13}N$ ✓



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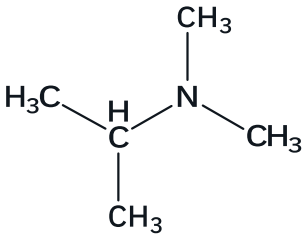

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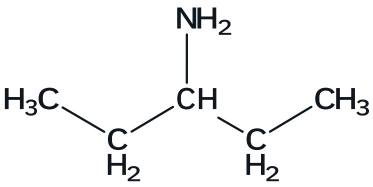

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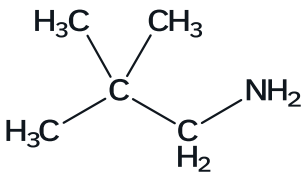

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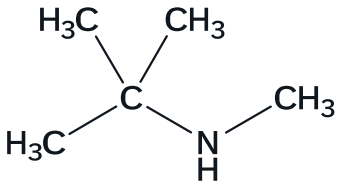


Use of 24000

3 marks max possible for use of 72.0 cm^3 **OR** 0.720 dm^3 by **ECF**

Calculation

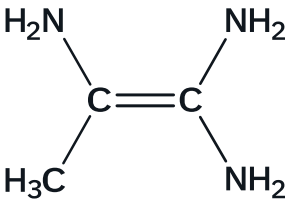
e.g. $n = \dfrac{72.0}{24000} = 3.00 \times 10^{-3}$ No mark (calculation much simpler)

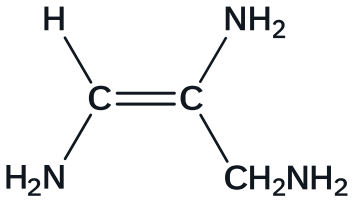
$M = \dfrac{0.202}{3.00 \times 10^{-3}} = 67.3$ **OR** 67 ✓ **ECF**

Molecular formula = C_4H_5N ✓ **ECF**

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

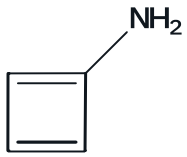
ALLOW *structures below from molecular formula =* $C_3H_9N_3$





ALLOW ECF *but only if structure has calculated* M_r ***AND*** *has 3 peaks in* ^{13}C *NMR spectrum.*

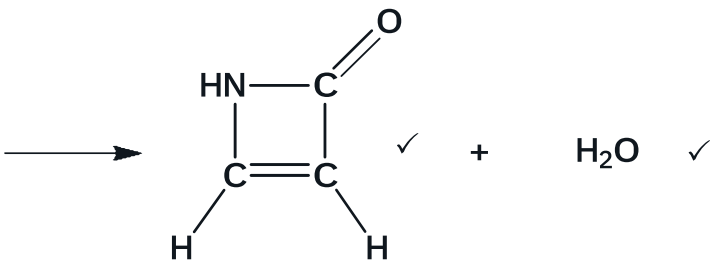
Structure



✓ ECF

[6 marks]

1(c)



Organic product and water marked independently.

1st mark correct organic product **OR** water

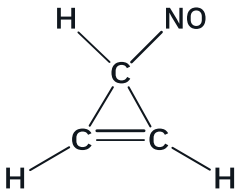
IGNORE *balancing numbers*

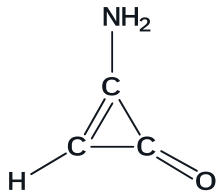
2nd mark BOTH products **AND** correctly balanced.

[2 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW





NOTE*: For* ***ECF****, any structure must have correct number of bonds to C, H, O and N*

DO NOT ALLOW *structure of dimer*

Question states molecular formula = C_3H_3NO

Q137 · Amount of substance · [19 marks]

OCR MARK SCHEME

4(a)(i)

Overall equation AND state symbols:

$M(s) + 2HCl(aq) \rightarrow MCl_2(aq) + H_2(g)$ ✓

STATE SYMBOLS required in overall equation ONLY

Half equations:

Oxidation $M \rightarrow M^{2+} + 2e^-$ ✓

Reduction $2H^+ + 2e^- \rightarrow H_2$

OR $H^+ + e^- \rightarrow ½H_2$ ✓

EXAMINER GUIDANCE

All 3 marks are independent.

IGNORE *charges/oxidation numbers shown around overall equation. Treat as rough working*

ALLOW *overall equation shown with some or all ions that are present*

e.g. (<u>with state symbols</u>)

$M + 2H^+ \rightarrow M^{2+} + H_2$

[3 marks]

$M + 2HCl \rightarrow M^{2+} + 2Cl^- + H_2$

$M + 2H^+ + 2Cl^- \rightarrow M^{2+} + 2Cl^- + H_2$

In half equations,

IGNORE *state symbols even is wrong BUT half equations MUST only have species that change.*

For charges on half equations,

ALLOW M^{+2} *for* M^{2+} ***OR*** H^{+1} *for* H^+

ALLOW $M - 2e^- \rightarrow M^{2+}$

If BOTH half equations are correct but shown with oxidation and reduction the wrong way around, award 1 mark from the 2 marks for half equations

4(a)(ii)

Bubbles/effervescence/fizzing stops ✓

M/metal/solid has disappeared/dissolved ✓

[2 marks]

Responses must imply that all fizzing has stopped and that all the solid has dissolved

i.e. 'metal disappears' is not quite enough.

'All the metal disappears' is enough

IGNORE *constant mass*

IGNORE *no increase in temperature*

4(a)(iii)

$H^+ + OH^- \rightarrow H_2O$ ✓

[1 mark]

ALLOW *multiples*

e.g. $2H^+ + 2OH^- \rightarrow 2H_2O$

IGNORE *state symbols, even if wrong*

4(a)(iv)

Mean titre 1 mark

$= \frac{(27.30 + 27.20)}{2} = 27.25\ (cm^3)$ ✓

Analysis of results 5 marks

$n(NaOH) = \frac{27.25 \times 0.320}{1000} = 8.72 \times 10^{-3}$ (mol) ✓

$n(HCl)$ in 25.0 cm^3 = $n(NaOH)$

$n(HCl)$ in 250 $cm^3 = 8.72 \times 10^{-3} \times 10 = 8.72 \times 10^{-2}$ (mol) ✓

Common error:

Incorrect mean from all 3 titres = 27.35 cm^3

Use ECF throughout

Intermediate values for working to at least 3 SF.

TAKE CARE: Value written down may be truncated calculator value.

Depending on rounding, either can be credited.

n(HCl) that reacted with M = $0.210 - 8.72 \times 10^{-2}$ = 0.1228 (mol) ✓

n(M) that reacted = $\frac{0.1228}{2}$ = 0.0614 (mol) ✓

A_r of M = $\frac{6.90}{0.0614}$ = 112.4 **AND M** = cadmium/Cd ✓

COMMON ERRORS:

Mean of 27.35 (use of all 3 titres)

→ 8.752×10^{-3} → 8.752×10^{-2} → 0.12248

→ 0.06124 → 112.7 **AND** Cd: 5 marks

No ÷2 to obtain n(M)

→ 56.2 **AND** Fe (from 27.25) 5 marks

→ 56.3 **AND** Fe (from 27.35) 4 marks

No subtraction from 0.210

→ $\frac{8.72 \times 10^{-2}}{2}$ → 4.36×10^{-2} → $\frac{6.90}{4.36 \times 10^{-2}}$

→ 158.2 to 158.3 **AND** Tb 5 marks

[6 marks]

ALLOW *0.123 (mol) i.e. 3SF*

ALLOW *0.0615 (mol)* ***IF*** *0.1228 rounded to 0.123*

ALLOW *112.2 from 0.0615* ***AND*** *Cd*

ALLOW *A_r to nearest whole number*

ALLOW ECF *for metal closest to calculated A_r*

DO NOT ALLOW *Ga* ***OR*** *Sc (Form 3+ ions only)*

No ×10 to obtain n(HCl) in 250 cm^3 5 marks

$0.210 - 8.72 \times 10^{-3}$ = 0.20128 **OR** 0.201

n(M) = $\frac{0.20128}{2}$ = 0.10064

A_r = $\frac{6.90}{0.10064}$ = 68.56 → Zn

No ×10 and no ÷ 2 4 marks

$0.210 - 8.72 \times 10^{-3}$ = 0.20128

A_r = $\frac{6.9}{0.20128}$ = 34.28 → Ca

Omitting initial titration calculation

Zero marks

$\frac{0.210}{2}$ = 0.105 → $\frac{6.9}{0.105}$ = 65.71 → Zn

4(b)(i)

$n(CO_2)$ = $\frac{2.75}{44}$ = 0.0625 (mol) ✓

[1 mark]

4(b)(ii)

$n(X_2CO_3)$ = 0.0625 (mol)

OR

0.0625 used in molar mass expression below ✓

Molar mass of X_2CO_3 = $\frac{14.57}{0.0625}$ = 233.12 ($g\ mol^{-1}$) ✓

Metal X = Rubidium/Rb ✓

[3 marks]

ALLOW ECF *from 4b(i)*

ALLOW *to nearest whole number*

DO NOT ALLOW *strontium/Sr*

wrong carbonate formula

ALLOW ECF *for X from calculated molar mass* ***ONLY IF X*** *is a Group 1 metal* ***OR*** *Ag*

Working:

Mass of X in X_2CO_3 = 233.14 – 60

= 173.12 **OR** 173

A_r of X = $\frac{173.12}{2}$ **OR** 86.56 **OR** 85.6 **OR** 87

4(c)(i)

Reweigh to constant mass ✓

[1 mark]

ALLOW *response implying leaving for longer and monitoring by reweighing to constant mass,*

e.g. Leave flask until the mass does not change

IGNORE *'leave for longer'* ***OR*** *wait till fizzing stops*

Needs link to constant mass

ALLOW *Collect gas until gas volume is constant*

4(c)(ii)

Mass (CO_2) **OR** $n(CO_2)$ loss would be smaller

OR

Mass X_2CO_3 **OR** $n(X_2CO_3)$ reacted (seems to be) less ✓

Molar mass would be greater ✓

[2 marks]

Q138 · Amount of substance · [8 marks]

OCR MARK SCHEME

25(a)(i)

Moles Sc OR moles O

$n(Sc) = \frac{0.27}{45} = 6 \times 10^{-3}$ (mol)

OR

$n(O) = \frac{0.144}{16.0} = 9 \times 10^{-3}$ (mol) ✓

Empirical formula

Sc_2O_3 ✓

[2 marks]

EXAMINER GUIDANCE

NO ECF

25(a)(ii)

Heat to constant mass ✓

ALLOW *response that implies heating to constant mass,*

[1 mark]

e.g. Heat again until mass does not change

IGNORE *'heat for longer'*

No link to constant mass

25(b)

Rearranging ideal gas equation

$n = \frac{pV}{RT}$ ✓

ALLOW ECF throughout

IF $n = \frac{pV}{RT}$ *is omitted,* ***ALLOW*** *when values are substituted into rearranged ideal gas equation.*

Unit conversion AND substitution into $n = \frac{pV}{RT}$:

- $R = 8.314$ **OR** 8.31
- $V = 9.39 \times 10^{-3}$ m^3
- T in K: 293 K

e.g. $n = \frac{1.37 \times 10^7 \times 9.39 \times 10^{-3}}{8.314 \times 293}$ ✓

ALLOW ECF *from incorrectly rearranged ideal gas equation, e.g.* $n = \frac{RT}{pV} \rightarrow 0.0189361411$

Calculation of n

$n = 52.80906994$ (mol) ✓

$M \rightarrow 89247$ *(Likely to be 3/5 max)*

ALLOW *use of 8.31 for R, which gives:*

$n = 52.83448947$

Calculation of M

$M = \frac{1.69 \times 10^3}{52.80906994} = 32.00207847$ ✓

ALLOW *3 SF or more, e.g. 52.8*

Using 52.8, $M = 32.00757576$

ALLOW ECF *for a 'reasonable gas' that matches calculated molar mass*

Gas

O_2 **OR** oxygen ✓

[5 marks]

Q139 · Amount of substance · [1 mark]

Answer: **C**

C_4H_{10}

Q140 · Amount of substance · [1 mark]

Answer: **C**

150 cm^3 of $N_2(g)$

Q141 · Amount of substance · [1 mark]

Answer: **D**

0.175

Q142 · Amount of substance · [1 mark]

Answer: **A**

2.53

Q143 · Amount of substance · [1 mark]

Answer: **B**

$NaClO_4$

Q144 · Amount of substance · [1 mark]

Answer: **B**

180.0 g C_2H_6

Q145 · Amount of substance · [1 mark]

Answer: **D**

5.47 g

Q146 · Amount of substance · [1 mark]

Answer: **C**

220.0

Q147 · Amount of substance · [1 mark]

Answer: **B**

CO / mol: 1 · NO_2 / mol: 0 · CO_2 / mol: 1 · NO / mol: 1

Q148 · Amount of substance · [1 mark]

Answer: **C**

40.0 g CH_3CHO

Q149 · Amount of substance · [9 marks]

OCR MARK SCHEME

2(a)

Closed system that would work (Labels not required)

Reaction apparatus with tube/side arm

AND gas collection apparatus

AND closed system ✓

Labels

Reaction apparatus, e.g.:

Conical flask, Buchner flask/conical flask with side arm, test-tube, boiling tube.

EXAMINER GUIDANCE

ALLOW *small gaps provided there is an attempt to show closed system*

DO NOT ALLOW *delivery tube below reaction mixture*

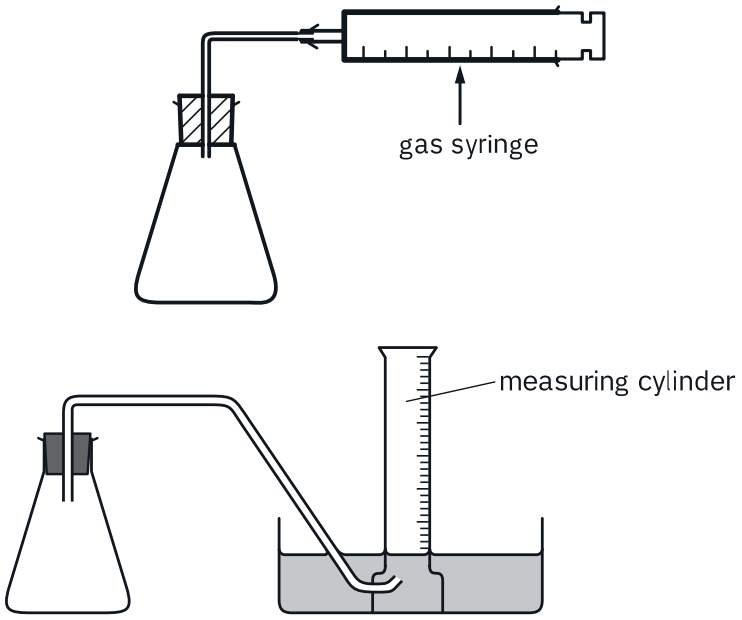
For reaction apparatus,

- **DO NOT ALLOW** flask, volumetric flask, beaker, measuring cylinder

AND

Gas collection apparatus: (gas) syringe

OR gas collection over water with labelled measuring cylinder / burette ✓



[2 marks]

2(b)

$n(H_2)$ = 152 / 24000 **OR** 6.33.... × 10^{-3} (mol) ✓

$n(Eu) = \frac{0.988}{152}$ **OR** 6.5(0) × 10^{-3} (mol) ✓

Ratio H_2 : Eu 1 : 1

AND

Equation 2 is correct ✓

Only **ALLOW** if $n(H_2)$ **AND** n(Eu) are approximately equal

ALLOW *use of ideal gas equation at a reasonable temperature and pressure.*

e.g. Using 100 kPa and 298 K, $n(H_2)$ = 6.14 × 10^{-3} mol

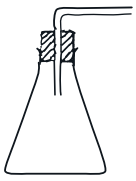
[3 marks]

- Delivery tube, bung does **NOT** need a label

ALLOW *labels for diagram without closed system (e.g. bung missing),*

i.e. 2nd mark but not 1st mark

ALLOW *any of these diagrams.*





ALLOW *a single line for the tube*

IGNORE *Sealed end of delivery tube*

IGNORE *size of syringe/measuring cylinder/burette*

152 6.5(0) × 10^{-3} (mol)

ALLOW *0.97(4) : 1*

ALLOW ECF *from incorrect n(Eu)* ***OR/AND*** *n (H_2)*

ALLOW *approach that calculates mass Eu from 6.33.... × 10^{-3} mol H_2 for each equation, e.g.*

Equation 1: 2 × 6.33 × 10^{-3} × 152 = 1.9.. g

Equation 2: 1 × 6.33 × 10^{-3} × 152 = 0.96.. g

Equation 3: $\frac{2}{3}$ × 6.33 × 10^{-3} × 152 = 0.64.. g ✓

0.988 matched to 0.96 g and Equation 2 ✓

Use judgment

ALLOW *approach that calculates volume H_2 from 6.50×10^{-3} mol Eu for each equation, e.g.*

Equation 1: $0.5 \times 24000 \times 6.50 \times 10^{-3} = 78$ cm^3

Equation 2: $1 \times 24000 \times 6.50 \times 10^{-3} = 156$ cm^3

Equation 3: $1.5 \times 24000 \times 6.50 \times 10^{-3} = 234$ cm^3 ✓

152 matched to 156 cm^3 and Equation 2 ✓

Use judgment

2(c)

The gas volume would be larger (than at RTP) ✓

Ratio H_2 : Eu would be larger ✓

[2 marks]

IGNORE *effect of rate, e.g. rate increases*

IGNORE *gas equation should be used to find n(H_2)*

ALLOW *Equation 3 linked to H_2 : Eu > 1*

2(d)

Qual

Precipitates have different molar masses

OR

Precipitates have different formulae ✓

Quant

Equation 2 forms precipitate with $M = 186$

OR with formula $Eu(OH)_2$

OR

Equation 2 forms 1.86 g precipitate

OR

Molar mass M of precipitate $= \dfrac{\text{mass of precipitate}}{\text{moles precipitate}}$

OR $\dfrac{\text{mass of precipitate}}{\text{moles Eu}}$

OR $\dfrac{\text{mass of precipitate}}{0.01}$ ✓

[2 marks]

ALLOW *precipitates are EuOH, $Eu(OH)_2$ $Eu(OH)_3$*

OR precipitates have different number of OH^- ions

ALLOW *Moles OH^- $= \dfrac{(\text{mass of precipitate} - \text{mass of Eu})}{\text{molar mass of } OH^-}$*

OR Moles $OH^- = \dfrac{\text{mass of precipitate} - 1.52}{17}$

Q150 · Amount of substance · [20 marks]

OCR MARK SCHEME

5(a)(i)

Reduction: $Na^+ + e^- \rightarrow Na$ ✓

Oxidation: $2N_3^- \rightarrow 3N_2 + 2e^-$ ✓

ALLOW *1 mark for 2 correct equations but wrong way round*

[2 marks]

EXAMINER GUIDANCE

ALLOW multiples

e.g. $2Na^+ + 2e^- \rightarrow 2Na$

IGNORE *state symbols*

5(a)(ii)

FIRST CHECK ANSWER ON ANSWER LINE

IF *mass = 34.5 (g)* ***AND*** *working using ideal gas equation*

Award 5 marks for calculation

Rearranging ideal gas equation

$n = \frac{pV}{RT}$ ✓

Unit conversion AND substitution into $n = \frac{pV}{RT}$:

- R = 8.314 **OR** 8.31
- $V = 16(.0) \times 10^{-3}$
- T in *K*: 290 *K* e.g. $\frac{1.20 \times 10^5 \times 16.0 \times 10^{-3}}{8.314 \times 290}$ ✓

Calculation of *n*

n = 0.796 (mol) ✓

Calculation of mass

$n(NaN_3) = \frac{2}{3} \times 0.796 = 0.531$ (mol) ✓

mass $NaN_3 = 0.531 \times 65 = 34.5$ (g) ✓

3 SF required

[5 marks]

TAKE CARE as value written down may be truncated value stored in calculator.

IF $n = \frac{pV}{RT}$ *is omitted,* ***ALLOW*** *when values are substituted into rearranged ideal gas equation.*

Calculator: 0.7963302448

From unrounded 0.7963302448, $n(NaN_3)$ = 0.5308868299

mass = 0.5308868299 × 65 = 34.50764394 → 34.5 to 3 SF

COMMON ERROR

51.7 OR 51.8 → 4 marks (2/3 omitted depending on intermediate rounding

0.796 × 65 = 51.7 **OR** 51.8

54.4 → 4 marks (inverted gas equation)

$n = \frac{RT}{pV}$ →1.255760417→ 0.8371736111

→ 54.4 (g) CARE with intermediate rounding

81.6 OR 81.7 → 3 mks (as above but no 2/3)

5(b)(i)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 2.75 award 2 marks

ALLOW ECF *throughout*

IGNORE *error with HN_3 shown as NH_3*

$[H^+]^2 = K_a \times [HN_3]) = 2.51 \times 10^{-5} \times 0.125$

$[H^+] = \sqrt{(K_a \times [HN_3])}$

$[H^+]^2 = 2.51 \times 10^{-5} \times 0.125$

OR $[H^+] = \sqrt{(2.51 \times 10^{-5} \times 0.125)}$

OR $[H^+] = 1.77.... \times 10^{-3}$ (mol dm^{-3}) ✓

pH = $-\log 1.77.... \times 10^{-3} = 2.75$ (Must be to 2DP) ✓

[2 marks]

ALLOW *pH mark by* ***ECF*** *ONLY if* $2.51 \times 10^{-5} \times 0.125$ *used* ***AND*** *pH <7*

Common errors (Must be to 2 DP)

pH = 5.50 → 1 mark (No square root)

$[H^+] = 6.26 \times 10^{-4}$ from $\sqrt{(2.51 \times 10^{-5}) \times 0.125}$

pH = 3.20 → 1 mark

$[H^+] = 8.87 \times 10^{-6}$ from $\sqrt{(0.125) \times 2.51 \times 10^{-5}}$

pH = 5.05 → 1 mark

5(b)(ii)

- Correct equation ✓
- Correct acid–base pair labels for correct equation ✓

HN_3	+	H_2O	⇌	N_3^-	+	H_3O^+ ✓
A1		**B2**		**B1**		**A2** ✓
OR						
A2		**B1**		**B2**		**A1**

ALLOW *1 mark for one correct acid–base pair WITH correct labels*

e.g.	H_2O	H_3O^+
WITH	B1	A1
OR	B2	A2

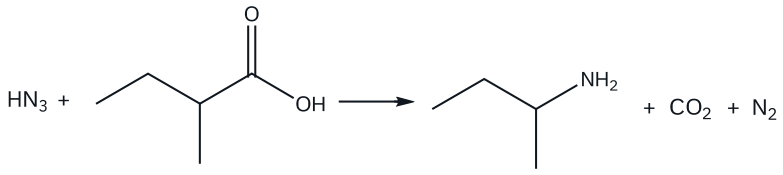
[2 marks]

5(b)(iii)

Structure of 2-methylbutanoic acid ✓

Structure of organic product (primary amine) ✓

CO_2 **AND** N_2 as products ✓



[3 marks]

ALLOW *correct structural* ***OR*** *skeletal* ***OR*** *displayed formula* ***OR*** *mixture of the above as long as non-ambiguous*

Common error

With NH_3, → $CO_2 + H_2$

ALLOW ECF *for equation using a different amine isomer of the organic product*

e.g. $(CH_3)_2CHCH_2NH_2$

DO NOT ALLOW ECF *from unbranched species, e.g.* $CH_3CH_2CH_2NH_2$

IGNORE *HN_3 in equation, even if missing*

IGNORE *poor connectivity to all groups*

5(c)

Level 3 (5–6 marks)

Reaches a comprehensive conclusion to determine the correct formulae of almost all of E, F, G, H, I and J

There is a well-developed line of reasoning which is clear and logically structured.

The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Reaches a sound conclusion to determine the correct formulae of at least half of E, F, G, H, I and J

There is a line of reasoning presented with some structure.

The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Reaches a simple conclusion to determine the correct formulae of some of E, F, G, H, I and J

There is an attempt at a logical structure with a line of reasoning.

The information is in the most part relevant.

0 marks No response or no response worthy of credit.

[6 marks]

Indicative scientific points may include:

Identify of E, F, G, H, I and J

- E Cu/copper
- F: H_2O/water
- G: N_2/nitrogen
- H: CH_3COCl **OR** $ClCH_2CHO$ **OR** C_2H_3OCl
- I: CH_3CONH_2 **OR** H_2NCH_2CHO
- J: NH_4Cl/ammonium chloride

Examples of reasoning

Working

$n(CuO) = \dfrac{4.77}{(63.5 + 16)} = 0.06$ (mol)

$M(E) = \dfrac{3.81}{0.06} = 63.5$

$n(G) = \dfrac{480}{24000} = 0.02$

$M(G) = \dfrac{0.560}{0.02} = 28$ (g mol^{-1})

Infrared spectrum

I contains

- C=O (~1700 cm^{-1})
- NH_2 (~3200–3400 cm^{-1})

Equations

$3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2$

$CH_3COCl + 2NH_3 \rightarrow CH_3CONH_2 + NH_4Cl$

OR

$ClCH_2CHO + 2NH_3 \rightarrow H_2NCH_2CHO + NH_4Cl$

Q151 · Atomic structure and isotopes · [1 mark]

Answer: **B**

protons: 17 · neutrons: 20 · electrons: 18

Q152 · Atomic structure and isotopes · [9 marks]

OCR MARK SCHEME

21(a)

Similarities:

(Same) number of protons **AND** electrons ✓

Differences:

(Different) number of neutrons ✓

[2 marks]

EXAMINER GUIDANCE

ALLOW *same electron configuration*

ALLOW *'amount' for 'number'*

IGNORE *different masses/mass numbers (Question asks for atomic structures)*

21(b)(i)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 63.62 award 2 marks

$$\frac{(63 \times 69.17) + (65 \times 30.83)}{100}$$

OR 63.6166 **OR** 63.617 ✓

= 63.62 (to 2 DP) ✓

IGNORE *any units with* A_r

[2 marks]

ALLOW ECF *for a correct calculation to 2 DP if:*

- %s have been used with wrong isotopes

i.e. $\frac{(63 \times 30.83) + (65 \times 69.17)}{100}$ → 64.38

OR

- decimal places for ONE % have been transposed,

i.e. 69.71 → 63.96; 30.38 → 63.32

21(b)(ii)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 3.97×10^{22} (from 63.62) award 2 marks

If answer = 3.98×10^{22} (from 63.5) award 2 marks

Using 63.62: correct A_r of Cu from 21(b)(i)

See bottom of answer zone

$n(\text{Cu}) = \frac{5.00 \times 0.840}{63.62} = \frac{4.2}{63.62} = 0.066(0)$ (mol) ✓

Cu atoms = $0.0660 \times 6.02 \times 10^{23} = 3.97 \times 10^{22}$ ✓

Must be calculated in standard form **AND** to 3 SF

OR---

Using 63.5: A_r of Cu from periodic table

If there is an alternative answer, check to see if there is any ***ECF*** *credit possible*

SEE answer from 21b(i) at bottom of answer zone

ALLOW *correct answer from 3 SF up to calculator value of 0.06601697579*

ALLOW *incorrect n(Cu) × 6.02×10^{23} correctly calculated to 3 SF* ***AND*** *in standard form*

For **ECF**, A_r must have been used for *n*(Cu)

$n(Cu) = \frac{5.00 \times 0.840}{63.5} = \frac{4.2}{63.5} = 0.0661$ (mol) ✓

Cu atoms = $0.0661 \times 6.02 \times 10^{23} = 3.98 \times 10^{22}$ ✓

Must be calculated in standard form **AND** to 3 SF

[2 marks]

ALLOW *correct answer from 3 SF up to calculator value of 0.06614173228*

ALLOW *incorrect n(Cu) × 6.02 × 10^{23} correctly calculated to 3 SF* ***AND*** *in standard form*

For **ECF**, A_r must have been used for *n*(Cu)

Common errors

Using 63.62:

3.984×10^{22} 1 mark (SF)

4.73×10^{22} 1 mark (ECF: omitting 0.840)

Using 63.5:

3.982×10^{22} 1 mark (SF)

4.74×10^{22} 1 mark (ECF: omitting 0.840)

21(c)(i)

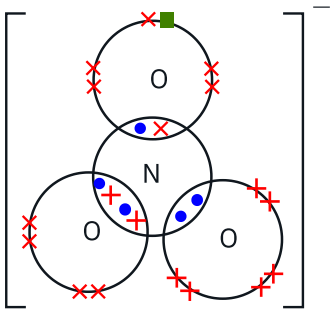
$NiO + 2HNO_3 \rightarrow Ni(NO_3)_2 + H_2O$ ✓

[1 mark]

ALLOW *multiples*

IGNORE *state symbols (even if wrong)*

21(c)(ii)



Global rules

- N and O electrons must be shown differently, e.g. • for N and × for O
- 'Extra' electron shown with different symbol

MARKING

Bonding around central N atom ✓

- 5 electrons for N shown as • **OR** ×
- 3 electrons for O, different from N as • **OR** ×

NOT REQUIRED

- Charge ('–')
- Brackets
- Circles

IGNORE *inner shells*

ALLOW *rotated diagram*

ALLOW *diagram with missing N or O symbols.*

Shown as diagram on QP anyway

In N=O bond, **ALLOW** sequence × × • •

In N–O bond, **ALLOW** 'extra' electron with different symbol for O electron

ALLOW *non-bonding electrons unpaired*

- N=O bond with 2 N electrons **AND** 2 O electrons
- N→O bond with 2 N electrons
- N–O bond with 1 N electron **AND** 1 O electron

Non-bonded (nb) electrons around 3 O atoms ✓

- N=O oxygen has 4 nb ‘O’ electrons
- N→O oxygen has 6 nb ‘O’ electrons
- $N–O^-$ oxygen has 5 nb ‘O’ electrons **AND** 1 ‘extra’ electron with different symbol

If ‘extra’ electron has been used in $N–O^-$ bond, $N–O^-$ oxygen MUST have 6 nb ‘O’ electrons

***ALLOW** ‘extra’ electron as • **OR** × if it has been labelled ‘extra electron’ or similar*

[2 marks]

Q153 · Atomic structure and isotopes · [1 mark]

Answer: **A**

Ga^{3+}

Q154 · Atomic structure and isotopes · [1 mark]

Answer: **D**

Number of neutrons: 77 · Mass number: 129

Q155 · Atomic structure and isotopes · [1 mark]

Answer: **C**

80%

Q156 · Atomic structure and isotopes · [7 marks]

OCR MARK SCHEME

22(a)

FIRST CHECK ANSWER ON THE ANSWER LINE

***IF** answer = 190.47 (to 2 DP) award 2 marks*

$$\frac{(188 \times 12.13) + (189 \times 16.75) + (190 \times 27.23) + (192 \times 43.89)}{100}$$

OR 190.4677 **OR** 190.468 ✓

= 190.47 (to 2 DP) ✓

[2 marks]

EXAMINER GUIDANCE

For 1 mark: ALLOW ECF → to 2 DP if:

- %s used with wrong isotopes ONCE

OR

- transposed decimal places for ONE %

22(b)

Shaded cells were given in the question.

Element	Mass number	Protons	Neutrons	Electrons	Charge
Ni	62	28	34	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$	0 ✓
P	33	15	18	$1s^2 2s^2 2p^6 3s^2 3p^6$	3− ✓

Mark by row

[2 marks]

Easiest to check element first

***ALLOW** P^{3-}*

***ALLOW** names for elements*

***IGNORE** charges with element in 1st column, even if wrong.*

For electron configuration,

***ALLOW** $4s^2$ before $3d^8$*

i.e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$

***ALLOW** upper case D, etc and subscripts,*

e.g. .....$4S_2 3D_1$

***ALLOW** $[Ar]3d^8 4s^2$*

22(c)

Molar ratios

Zn : H : N : O

$$= \frac{21.99}{65.4} : \frac{4.04}{1.0} : \frac{9.41}{14.0} : \frac{64.56}{16.0}$$

OR 0.336 : 4.04 : 0.672 : 4.04

OR 1 : 12 : 2 : 12 ✓

Empirical formula

$ZnH_{12}N_2O_{12}$ ✓

Any order

With water of crystallisation

$ZnN_2O_6 \cdot 6H_2O$

OR $Zn(NO_3)_2 \cdot 6H_2O$ ✓

***NOTE**: If only the correct answer of $ZnN_2O_6 \cdot 6H_2O$ **OR** $Zn(NO_3)_2 \cdot 6H_2O$ is seen with no working, award 1 mark only*

ALLOW ECF from incorrect molar ratios of Zn : H : N : O

e.g. from use of atomic number(s)

***ALLOW** $Zn(NO_3)_2(H_2O)_6$*

ALLOW ECF from incorrect empirical formula

e.g. $ZnNO_3 \cdot 3H_2O$ from ZnH_6NO_6

Inverse fractions → NO MARKS

[3 marks]

Q157 · Atomic structure and isotopes · [16 marks]

OCR MARK SCHEME

1(a)(i)

Structure and bonding

NH_3 is (simple) molecular/simple covalent/ /has intermolecular forces

AND

NH_4NO_3 is ionic ✓

Comparison of strength

Ionic bonds are stronger than intermolecular bonds / forces between molecules

OR

Ionic bonds need more energy to break than intermolecular bonds ✓

[2 marks]

EXAMINER GUIDANCE

For intermolecular bonds/forces

ALLOW *hydrogen bonds*

OR London Forces/induced dipole forces/permanent dipole forces

OR van der Waals' forces

ALLOW *NH_4NO_3 has molecular ions*

NH_4^+ and NO_3^- are molecular ions

ORA

ALLOW:

Intermolecular bonds are weak

AND ionic bonds are strong ✓

1(a)(ii)

(NH_4^+) nitrogen has oxidation number of –3

AND

(NO_3^-) nitrogen has oxidation number of +5 ✓

i.e. nitrogens are –3 **AND** +5 gets the mark

BOTH signs essential

[1 mark]

Statement that one student is correct is **NOT** required.

Implicit in answer

ALLOW *3– **AND** 5+*

1(b)(i)

Cu: 66% **AND** Zn 34% ✓

[1 mark]

1(b)(ii)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 65.42 (to 2 DP) award 2 marks

Numerator from Zn isotopes

(64 × 16.82) + (66 × 9.53) + (67 × 1.38) + (68 × 6.27)

OR

Refer to answer to 1b(i) for ECF from incorrect % composition of Zn and Cu

ECF *÷ by Zn % in b(i)*

Common errors

22.24

2224.28 ✓

Relative atomic mass

$\frac{\text{Numerator}}{34}$ **AND** answer to 2 DP ✓

Mark **ECF** from numerator

$\frac{((64 \times 16.82) + (66 \times 9.53) + (67 \times 1.38) + (68 \times 6.27))}{34}$ ✓

= 65.42 (to 2 DP) ✓

[2 marks]

÷100 and answer to 2 DP

→ 1 mark for numerator

64.23

All 6 isotopes used → No marks

188.91

All 6 isotopes used

→ 6423 for numerator

÷34 and 2 DP → 1 mark by ECF

1(c)(i)

Proton environment	Splitting pattern	
1	Triplet	Triplet **AND** quartet ✓
2	Quartet	
3	Doublet	Doublet **AND** triplet ✓
4	Triplet	

[2 marks]

For quartet,

ALLOW Quad*....*

e.g. quadruplet, quadlet, quadret, etc

For doublet, **ALLOW** duplet

ALLOW *diagrams to show splitting pattern e.g.*



for triplet



for quartet

ALLOW *splitting patterns shown as numbers*

i.e. '3' for triplet, '4' for quartet

1(c)(ii)

Environment 2:

(Protons) adjacent to (one) C=O ✓

Environment 3:

(Protons) adjacent/between/surrounded by 2 C=O / a ketone **AND** aldehyde

OR

C=O on both sides ✓

[2 marks]

ALLOW *HC–C=O*

DO NOT ALLOW *H–C=O*

DO NOT ALLOW *HC–O*

Simply reading δ = 3.6 ppm from data sheet)

IGNORE *'next to 2 Os'*

1(d)(i)

Bond angles

H_2NCH_2COONa, bond angle = 107°

ALLOW *107 ± 0.5*

ALLOW *109* ***OR*** *110°*

AND

$HOOCCH_2NH_3Cl$, bond angle = 109.5° ✓

Number of electron pairs

Mark independently of angles

In NaOH/107°, (NH_2 has) 3 bonded pairs / 3 bonds

AND

1 lone pair ✓

In HCl/109.5°, (NH_3^+ has) 4 bonded pairs / 4 bonds ✓

[3 marks]

ALLOW *NH_2 has 4 pairs, one of which is a lone pair*

For bonded pairs/bonds

ALLOW bonded *groups, atoms, elements, regions*

Bonded essential

IGNORE *electron region* ***OR*** *electron density*

IGNORE *NH_3 has no lone pairs*

IGNORE *lone pairs repel more (than bonded pairs)*

IGNORE *shapes, even if wrong*

ALLOW *bp for bonded pair and lp for lone pair*

1(d)(ii)

Equation:

$2H_2NCH_2COOH + Cu(CH_3COO)_2 \rightarrow Cu(H_2NCH_2COO)_2 + 2CH_3COOH$ ✓

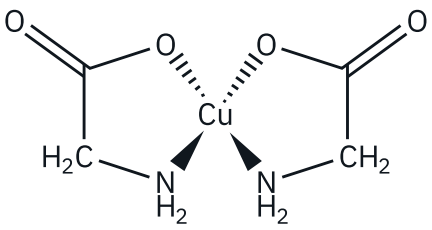
ALLOW *molecular formulae or mixture,*

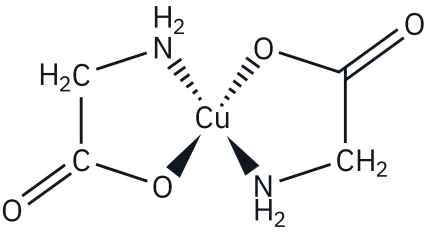
e.g. $2C_2H_5NO_2 + CuC_4H_6O_4 \rightarrow CuC_4H_8N_2O_4 + 2C_2H_4O_2$

IGNORE *charges*

i.e. IGNORE wrong or missing charges in ionic compounds if formula is correct/ e.g. **ALLOW** $Cu(CH_3COO^-)_2$, $Cu^+(CH_3COO^-)_2$

Structures





ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

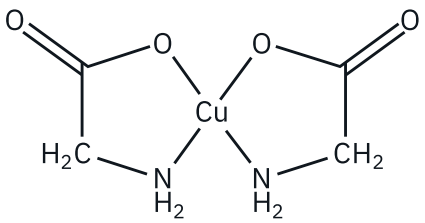
IGNORE *charges*

ALLOW *arc to represent –CH_2– between: C of C=O and NH_2*

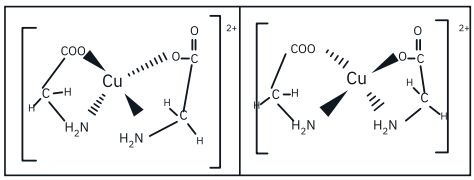


✓ ✓

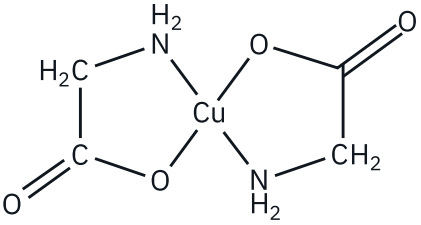
OR

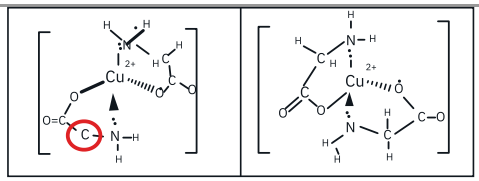


ALLOW *1 mark for 2 'correct' structures shown as tetrahedral e.g.*



IGNORE *missing Hs on C, e.g.*





✓ ✓

Ligands must shown as bidentate rings

IGNORE *connectivity for* NH_2

BUT connectivity must be to O of COO

[3 marks]

Q158 · Atomic structure and isotopes · [11 marks]

OCR MARK SCHEME

1(a)(i)

FIRST CHECK ANSWER ON ANSWER LINE

If answer = 47.92 (to 2 DP) seen award 2 marks

(46 x 8.3) + (47 x 7.4) + (48 x 73.7) + (49 x 5.4) + (50 x 5.2)

OR

381.8 + 347.8 + 3537.6 + 246.6 + 260

OR

4791.8 ✓

$$\frac{4791.8}{100}$$

= 47.92 ✓ 2DP required

[2 marks]

EXAMINER GUIDANCE

ALLOW one mark for ***ECF*** *from seen incorrect sum provided final answer between 46 and 50 and to 2 DP*

1(a)(ii)

$(1s^2)2s^22p^63s^23p^63d^24s^2$ ✓

Look carefully at $(1s^2)2s^22p^63s^23p^6$ – there may be a mistake

[1 mark]

ALLOW subscripts

ALLOW 4s before 3d i.e. $(1s^2)2s^22p^63s^23p^64s^23d^2$

ALLOW upper case D, etc and subscripts, e.g. .....$3S_2 3P^6$

DO NOT ALLOW *[Ar] as shorthand for* $1s^22s^22p^63s^23p^6$

1(a)(iii)

	Protons	Neutrons	Electrons
$^{48}Ti^{2+}$	22	26	20 ✓

ALL 3 numbers required for the mark

[1 mark]

1(b)(i)

Titanium (IV) oxide ✓

DO NOT ALLOW *titanium dioxide*

[1 mark]

1(b)(ii)

FIRST CHECK ANSWER ON ANSWER LINE

If answer = 2.67 kg award 4 marks

$n(\text{Ti}) = \frac{1000}{47.9}$ **OR** 20.8768... (mol) ✓

n(Na) for 72% yield = 20.88 × 4 **OR** 83.5073... (mol) ✓

$n(\text{Na})$ for 100% yield = $83.51 \times \frac{100}{72}$ **OR** 115.98237... (mol) ✓

mass Na = 115.98 x 23.0 = 2667.659... (g)

= 2.67 (kg) ✓

3 SF AND kg required

[4 marks]

ALLOW ECF *throughout*

TAKE CARE: values shown may be truncated calculator values.

Steps can be calculated in any order which will change the intermediate answers. Marks are for the processing of the data.

ALLOW 3SF up to calculated value throughout

IGNORE *rounding errors past 3SF*

Common Errors for 3 marks:

1.92 (missing yield)

1.38 (yield wrong way round)

0.673 (use of M_r 189.9 for $TiCl_4$ instead 47.9 for Ti)

1(b)(iii)

Add water AND filter ✓

Ti does not dissolve **OR** NaCl does dissolve ✓

[2 marks]

ALLOW dissolve in water

*ALLOW Ti is insoluble **OR** NaCl is soluble/aqueous*

*ALLOW Ti is the residue **OR** NaCl is the filtrate*

Q159 · Atomic structure and isotopes · [1 mark]

Answer: **C**

Protons: 12 · Neutrons: 13 · Electrons: 10

Q160 · Atomic structure and isotopes · [1 mark]

Answer: **C**

CH_3CHOH^+

Q161 · Atomic structure and isotopes · [7 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

21(a)

FIRST CHECK ANSWER ON THE ANSWER LINE

IF *answer = 54.63 (to 2 DP) award 2 marks*

$$\frac{(54 \times 78.54) + (56 \times 8.88) + (57 \times 5.10) + (58 \times 7.48)}{100}$$

OR 54.6298 **OR** 54.630 ✓

= 54.63 (to 2 DP) ✓

[2 marks]

For 1 mark: **ALLOW ECF** → to 2 DP if:

- %s used with wrong isotopes ONCE

OR

- transposed decimal places for ONE %

21(b)(i)

iron(III) oxide ✓

[1 mark]

IGNORE *iron(3) oxide, iron(III) dioxide, etc*

i.e. MUST be systematic

ALLOW *no brackets*

21(b)(ii)

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ ✓

[1 mark]

ALLOW *multiples*

e.g. $2Fe_2O_3 + 6CO \rightarrow 4Fe + 6CO_2$

ALLOW *1 Fe_2O_3 ..... but* ***NOT*** *0 Fe_2O_3 .....*

21(c)

FIRST CHECK ANSWER ON THE ANSWER LINE

IF *answer = 1.8(0) (dm^3) award 3 marks*

$n(Fe(NO_3)_3) = \frac{4.836}{241.8}$ = 0.02(00) (mol) ✓

$n(NO_2 + O_2)$ = 0.06 + 0.015

OR $\frac{15}{4} \times 0.0200$

OR 0.0750 (mol) ✓

Total volume = 0.0750 × 24 = 1.8(0) (dm^3) ✓

DO NOT ALLOW *0.02 × 24 = 0.48 dm^3*

0.48 dm^3 is 1 mark only for whole question

[3 marks]

ALLOW ECF *throughout*

ALLOW *no trailing zeroes (e.g. 0.02 for 0.0200)*

Only award **ECF** using moles for NO_2, O_2, $NO_2 + O_2$

e.g. NO_2: 0.06 × 24 = 1.44 (dm^3)

O_2: 0.015 × 24 = 0.36 (dm^3)

ALLOW

Omission of ÷4 for 1 NO_2 AND/**OR** O_2

e.g. 1.8 × 24 = 7.2 (dm^3)

ALLOW *use of ideal gas equation using sensible p and T for final mark. e.g.*

from 100 kPa and 293 K

→ *V*

$= \frac{nRT}{p} = \frac{0.075 \times 8.314 \times 293}{1000} =$ 1.83 dm^3

ALLOW *1 DP: 1.8 dm^3*

from 100 kPa and 298 K

→ $V = \frac{nRT}{p} = \frac{0.075 \times 8.314 \times 298}{1000} =$ 1.86 dm^3

ALLOW *1 DP: 1.9 dm^3*

from 100 kPa and 273 K

→ $V = \frac{nRT}{p} = \frac{0.075 \times 8.314 \times 273}{1000} =$ 1.7(0) dm^3

Examples of 'sensible' p and T:

p = 100 kPa, 101 kPa, 101,325 Pa

T = 273 – 298 K

Q162 · Atomic structure and isotopes · [1 mark]

Answer: **B**

The elements are ordered by increasing atomic mass.

Q163 · Atomic structure and isotopes · [13 marks]

OCR MARK SCHEME

21(a)

Species	Protons	Neutrons	Electrons
^{34}S	16	18	16
$^{32}S^{2-}$	16	16	18

4 correct ✓✓

3 correct ✓

[2 marks]

EXAMINER GUIDANCE

NOTE*: Look out for the 2– on $^{32}S^{2-}$*

ALLOW *$^{32}S^{-2}$*

21(b)

FIRST CHECK ANSWER ON THE ANSWER LINE **IF answer = 24.34 (to 2 DP) award 2 marks**

$$\frac{75.45 \times 24 + 15.21 \times 25 + 9.34 \times 26}{100}$$

OR 24.3389 **OR** 24.339 ✓

For 1 mark: ALLOW ECF → to 2 DP if:

- %s used with wrong isotopes ONCE

OR

= 24.34 (to 2 DP) ✓

[2 marks]

- transposed decimal places for ONE %

21(c)

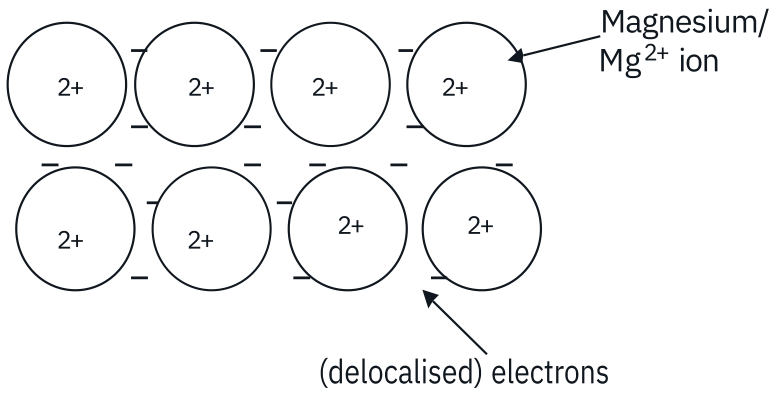


Diagram showing a regular arrangement of labelled 'Mg^{2+} ions' or '2+ ions' ✓

Regular arrangement must have at least 2 rows of correctly charged ions and a minimum of 2 ions per row

ALLOW *as label: positive ions, cations if correct charge is seen within circle*

ALLOW *for labelled Mg^{2+} ions: circles with Mg^{2+} inside*

DO NOT ALLOW *incorrect charge for ions e.g.+ , 3+ etc*

Scattering of labelled electrons between other species

AND

statement anywhere of delocalised electrons (can be in text or in diagram) ✓

Delocalised electrons move/flow (in an electric field/across a p.d.) ✓

Idea of movement required

DO NOT ALLOW *for label of ions:*

nuclei **OR** positive atom **OR** protons

ALLOW *e– or 'e' as a label for electron*

IGNORE *"–" for electron label (i.e. needs an additional label)*

ALLOW *'electrons are mobile (charge carriers)'* ***OR*** *'sea of electrons moves'*

IGNORE *electrons are free*

DO NOT ALLOW *ions can move*

[3 marks]

21(d)(i)

FIRST CHECK ANSWER ON THE ANSWER LINE **IF** answer = 2.0×10^{-1} award 3 marks

ALLOW ECF *throughout*

ALLOW *use of ideal gas equation for all 3 marks provided 'sensible' p and T used:*

$n(H_2) = \dfrac{60}{24000} = 2.50 \times 10^{-3}$ **OR** 0.0025(0) (mol) ✓

$n(HCl) = 5.00 \times 10^{-3}$ **OR** 0.005(00) (mole ratio = 2:1) ✓

$c(HCl) = \dfrac{5.00 \times 10^{-3}}{0.0245} = 0.204 = 2.0 \times 10^{-1}$

2 SF and standard form required ✓

e.g.

from 101 kPa and 298 K

→ nH_2 = 0.0024459 → nHCl = 0.0048919 → cHCl 0.1996688 → 2.0×10^{-1} (2SF and standard form)

from 100 kPa and 273 K

→ nH_2 = 0.0026435→ nHCl = 0.005287 → 0.21579656 → 2.2×10^{-1} (2SF and standard form)

Examples of 'sensible'

p = 100 kPa, 101 kPa, 101,325 Pa

[3 marks]

$T = 273 - 298$ K

Common errors (final answer)

Use of $24.5cm^3$ for H_2 volume

8.3×10^{-2} → 2 marks

Incorrect units for H_2 volume (i.e. 60/24)

2.0×10^{2} → 2 marks

Not 2SF or standard form

0.204 → 2 marks

calculator 0.2040816327

21(d)(ii)

Concentration

(Acid) concentration decreases ✓

Collisions

Fewer collisions per second

OR less frequent collisions ✓

Reaction stops/graph plateaus

(Acid/reactant/limiting reagent) has reacted/been used up ✓

[3 marks]

For Concentration and Collisions, **ALLOW ORA** for initial conditions (when t = 0), but answer must be comparative (e.g. initially the concentration is highest/higher)

ALLOW *'fewer particles in a given volume/space' for concentration decreases*

IGNORE *amount of acid decreases*

IGNORE *magnesium concentration decreases*

(Mg is solid)

DO NOT ALLOW *(line increases so) rate increases*

IGNORE *references to energy even if incorrect*

IGNORE *responses not linked to time, e.g.*

- fewer successful collisions
- fewer collisions, less chance of collisions

No link to rate.

ALLOW *idea that reaction stops e.g. no more collisions*

DO NOT ALLOW
MagnesiumS/reactantS used up

(Magnesium is in excess)

Q164 · Atomic structure and isotopes · [1 mark]

Answer: **C**

X and Z

Q165 · Atomic structure and isotopes · [1 mark]

Answer: **A**

Q166 · Atomic structure and isotopes · [8 marks]

OCR MARK SCHEME

1(a)(i)

m/z	Number of protons	Number of neutrons	Number of electrons
79	35	44	34
81	35	46	34

Protons **AND** Neutrons correct ✓

Electrons correct ✓

[2 marks]

1(a)(ii)

Explanation

(*m/z*) 158: $^{79}Br^{79}Br$ **OR** $^{79}Br_2$ **OR** 79 + 79

(*m/z*) 160: $^{79}Br^{81}Br$ **OR** $^{81}Br^{79}Br$ **OR** 79 + 81

(*m/z*) 162: $^{81}Br^{81}Br$ **OR** $^{81}Br_2$ **OR** 81 + 81

3 correct ✓ ✓

2 correct ✓

Relative abundancies

1 : 2 : 1 ✓

OR

25 : 50 : 25

[3 marks]

1(b)

Shaded cells were given in the question.

Compound	Number of peaks	CH_2 splitting pattern(s)
$BrCH_2CH_2Br$	1	Singlet ✓
$BrCH_2CH_2CH_2Br$	**AND** 2 ✓	Triplet **AND** Quintet ✓

Mark number of peaks and splitting patterns independently

EXAMINER GUIDANCE

Mark explanation and Relative Abundances together

IGNORE *charges*

m/z value needs linking with isotopes in Br_2

ALLOW *0.25 : 0.5 : 0.25*

ALLOW *peak at 160 is twice/double 158 and 162*

For $BrCH_2CH_2Br$ splitting pattern,

ALLOW *'No splitting'* **OR** *'None'*

For $BrCH_2CH_2CH_2Br$ splitting pattern

ALLOW

multiplet,

quinruplet, quinlet, quinret, pentet, pentuplet, pentex etc

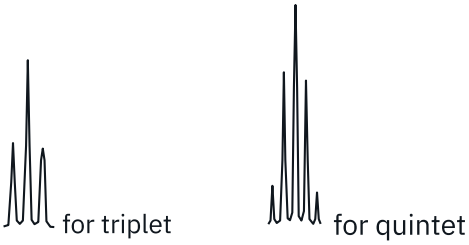
ALLOW *splitting patterns shown as numbers*

i.e. '1' for singlet, '3' for triplet, '5' for quintet

[3 marks]

ALLOW *diagrams to show splitting pattern*

e.g.



Q167 · Atomic structure and isotopes · [7 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

21(a)

Shell	1st shell	2nd shell	3rd shell	4th shell
Electrons	**2**	**8**	**18**	**32**

Requires all 4 numbers to be correct ✓

[1 mark]

21(b)

Differences:

(Different number of) neutrons ✓

Similarities:

(Same number of) protons **AND** electrons ✓

[2 marks]

IGNORE *different masses/mass numbers throughout*

(Question asks for atomic structures)

ALLOW *'amount' for 'number'*

ALLOW *'electron configuration' for electrons*

21(c)(i)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 35.48 (to 2 DP) award 2 marks

$\frac{(35 \times 75.76) + (37 \times 24.24)}{100}$ **OR** 35.4848 **OR** 35.485 ✓

= 35.48 (to 2 DP) ✓

[2 marks]

For 1 mark: ALLOW ECF → to 2 DP if:

- %s used with wrong isotopes ONCE

OR

- transposed decimal places for ONE %

AND

- calculated A_r is between 35 and 37

21(c)(ii)

m/z = 72: $^{35}Cl^{37}Cl$

OR Contains chlorine-35 **AND** chlorine-37 ✓

m/z values: 70 **AND** 74 ✓

[2 marks]

Q168 · Atomic structure and isotopes · [8 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

21(a)

Shell	Total number of electrons	Sub-shell s	Sub-shell p	Sub-shell d
1st	**2**	**2**		
2nd	**8**	**2**	**6**	
3rd	**18**	**2**	**6**	**10**

1st 2 rows correct → 1 mark ✓

3rd row correct → 1 mark ✓

[2 marks]

ALLOW

(1)s^2

(2)s^2 (2)p^6

(3)s^2 (3)p^6 (3)d^{10}

DO NOT ALLOW *extra numbers*

21(b)

	Protons	Neutrons	Electrons
^{76}Se	34	42	34
^{82}Se	34	48	34

ALL 6 entries correct for mark ✓

[1 mark]

21(c)

FIRST CHECK ANSWER ON THE ANSWER LINE

IF answer = 32.094 (to 3 DP) award 2 marks

$$\frac{(32 \times 94.93) + (33 \times 0.78) + (34 \times 4.29)}{100}$$

OR 32.0936 ✓

= 32.094 (to 3 DP) ✓

[2 marks]

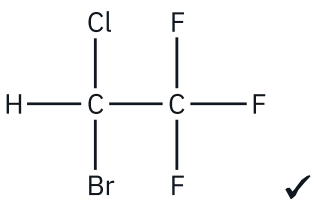
For 1 mark: ALLOW ECF → to 2 DP if:

- %s used with wrong isotopes ONCE

OR

- transposed decimal places for ONE %

21(d)(i)



✓

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous, e.g.* $CF_3CHClBr$

[1 mark]

21(d)(ii)

FIRST, CHECK ANSWER

IF answer = 7.224 × 10^{22}, award 2 marks

$n(C_2HBrClF_3) = \frac{7.896}{197.4}$ **OR** 0.04(00) (mol) ✓

F atoms = 3 × 0.0400 × 6.02 × 10^{23}

= 7.224 × 10^{22} ✓

Minimum 3 SF required

[2 marks]

Alternative approaches

n(F atoms) = $\frac{7.896}{197.4}$ × 3 = 0.12 ✓

F atoms = 0.12 × 6.02 × 10^{23}

= 7.224 × 10^{22} ✓

OR

3 mol F atoms

= 3 × 6.02 × 10^{23} = 1.806 × 10^{24} ✓

F atoms = 1.806 × 10^{24} × 0.04

= 7.224 × 10^{22} ✓

OR

Mass F in 7.896 g

= $\frac{57}{197.4}$ × 7.896 = 2.28 (g) ✓

F atoms = $\frac{2.28}{19}$ × 6.02 × 10^{23}

= 7.224 × 10^{22} ✓

ALLOW ECF *from incorrect* $n(C_2HBrClF_3)$

ALLOW *use of 6.022 × 10^{23}* ***OR*** *6.023 × 10^{23}*

Common error

2.408 × 10^{22} **OR** 2.41 × 10^{22} → 1 mark	No × 3
1.806 × 10^{24} → 1 mark	No $n(C_2HBrClF_3)$

Q169 · Electrons, bonding and structure · [1 mark]

Answer: **B**

E-2,3-dichlorobut-2-ene

Q170 · Electrons, bonding and structure · [1 mark]

Answer: **C**

OCR MARK SCHEME

8

EXAMINER GUIDANCE

ALLOW *8 in box*

Q171 · Electrons, bonding and structure · [1 mark]

Answer: **B**

Name of shape: Pyramidal · Bond angle: 107°

Q172 · Electrons, bonding and structure · [1 mark]

Answer: **A**

Q173 · Electrons, bonding and structure · [1 mark]

Answer: **A**

OCl_2

Q174 · Electrons, bonding and structure · [16 marks]

OCR MARK SCHEME

1(a)(i)

Electrostatic attraction between positive and negative ions ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW *oppositely charged ions*

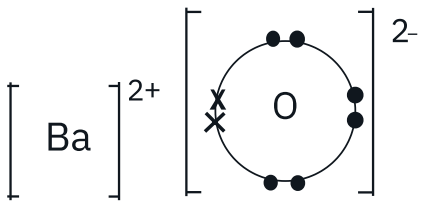
ALLOW *cations and anions*

ALLOW *'+' for positive and '-' for negative*

IGNORE *references to metal and non-metal*

IGNORE *references to transfer of electrons*

1(a)(ii)



Ba shown with either 0 or 8 electrons

AND

O shown with 8 electrons with 6 dots and 2 crosses (or vice versa) ✓

Correct charges on both ions ✓

For first mark,

if eight electrons are shown around Ba, the 'extra' electrons around O must match the symbol chosen for the electrons for Ba.

IGNORE *inner shells*

Circles not required

Brackets not required

[2 marks]

1(a)(iii)

FIRST CHECK THE ANSWER ON THE ANSWER LINE

***IF** answer = 5.89 × 10^{21} award 2 marks for calculation*

Moles of barium oxide

$n(BaO) = \frac{1.50}{153.3}$ **OR** 9.78×10^{-3} ✓

Number of barium ions

$(9.78 \times 10^{-3} \times 6.02 \times 10^{23}) = 5.89 \times 10^{21}$ ✓

3 SF AND standard form required

[2 marks]

***ALLOW** 0.00978 up to calculator value 0.009784735*

***ALLOW ECF** from incorrect moles of BaO*

Common incorrect answers are shown below

***IF** 137.3 is used for the molar mass*

***ALLOW 1 mark** total for 6.58 x 10^{21} (0.010924981 mol) **OR** 6.56 x 10^{21} (0.0109 mol)*

***IF** 153 is used for the molar mass*

***ALLOW 1 mark** total for 5.90 × 10^{21}*

1(b)(i)

Barium chloride does not conduct electricity when solid

AND

because it has ions which are fixed (in position/in lattice) ✓

Barium chloride conducts when in aqueous solution

AND

because it has mobile ions ✓

[2 marks]

***IGNORE** use of 'free' instead of 'mobile'*

***ALLOW** ions are not free to move*

***ALLOW ions** are held (in position/in lattice)*

***ALLOW ions** are not mobile*

***IGNORE** charge carriers*

***DO NOT ALLOW** electrons moving*

***ALLOW** one mark for comparison that does not identify (s) and (aq).*

1(b)(ii)

Test for sulfate/SO_4^{2-} ✓

White precipitate forms (when barium chloride solution is mixed with a solution containing sulfate ions) ✓

[2 marks]

***IGNORE** hydrochloric acid*

***ALLOW** white solid*

***IGNORE** cloudy*

***DO NOT ALLOW** test result linked to incorrect anion*

1(b)(iii)

FIRST CHECK THE ANSWER ON THE ANSWER LINE

***IF** answer = 2 award 2 marks*

$M(BaCl_2) = ((137.3 + (35.5 \times 2)) = 208.3$ (g mol^{-1}) ✓

244.3 – 208.3 = 36

AND

$\frac{36}{18} = 2$ ✓

***ALLOW** 208 (g mol^{-1})*

***ALLOW ECF** for incorrectly calculated molar mass provided the final answer is rounded to nearest whole number*

[2 marks]

1(c)(i)

$(1s^2)2s^2\ 2p^6$ ✓

IGNORE *$1s^2$ seen twice*

ALLOW *upper case letters* ***AND*** *subscripts*

[1 mark]

1(c)(ii)

Products of reaction

A = Barium hydroxide/$Ba(OH)_2$ ✓

B = Ammonia/NH_3 ✓

Formula for barium nitride

Ba_3N_2 ✓

Balanced equation **AND** state symbols

$Ba_3N_2(s) + 6H_2O(l) \rightarrow 3Ba(OH)_2(aq) + 2NH_3(g)$ ✓

State symbols are required

ALLOW *one mark for correct products incorrectly labelled*

Formulae must be correct

No **ECF** from any incorrect formula

ALLOW *multiples*

Correct equation with state symbols scores 4 marks

[4 marks]

Q175 · Electrons, bonding and structure · [1 mark]

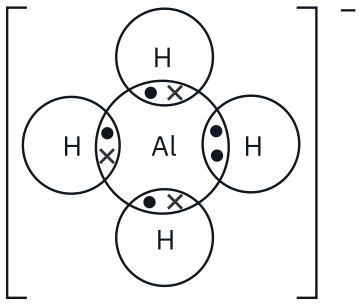
Answer: **B**

Only 1 and 2

Q176 · Electrons, bonding and structure · [7 marks]

OCR MARK SCHEME

16(a)



✓

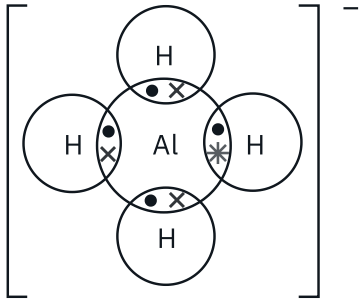
[1 mark]

EXAMINER GUIDANCE

IGNORE *no brackets, no charge or wrong charge*

Circles not needed

ALLOW *different sign for 'extra' electron, e.g.*



DO NOT ALLOW *4 dots and 4 crosses*

16(b)

NH_4^+: tetrahedral **AND** 109.5(°) ✓

NH_2^-: non-linear **AND** 104.5(°) ✓

[2 marks]

ALLOW *109–110(°)*

ALLOW *104–105(°)*

ALLOW *bent, v-shaped, angular*

IGNORE *planar, 'not straight'*

16(c)(i)

NH_3 has hydrogen bonding

OR

PH_3 does not have hydrogen bonding ✓

Hydrogen bonding is stronger

OR

More energy to overcome hydrogen bonding ✓

[2 marks]

ORA *throughout*

Assume that comparison is with PH_3

DO NOT ALLOW *response that implies covalent or ionic bonds breaking*

16(c)(ii)

AsH_3 / As has more electrons (than PH_3 / P) ✓

in AsH_3,

stronger/more induced dipole–dipole interactions

OR stronger/more London forces (than PH_3)

OR more energy required to overcome induced dipole–dipole interactions ✓

ORA *throughout*

ALLOW *larger electron cloud*

ALLOW *'forces' **OR** 'bonds' for 'interactions'*

ALLOW *instantaneous/temporary–induced dipole interactions*

ALLOW *dispersion forces*

IGNORE *van der Waals' / vdW*

[2 marks]

IGNORE *permanent dipole–dipole*

DO NOT ALLOW *response that implies covalent or ionic bonds breaking*

Q177 · Electrons, bonding and structure · [1 mark]

Answer: **C**

OCR MARK SCHEME

Atom 3

EXAMINER GUIDANCE

ALLOW *3 (This is the trigonal planar atom)*

Q178 · Electrons, bonding and structure · [1 mark]

Answer: **C**

Na_2X

Q179 · Electrons, bonding and structure · [1 mark]

Answer: **D**

sulfur

Q180 · Electrons, bonding and structure · [8 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

21(a)(i)

Shaded cells were given in the question.

	Protons	Neutrons	Electrons	
^{30}Si	14	16	14	✓

[1 mark]

21(a)(ii)

FIRST CHECK ANSWER ON THE ANSWER LINE

IF answer = 28.11 (to 2 DP) award 2 marks

$$\frac{(28 \times 92.23) + (29 \times 4.68) + (30 \times 3.09)}{100}$$

OR 28.1086 **OR** 28.109 ✓

= 28.11 (to 2 DP) ✓

[2 marks]

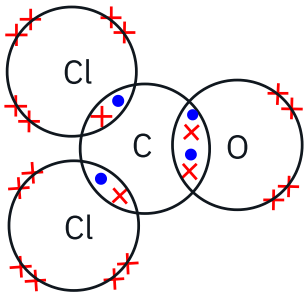
For 1 mark: ALLOW ECF → to 2 DP if:

- %s used with wrong isotopes ONCE

OR

- transposed decimal places for ONE %

21(b)(i)



✓

CARE: Check that lone pairs on Cl and O are included

- Cl (×2) has 6 non-bonded electrons (3 LPs)
- O has 4 non-bonded electrons (2 LPs)

[1 mark]

***NOTE**: O and Cl electrons MUST be shown differently from C electrons*

(e.g. expected answer)

***IGNORE** inner shells*

***ALLOW** diagram with missing C, O or Cl symbols.*

For C=O bond, **ALLOW** sequence × × • •

***ALLOW** non-bonding electrons unpaired*

21(b)(ii)

Shape

Trigonal planar ✓

Number of bonded regions

(C has) 3 electron (dense) regions

OR 3 bonding regions ✓

Electron pair repulsion (Seen anywhere)

***ALLOW** bp for bonded pair*

***ALLOW** 3 bonded pairs (BOD)*

OR 3 sigma bonds

OR 2 bonded pairs and 1 double bond

OR 4 bonded pairs including a double bond

***IGNORE** bonded atoms*

electron pairs/bonded pairs/bonded regions repel

OR

electron pairs move as far apart as possible

OR

bonds repel ✓

[3 marks]

IGNORE *just 3 bonds*

ALLOW *alternative phrases/words for repel*

e.g. 'push apart'

IGNORE *electrons repel (pairs needed)*

DO NOT ALLOW *atoms repel*

21(c)

Highest energy electron(s) in a p orbital/p sub-shell ✓

[1 mark]

ALLOW outer *electron(s) in a p orbital/sub-shell*

BUT IGNORE p shell

ALLOW *electron configuration ends in p*

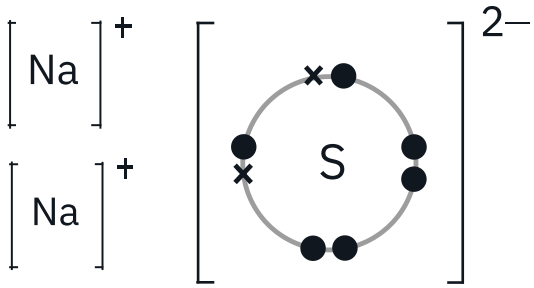
OR the last electron is in a p orbital

ALLOW *valence electron(s) in p orbital/sub-shell*

Q181 · Electrons, bonding and structure · [8 marks]

OCR MARK SCHEME

2(a)



Na shown with either 0 or 8 electrons

AND

S shown with 8 electrons with 6 dots and 2 crosses (or vice versa) ✓

Correct charges ✓

[2 marks]

EXAMINER GUIDANCE

ALLOW $2[Na]^+$

ALLOW $[Na]^+_2$

Brackets not required

For first mark,

if eight electrons are shown around Na, the 'extra' electrons around S must match the symbol chosen for the electrons for Na.

IGNORE *inner shells*

Circles not required

2(b)

	Na_2S	Na	S
Melting point / °C	1180	98	113

Mark by **COLUMN**

	Na_2S	Na	S
Type of structure	**giant**	**giant**	**simple**
Conductivity of solid	**poor**	**good**	**poor**
Conductivity of liquid	**good**	**good**	**poor**
	✓	✓	✓

One mark for each correct column

[3 marks]

2(c)(i)

$(1s^2)2s^22p^63s^23p^63d^{10}4s^24p^4$ ✓

Look carefully at $(1s^2)2s^22p^63s^23p^6$ – there may be a mistake

[1 mark]

ALLOW *subscripts*

ALLOW *in any order i.e.* $3d^{10}$ *after* $4s^2$ *or after* $4p^4$

ALLOW *upper case D, etc and subscripts,*

e.g. .....$3S_2 3P^6$

DO NOT ALLOW *[Ar] as shorthand for* $1s^22s^22p^63s^23p^6$

2(c)(ii)

Gas B

H_2Se / Hydrogen selenide / Selenium hydride ✓

Equation

$Na_2Se + 2HCl \rightarrow 2NaCl + H_2Se$

All formulae and balancing ✓

[2 marks]

ALLOW SeH_2

ALLOW *correct multiples*

IGNORE *STATE SYMBOLS*

DO NOT ALLOW H_2S *for gas B*

BUT **ALLOW ECF** from H_2S for equation:

$Na_2S + 2HCl \rightarrow 2NaCl + H_2S$

Q182 · Electrons, bonding and structure · [1 mark]

Answer: **B**

C_2H_6

Q183 · Electrons, bonding and structure · [1 mark]

Answer: **A**

C_2H_4

Q184 · Electrons, bonding and structure · [13 marks]

OCR MARK SCHEME

21(a)

TWO correct responses from ✓

- Different numbers of neutrons
- Different (atomic) masses/mass numbers
- Different physical properties

Physical required

[1 mark]

EXAMINER GUIDANCE

IGNORE *heavier/lighter*

DO NOT ALLOW *different relative atomic masses*

BUT ALLOW different relative isotopic masses

DO NOT ALLOW *different chemical properties*

OR different properties

IGNORE *different abundancies*

21(b)

Shaded cells were given in the question.

Element	Mass number	Protons	Neutrons	Electrons	Charge	
Fe	54	26	28	26	0	✓
Se	80	34	46	36	2–	✓

Mark by row

[2 marks]

THREE responses for each mark

Easiest to check element first

ALLOW Se^{2-}

ALLOW *names for elements*

21(c)

Sub-shells labels

2s (single box) **AND** 2p (3 boxes) ✓

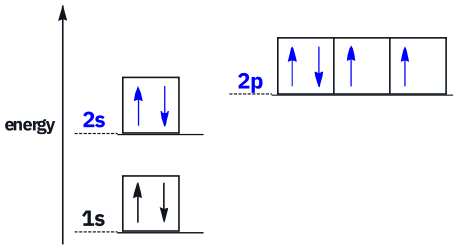
Electrons as arrows

unpaired electrons in 3 boxes: ↑ ↓ ↑ ↑

AND

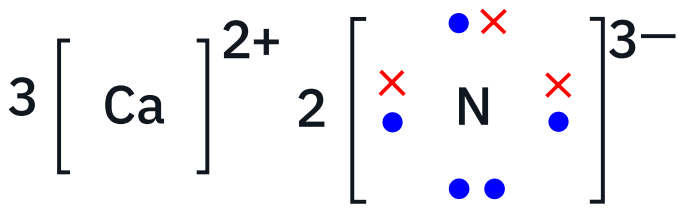
Paired electrons in single box: ↑ ↓ ✓

[2 marks]



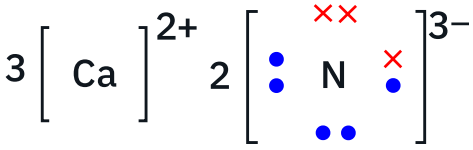
ALLOW *single headed arrows, e.g.* ↿

21(d)(i)



CARE:

ALLOW any *pairing if electrons correct, e.g.*



Ca shown with either 0 or 8 electrons

AND

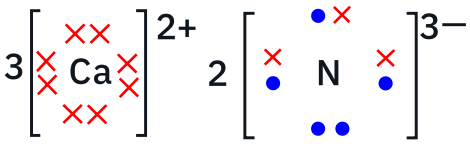
N shown with 8 electrons with 5 dots and 3 crosses (or vice versa) ✓

3 Ca **AND** 2 N **AND** correct charges on ions, i.e. $3Ca^{2+}$ $2N^{3-}$ ✓

Circles **OR** Brackets **NOT** required

[2 marks]

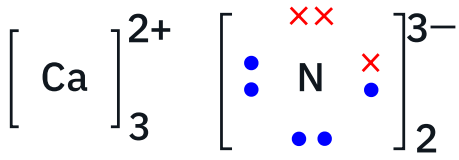
***IF** 8 electrons shown around Ca, 'extra' 3 electrons around N must match symbol for Ca electrons, e.g.*



***IGNORE** inner shells*

***ALLOW** drawing with 3 Ca^{2+} and 2 N^{3-}*

e.g.



21(d)(ii)

$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$

$Ca(OH)_2$ **OR** NH_3 as product ✓

All species correct **AND** correct balancing ✓

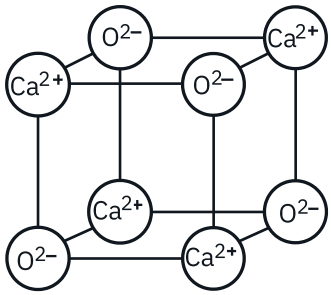
[2 marks]

***ALLOW** NH_4OH for NH_3*

***ALLOW** $Ca_3N_2 + 8H_2O \rightarrow 3Ca(OH)_2 + 2NH_4OH$*

***IGNORE** other products*

21(d)(iii)



Ca^{2+} shown alternately in FOUR circles ✓

O^{2-} shown alternately in FOUR circles ✓

[2 marks]

***ALLOW** labels if seen outside circles provided it clear which circle the label applies to*

***ALLOW** 1 mark for Ca **AND** O shown alternately, each in FOUR circles*

i.e. with no charges or incorrect charges

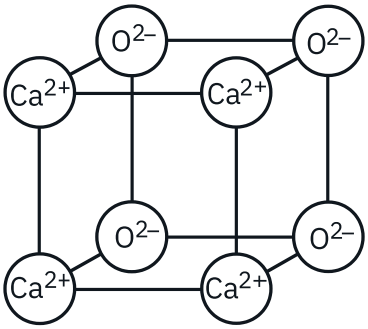
***ALLOW** 1 mark for **2+/+2 AND 2–/–2** shown alternately in FOUR circles (with no Ca and O)*

***DO NOT ALLOW** All circles with same ion,*

i.e. all Ca^{2+} **OR** all O^{2-}

***ALLOW** 1 mark for 4 Ca^{2+} **AND** 4O^{2-} but NOT shown alternately*

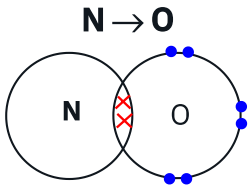
e.g.



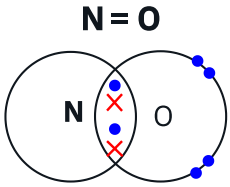
✓

21(d)(iv)

'Dot and cross' of central N to O OR N ✓



OR



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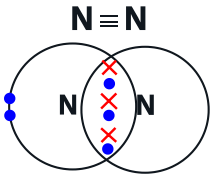
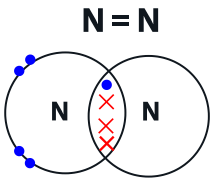
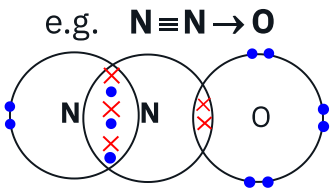


OR



Rest of 'dot and cross' diagram correct ✓



Electrons do NOT need to be shown paired.

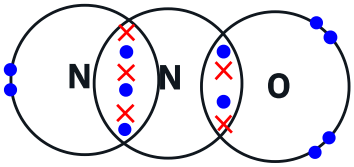
'Dot and cross' of NO_2

ALLOW *1st mark for N→O* ***OR*** *N=O*

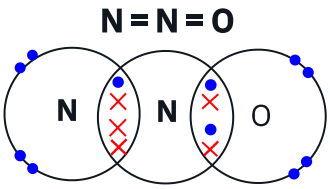
DO NOT ALLOW *ions*

CARE For 2nd mark, watch for stray paired **OR** unpaired electrons on central N

ALLOW *10 electrons around central N atom for 2 marks, i.e.*



OR



[2 marks]

Q185 · Electrons, bonding and structure · [1 mark]

Answer: **D**

Q186 · Electrons, bonding and structure · [1 mark]

Answer: **A**

The ability of an atom to attract the electrons in a covalent bond.

Q187 · Electrons, bonding and structure · [9 marks]

OCR MARK SCHEME

23(a)(i)

(Electrostatic) attraction between oppositely charged **OR** + and – ions ✓

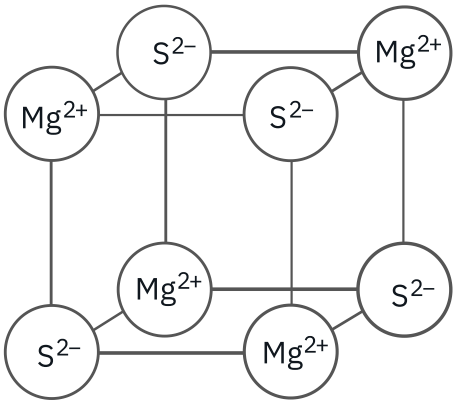
[1 mark]

EXAMINER GUIDANCE

Attraction is essential

IGNORE references to metal and non-metal

23(a)(ii)



Mg^{2+} shown alternately in FOUR circles ✓

S^{2-} shown alternately in FOUR circles ✓

[2 marks]

ALLOW labels if seen outside circles provided it clear which circle the label applies to

ALLOW 1 mark for Mg AND S shown alternately, each in FOUR circles

i.e. with no charges or incorrect charges

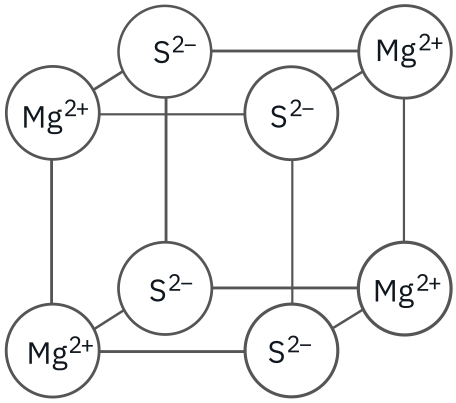
ALLOW 1 mark for 2+/+2 AND 2–/–2 shown alternately in FOUR circles (with no Mg and S)

***DO NOT ALLOW** All circles with same ion,*

i.e. all Mg^{2+} **OR** all S^{2-}

*ALLOW 1 mark for 4 Mg^{2+} AND 4S^{2-} but **NOT** shown alternately*

e.g.



✓

ALLOW PO_4^{-3}

23(b)

Shaded cells were given in the question.

Name of oxyanion	Ionic charge	Formula of oxyanion
Bromate(III) ✓	1–	BrO_2^-
Sulfate(VI)	2–	SO_4^{2-}
Phosphate(V)	3–	PO_4^{3-} ✓

[2 marks]

23(c)

Structure

Giant ✓

Bonding

Metallic (bonding) ✓

Particles

2+ /Ca^{2+} ions and delocalised electrons ✓

Conductivity

(Delocalised) electrons move/flow ✓

Idea of movement required

Delocalised can be seen anywhere

[4 marks]

ALLOW marks from labelled diagram

'Giant metallic' gains BOTH structure and bonding marks

ALLOW attraction between cations and electrons

Attraction between nucleus and electrons is CON

Watch for 'metallic' being CONNed within overall response

ALLOW charge flows ONLY when linked to electrons

IGNORE electrons carry charge

IGNORE electrons are free

BUT

ALLOW mobile electrons carry charge

Q188 · Electrons, bonding and structure · [1 mark]

Answer: **C**

OCR MARK SCHEME

7

EXAMINER GUIDANCE

ALLOW *7*

Q189 · Electrons, bonding and structure · [1 mark]

Answer: **A**

1, 2 and 3

Q190 · Electrons, bonding and structure · [1 mark]

Answer: **B**

Induced dipole–dipole interactions (London forces) become stronger.

Q191 · Electrons, bonding and structure · [7 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

21(a)(i)

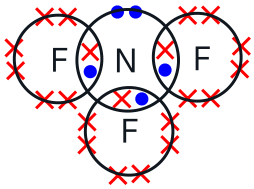
Shared pair of electrons ✓

[1 mark]

IGNORE *comments about attraction between nuclei and shared pair* ***OR*** *magnetic attraction*

21(a)(ii)

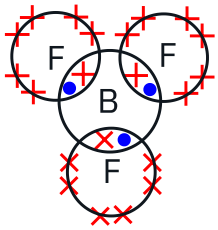
NF_3:



3 '*dot-and-cross*' bonds AND 1 lone pair around N

AND 3 lone pairs around each of the 3 F atoms ✓

BF_3:



3 '*dot-and-cross*' bonds ONLY around B

AND 3 lone pairs around each of the 3 F atoms ✓

[2 marks]

Must be '*dot-and-cross*' using 2 different symbol for electron source ONLY

IGNORE *absence of circles*

ALLOW 1 mark for correct dot and cross diagrams for NF_3 AND BF_3

BUT with F lone pairs omitted

ALLOW absent symbols from circles

A lone pair can be shown as 2 single electrons

IGNORE *charges*

21(b)(i)

Bond angles and shapes

	Bond angle	Name of shape
NF_3	107°	pyramidal
BF_3	120°	trigonal planar

ALL 4 points → 2 marks ✓✓

2 **OR** 3 points → 1 mark ✓

[2 marks]

For NF_3

*ALLOW 106–108° **OR** 109.5° – 2.5°*

ALLOW pyramid

ALLOW trigonal pyramid(al)

For BF_3

ALLOW planar triangle

BUT 'planar' is insufficient

21(b)(ii)

- NF_3 has 3 bonded pairs AND 1 lone pair (of electrons) AND lone pairs repel more (than bonded pairs) ✓

ALLOW lp for lone pair (of electrons)

bp for bonding pair (of electrons)

regions for electron pairs

- BF_3 has three bonded pairs (of electrons) ✓

[2 marks]

ALLOW 'bonds' for 'bonded pair'

IGNORE *'electrons repel'*

DO NOT ALLOW *'atoms repel'*

Q192 · Electrons, bonding and structure · [1 mark]

Answer: **C**

OCR MARK SCHEME

6

EXAMINER GUIDANCE

ALLOW *6*

Q193 · Electrons, bonding and structure · [1 mark]

Answer: **B**

Only 1 and 2

Q194 · Electrons, bonding and structure · [1 mark]

Answer: **A**

HCN

Q195 · Electrons, bonding and structure · [1 mark]

Answer: **A**

1, 2 and 3

Q196 · Electrons, bonding and structure · [23 marks]

OCR MARK SCHEME

6(a)

H–O–N

104.5° ✓

2 bonded pairs/regions AND 2 lone pairs (around O)

AND lone pairs repel more ✓

Independent of bond angle

O–N–O

120° ✓

3 bonded regions/pairs (around N) ✓

Independent of bond angle

[4 marks]

EXAMINER GUIDANCE

Throughout,

- IGNORE names of shapes (even if wrong)
- IGNORE 'electrons repel'
- **DO NOT ALLOW** 'atoms repel'

ALLOW 104–105°

ALLOW lp for lone pair (of electrons)

bp for bonding pair (of electrons)

'bond' for 'bonded pair'

IGNORE electron density

ALLOW 115–125°

ALLOW 3 bonded areas/environments

3 regions/areas of electron density

3 bonded groups

ALLOW 2 bonded pairs and 1 double bond

OR 2 bonded pairs and 1 bonded region

6(b)(i)

$Al_2O_3 + 6HNO_3 \rightarrow 2Al(NO_3)_3 + 3H_2O$

Any THREE species correct ✓

Correct balanced equation ✓

DO NOT ALLOW *more than 4 species in equation*

[2 marks]

ALLOW multiples

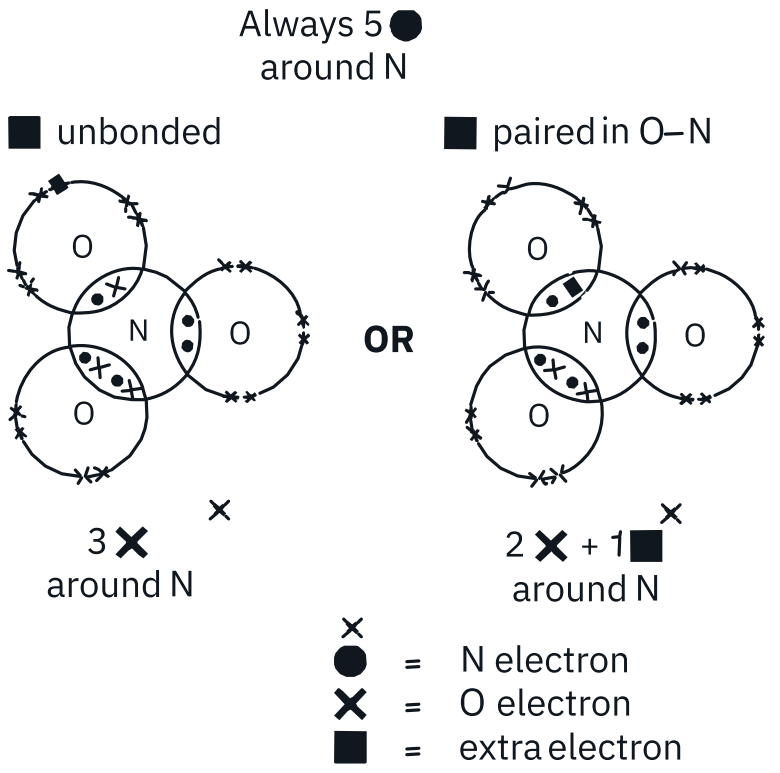
IGNORE state symbols (even if wrong)

ALLOW ionic equation

$Al_2O_3 + 6H^+ \rightarrow 2Al^{3+} + 3H_2O$

Mark using same criteria

6(b)(ii)



NOT *REQUIRED*

- Charge ('–')
- Brackets
- Circles
- N and O symbols

IGNORE inner shells

ALLOW rotated diagram

In N=O bond, ALLOW sequence × × • •

ALLOW non-bonding electrons unpaired

ALLOW dot and cross labels swapped:

i.e. • for O electrons and × for N electrons

1st mark: 8 Electrons around N as above

1 single covalent bond,

1 dative covalent bond

1 double bond

2nd mark: 8 electrons around each O

AND 6 O electrons around each O

Only award 2nd mark if 1st mark awarded

NO **ECF**

[2 marks]

6(c)(i)

$Au + 4HCl \rightarrow 4H^+ + AuCl_4^- + 3\ e^-$ ✓

[1 mark]

6(c)(ii)

Formulae

X = NO ✓

Z = H_2O ✓

Equation Independent from ID of X and Z

$HNO_3 + 3H^+ + 3\ e^- \rightarrow NO + 2H_2O$

OR

$NO_3^- + 4H^+ + 3\ e^- \rightarrow NO + 2H_2O$ ✓

CHECK BELOW ANSWER SPACE FOR RESPONSES

If X and Z in wrong order award 1 out of 2 formula marks

i.e. X = H_2O and Z = NO 1 mark

ALLOW multiples

[3 marks]

6(d)

FIRST CHECK THE ANSWERS ON ANSWER LINE

*If K_c value = 2931 **OR** 2930 award 4 calc marks*

*If units = $dm^3\ mol^{-1}$ **OR** $mol^{-1}\ dm^3$ award 1 unit mark*

SO_2 and O_2 equilibrium moles

$n(SO_2) = 6.20 \times 10^{-3}$	$(5.82 \times 10^{-2} - 5.20 \times 10^{-2})$
AND $n(O_2) = 4.80 \times 10^{-2}$ ✓	$(7.4 \times 10^{-2} - \frac{5.20 \times 10^{-2}}{2})$

Equilibrium concentrations $(\frac{\text{moles}}{2})$

Use of fractions is fine but final answer MUST be shown using normal numbers

COMMON ERRORS

$K_c = 1{,}465\ (\frac{2{,}930}{2}) \rightarrow$ 3 calc marks

Moles not converted to concentration (No ÷2)

$$\frac{(5.20 \times 10^{-2})^2}{((6.2 \times 10^{-3})^2\ (4.80 \times 10^{-2}))}$$

$K_c = 21.6 \rightarrow$ 3 calc marks

Original values used,

$$\frac{(2.60 \times 10^{-2})^2}{((2.91 \times 10^{-2})^2\ (3.70 \times 10^{-2}))}$$

$K_c = 10.8 \rightarrow$ 2 calc marks

Original values used and no ÷2,

$$\frac{(5.20 \times 10^{-2})^2}{((5.82 \times 10^{-3})^2\ (7.40 \times 10^{-2}))}$$

$[SO_2]$ = **3.10 × 10^{-3}**	$\frac{6.20 \times 10^{-3}}{2}$ (mol dm^{-3})
AND $[O_2]$ = **2.40 × 10^{-2}**	$\frac{4.80 \times 10^{-2}}{2}$ (mol dm^{-3})
AND $[SO_3]$ = **2.60 × 10^{-2}** ✓	$\frac{5.20 \times 10^{-2}}{2}$ (mol dm^{-3})

K_c calculation

$$K_c = \frac{(2.60 \times 10^{-2})^2}{((3.10 \times 10^{-3})^2 (2.40 \times 10^{-2}))}$$ ✓

= 2,930 **OR** 2,931 ✓ At least 3 SF required

Calc value from unrounded values: 2,930.974679

Units

dm^3 mol^{-1} ✓ **DO NOT ALLOW** dm^3 mol$^-$

For units, ALLOW ECF using incorrect K_c expression

Units must match K_c expression used

[5 marks]

K_c = 732.74 → 3 calc marks

× 2 instead of ÷ 2 for concentration

$$\frac{(0.104)^2}{((0.0124)^2 (0.096))}$$

K_c = 112729.8 → 3 calc marks

2.60 × 10^{-2} not squared

$$\frac{(2.60 \times 10^{-2})}{((3.10 \times 10^{-3})^2 (2.40 \times 10^{-2}))}$$

K_c = 3.41... × 10^{-4} Calculator

3.41183432 × 10^{-4}

Inverted K_c → 3 calc marks

$$\frac{((3.10 \times 10^{-3})^2 (2.40 \times 10^{-2}))}{(2.60 \times 10^{-2})^2}$$

Units mol dm^{-3}

6(e)

Level 3 (5–6 marks)

- Reaches a comprehensive conclusion to determine all three correct formulae of D, E AND F
- AND constructs most equations with few errors

There is a well-developed line of reasoning which is clear and logically structured.

The information presented is relevant and substantiated.

Level 2 (3–4 marks)

- Reaches a comprehensive conclusion to determine two correct formulae of D, E AND F
- AND constructs some equations with some errors

There is a line of reasoning presented with some structure.

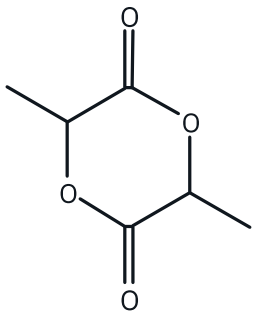
The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Indicative scientific points may include:

Identify of D, E and F

- D: $NiSO_4 \cdot 6H_2O$ **OR** $NiSO_4(H_2O)_6$ **OR** $NiSO_{10}H_{12}$
- E: SO_2
- F: Cyclic diester



OR unsaturated ester/acid

- Determines a correct formula for one of D, E AND F
- AND provides some evidence to support the formula

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks No response or no response worthy of credit.

EQUATIONS SHOULD BE USED TO INFORM THE COMMUNICATION STRAND

See next page for details

CHECK TOP OF QUESTION FOR RESPONSES

IGNORE CONNECTIVITY FOR F

SUMMARY

Setting the level

For Level 3 (5–6 marks),

- All 3 identified: D, E and F
- Most equations

For Level 2 (3–4 marks),

- 2 identified from D, E and F
- 2 equations

For Level 1 (1–2 marks),

- 1 identified from D, E and F
- Evidence

Evidence to support a formula for Level 1

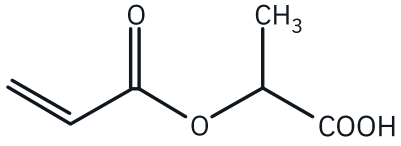
Molar ratios of D

Ni	:	S	:	O	:	H
$\frac{22.33}{58.7}$	:	$\frac{12.20}{32.1}$	:	$\frac{60.87}{16.0}$	:	$\frac{4.60}{1.0}$
0.38	:	0.38	:	3.80	:	4.60
1	:	1		10		12

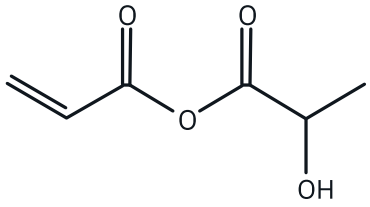
OR $NiSO_{10}H_{12}$

Molar mass of E

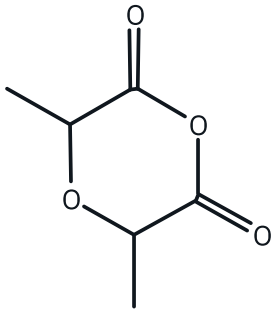
Molar mass = 2.67 × 24 = 64(.08) g mol^{-1}



OR unsaturated acid anhydride



OR cyclic acid anhydride



Equations

$H_2SO_4 + Ni(OH)_2 \rightarrow NiSO_4 + 2H_2O$

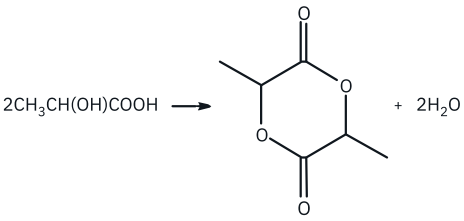
OR

$H_2SO_4 + Ni(OH)_2 + 4H_2O \rightarrow NiSO_4 \bullet 6H_2O$

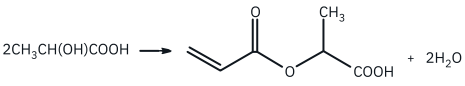
For equation

ALLOW $NiSO_4 \bullet 6H_2O$ ***OR*** *$NiSO_4(H_2O)_6$*

$H_2SO_4 + 2HBr \rightarrow Br_2 + SO_2 + 2H_2O$

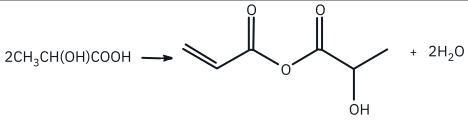


OR



OR

[6 marks]



If structure of F is shown, ALLOW equation using molecular formulae,

e.g. $2C_3H_6O_3 \rightarrow C_6H_8O_4 + 2H_2O$

Q197 · Electrons, bonding and structure · [1 mark]

Answer: **C**

Q198 · Electrons, bonding and structure · [1 mark]

Answer: **B**

$C + O_2 \rightarrow$

Q199 · Electrons, bonding and structure · [15 marks]

OCR MARK SCHEME

1(a)

The ability/tendency of an atom to attract electrons ✓

in a covalent bond ✓

[2 marks]

EXAMINER GUIDANCE

ALLOW 'attraction of an atom for electrons'

ALLOW 'pull' for 'attract'

DO NOT ALLOW 'element' for 'atom'

DO NOT ALLOW ability to attract an electron (i.e. reference to a single electron)

ALLOW 'shared pair' or 'bond(ing) pair' for 'covalent bond'

2nd mark is independent of first mark

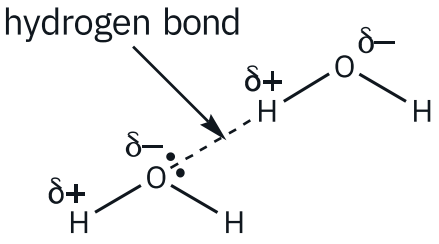
1(b)(i)

Dipole

At least one $H^{\delta+}$ **AND** one $O^{\delta-}$ shown correctly on each water molecule (see diagram) ✓

Hydrogen bonding

H bond between H in one H_2O molecule and lone pair of O in an adjacent H_2O molecule ✓



***IGNORE** lone pairs for first marking point*

All Hydrogen bonds must hit a lone pair.

Hydrogen bond does **NOT** need to be labelled but it must be different from the covalent bond if it is not labelled.

ALLOW H-bond as label

ALLOW only one lone pair on O atom

ALLOW additional, correctly drawn hydrogen bonded water molecules with correct dipoles

[2 marks]

DO NOT ALLOW more than 2 lone pairs on O atom

1(b)(ii)

Dipoles do not cancel out

OR

Has an overall dipole ✓

[1 mark]

ALLOW (Water is) unsymmetrical/ non-symmetrical/ asymmetrical

***IGNORE** polar bonds do not cancel*

***IGNORE** charges uneven/ do not cancel*

1(b)(iii)

(In ice) molecules are held apart by H bonds

OR

(Ice) has an open lattice due to H bonds ✓

[1 mark]

Response must refer to H bonds/bonding

ALLOW spread/spaced out/apart instead of 'held apart'

***IGNORE** length of hydrogen bonds*

DO NOT ALLOW 'atoms' instead of 'molecules'

ALLOW H bonding (in ice) creates gaps in the lattice/ structure/between molecules...

But DO NOT ALLOW if gaps contain 'air'

1(c)(i)

(Ammonia has) weaker hydrogen bonds (than ice/water) ✓

N has one lone pair **AND** O has two

OR

N less electronegative than O ✓

[2 marks]

***ORA** but assume 'it' refers to ammonia*

Answer must be comparative between hydrogen bonding in ammonia and ice

ALLOW Ammonia has less hydrogen bonds

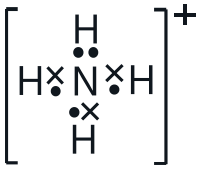
ALLOW response in terms of energy required to break hydrogen bonds e.g. less energy needed to break hydrogen bonds (in ammonia)

DO NOT ALLOW reference to breaking N-H and O-H bonds i.e. covalent bonds

***IGNORE** reference to other intermolecular forces e.g. London forces, dipole-dipole interactions.*

*ALLOW ammonia has one lone pair **AND** water/ice has two*

1(c)(ii)



Bonded pairs

Electron pairs in 3 x N-H covalent bonds shown correctly using dots and crosses ✓

Dative bond

shown with two crosses or two dots ✓

[2 marks]

ALLOW shell circles

***IGNORE** inner shell in N*

Charge and brackets not required

DO NOT ALLOW additional electrons on either N or H for dative bond mark

1(c)(iii)

Reagent and conditions

(Heat with) hydroxide ✓

Observation (Independent mark)

pH/litmus/indicator paper turns blue/purple ✓

[2 marks]

ALLOW NaOH/KOH/$Ca(OH)_2$/OH^-

DO NOT ALLOW Ammonium hydroxide OR ammonia

1(d)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 6.46 (g) or 6.5 (g) award 3 marks

Molar mass $ZnSO_4 \cdot 7H_2O$ = 287.5 ✓

$n(ZnSO_4 \cdot 7H_2O) = \frac{11.5}{287.5}$ OR 0.04 (mol) ✓

$m(ZnSO_4)$ = 0.04 × 161.5 = 6.46 (g) ✓

[3 marks]

ALLOW final answer to at least 2SF

***ALLOW ECF** from incorrect molar mass but not if 161.5 is used (as this is the molar mass of anhydrous)*

***ALLOW ECF** from incorrect number of moles; either multiplied by 161.5 or using alternative approach below*

Alternative approach, finding mass of water, for final mark:

$n(H_2O)$ = 0.04 x 7 = 0.28 (mol)

$m(H_2O)$ = 0.28 x 18 = 5.04 (g)

$m(ZnSO_4)$ = 11.50 – 5.04 = 6.46 (g) ✓

Q200 · Electrons, bonding and structure · [1 mark]

Answer: **D**

Q201 · Electrons, bonding and structure · [1 mark]

Answer: **D**

Only 1

Q202 · Electrons, bonding and structure · [12 marks]

OCR MARK SCHEME

18(a)(i)

FIRST CHECK THE ANSWER ON ANSWER LINE

IF answer = 0.455 award 4 marks

AND IF units = $atm^{1/2}$ award 5 marks

Equilibrium moles ✓

$n\,SO_3 = 1.35$, $n\,O_2 = 0.45(0)$ **AND** n total = 2.7(0)

Partial pressures ✓

$p(SO_3)$	$\frac{1.35}{2.7(0)} \times 2.80$ **OR** 1.4(0)
$p(SO_2)$	$\frac{0.900}{2.7(0)} \times 2.80$ **OR** 0.933
$p(O_2)$	$\frac{0.450}{2.7(0)} \times 2.80$ **OR** 0.467

$$(K_p) = \frac{p(SO_2)\ p(O_2)^{1/2}}{p(SO_3)}$$

OR $(K_p =)\ \frac{(0.933) \times (0.467)^{1/2}}{(1.40)}$ ✓

Answer to 3 SF

$K_p = 0.455$ ✓

Units

Substitution of units into correct K_p expression

$\frac{atm^1 \times atm^{1/2}}{atm^1} = atm^{½}$ ✓

[5 marks]

EXAMINER GUIDANCE

***IF** there is an alternative answer, check for any **ECF** credit possible using working below.*

***ALLOW** 3SF or more unless there is a trailing zero*

e.g. **ALLOW** $p(SO_3)$ = 1.4, n total =2.7

***ALLOW** all marks to be awarded if atmospheres are converted into other pressure units e.g. to kPa.*

***ALLOW** use of fractions for intermediate working*

ALLOW $(K_p) = \frac{(p(SO_2)\ p^{1/2}\ (O_2))}{p(SO_3)}$

ALLOW $K_p^2 = \frac{(p(SO_2)^2 \times p(O_2))}{p(SO_3)^2}$

***IGNORE** [ ] (we are just looking for the calculation)*

***ALLOW ECF** for units of an incorrect K_p expression*

ALLOW $atm^{0.5}$

DO NOT ALLOW $\sqrt{}atm$

Common errors

4 marks

(3 marks for calculation + unit mark)

0.207 (from expression $\frac{(p(SO_2)^2 \times p(O_2))}{p(SO_3)^2}$) Unit: atm

2.20 (from inverted expression) Unit: $atm^{-1/2}$

18(a)(ii)

ΔH is +ve / endothermic (in forward direction).

AND

(At higher temperature,) equilibrium shifts to right hand side ✓

***ORA** throughout*

***ALLOW** towards the products for right hand side*

***ALLOW** increases yield of products*

(T_2) has greater K_p value

OR $7.7 \times 10^{-2} > 3.3 \times 10^{-5}$ ✓

DO NOT ALLOW *T_1 has greater K_p value*

[2 marks]

18(a)(iii)

One mark per correct row ✓✓

Change	Decrease	No change	Increase
No catalyst		✓	
Increased pressure		✓	

[2 marks]

18(b)(i)

There are 3 bonding regions

OR 3 <u>double bonds</u> (round the S atom).

ALLOW *electron regions / areas of <u>electron density</u>*

ALLOW *- It has a resonance structure with all 3 bonds being the same/inbetween a single and double bond* ***OR*** *has 3 σ bonds.*

DO NOT ALLOW *bonding pairs*

[1 mark]

18(b)(ii)

S/Sulfur and O/Oxygen have different electronegativities (and S–O bonds are polar) ✓

(SO_2 lone pair gives) non-linear shape / asymmetrical **AND** dipoles don't cancel / dipoles do not act in opposite directions

OR

uneven electron charge density **AND** dipoles don't cancel ✓

ALLOW *if partial charges are seen on diagram.*

DO NOT ALLOW *sulfur is more electronegative than oxygen*

For non-linear, **ALLOW** bent **OR** v-shaped

IGNORE *shapes seen in diagrams, treat as rough working*

IGNORE *polar bonds cancel*

IGNORE *polarity cancels*

DO NOT ALLOW *charges cancel*

ORA

e.g.

SO_3 trigonal planar

shape/symmetrical **AND** dipoles cancel / dipoles act in opposite

[2 marks]

directions

OR

even electron charge density **AND** dipoles cancel

Q203 · Electrons, bonding and structure · [1 mark]

Answer: **B**

The hydrogen bonding between water molecules.

Q204 · Electrons, bonding and structure · [1 mark]

Answer: **C**

The induced dipole–dipole interactions (London forces) become stronger.

Q205 · Electrons, bonding and structure · [1 mark]

Answer: **B**

x: Trigonal planar · y: Tetrahedral

Q206 · Electrons, bonding and structure · [1 mark]

Answer: **A**

H_2S

Q207 · Electrons, bonding and structure · [1 mark]

Answer: **C**

OCR MARK SCHEME

11

EXAMINER GUIDANCE

ALLOW 11

Q208 · Electrons, bonding and structure · [1 mark]

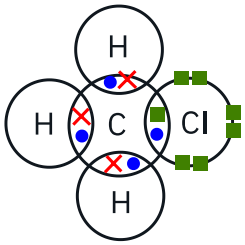
Answer: **B**

BCl_3

Q209 · Electrons, bonding and structure · [16 marks]

OCR MARK SCHEME

5(a)(i)



EXAMINER GUIDANCE

Circles are **NOT** required

IGNORE *inner shells*

ALLOW *non-bonding electrons unpaired*

Must have three different symbols (one for C, another for H and another for Cl)

✓

Check that lone pairs on Cl are included

Cl has 6 non-bonded electrons (3 LPs)

[1 mark]

e.g.

● = C electron
× = H electron
▨ = Cl electron

5(a)(ii)

Tetrahedral ✓

109.5° ✓

[2 marks]

ALLOW *109 to 110°*

5(b)

Bond Angle

120° ✓

Number of bonded regions

CH_3Cl has 4 bonded pairs (of electrons)

AND

$H_2C=CHCl$ has 3 bonded regions ✓

Electron pair repulsion (seen anywhere)

Electron pairs/bonded pairs repel (as far apart as possible) ✓

Electron pairs/bonded pairs essential

DO NOT ALLOW *'bonded atoms' for this mark*

[3 marks]

ALLOW *116-124°*

IGNORE *names of shapes (even if wrong)*

ALLOW *bp for bonded/bonding pair (of electrons)*

Bonded/Bonding is essential

ALLOW *for CH_3Cl/chloromethane:*

- 4 bonded areas/environments/regions
- 4 bonded groups/atoms

ALLOW *for $H_2C=CHCl$/chloroethene:*

- 2 bonded pairs and 1 double bond
- 2 bonded pairs and 1 bonded area/environment/region
- 3 bonded groups/atoms

IGNORE *areas of electron density*

ALLOW *alternative phrases/words for 'repel' e.g. 'push apart'*

DO NOT ALLOW *'atoms repel'*

IGNORE

- electrons repel
- bonds repel
- electron region **OR** electron density repel
- lone pairs repel (more) (irrelevant here)

5(c)

Level 3 (5–6 marks)

Describes ALL purification steps in correct order

AND

Explains MOST purification steps

AND

Calculates correct mass of $CH_3CH_2CHClCH_3$

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Describes ALL the purification steps

AND

Explains SOME purification steps.

OR

Describes **AND** explains a purification step

AND

Calculates correct mass of $CH_3CH_2CHClCH_3$

OR

Describes MOST purification steps

AND

Calculates mass of $CH_3CH_2CHClCH_3$ with some errors

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Describes MOST purification steps

OR

Describes **AND** explains a purification step.

OR

Calculates a mass of $CH_3CH_2CHClCH_3$ with some errors

OR

Describes a purification step **AND** attempts calculation of mass

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

Indicative scientific points may include:

Main purification steps

- Use a separating funnel
- Add anhydrous salt (to organic layer)
- Distillation

Explanations for each purification step

- Separating funnel to separate the organic layer from aqueous layer

AND Organic layer is the top layer

- Dry (the organic layer) with an anhydrous salt

OR Dry with $MgSO_4$ or $CaCl_2$

- Collect fraction at 70°C to separate product from unreacted reactants/side products

IGNORE *washing with carbonate/water*

not in spec.

Calculation of mass of $CH_3CH_2CHClCH_3$

Using moles method:

- $n\,(CH_3CH_2CHOHCH_3) = \frac{9.25}{74}$

= 0.125 (mol)

- moles of $CH_3CH_2CHClCH_3$ for 65% yield

= 0.125 × 0.65 = 0.08125 (mol)

- mass for 65% yield = 0.08125 x 92.5

= 7.52 g (3 sf)

Calculator value: 7.51625 g

Using mass method:

No response or no response worthy of credit.

[6 marks]

- $n(CH_3CH_2CHOHCH_3) = \frac{9.25}{74}$

= 0.125 (mol)

- mass if 100% yield $CH_3CH_2CHClCH_3$ = 0.125 × 92.5

= 11.5625 g

- mass for 65% yield = 11.5625 x 0.65

= 7.52 g (3 sf)

CHECK for extent of errors by **ECF**

ALLOW *3SF up to calculator value throughout*

TAKE CARE: values shown may be truncated calculator values.

ALLOW *for correct calculation, one small slip e.g using M_r of 73 instead of 74 or a rounding error*

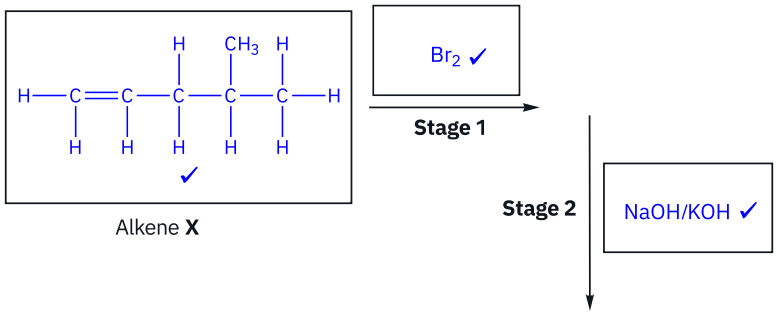
Aspects of the communication statement might typically have been met when:

- All information given is correct and relevant using appropriate scientific language
- Purification steps are described in a logical order
- Calculations are set out in a clear and logical way
- No small slips/rounding errors
- Final value for mass given to an appropriate number of significant figures/decimal places.

5(d)(i)

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

CHECK alkene carefully for correct number of Hs or missing CH_3 group.



[3 marks]

ALLOW *names for reagents e.g. bromine if formula not given*

DO NOT ALLOW *other additional reagents*

IGNORE *conditions e.g. reflux, heat*

IGNORE *solvent*

For Stage 2:

ALLOW *$OH^-(aq)$* ***OR*** *any other hydroxide*

ALLOW *H_2O but* ***DO NOT ALLOW*** *steam*

5(d)(ii)

Nucleophilic substitution ✓

[1 mark]

DO NOT ALLOW *hydrolysis*

Q210 · Electrons, bonding and structure · [17 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

16(a)(i)

S higher than P

AND

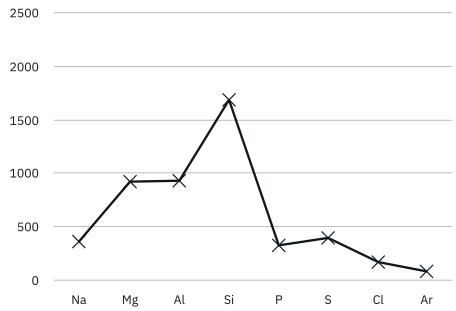
P higher than Cl

AND

Cl higher than Ar ✓

All points / line below the height of Mg ✓

[2 marks]



16(a)(ii)

Al giant (metallic) **AND** Si giant (covalent) ✓

Al metallic **AND** Si covalent ✓

Covalent bonds (in Si) stronger / more energy needed to break covalent bonds (than metallic in Al) ✓

[3 marks]

ALLOW *macromolecular for Si*

ALLOW *correct description of each bonding type*

CON if intermolecular forces are compared in Al

16(b)(i)

$S(g) \rightarrow S^+(g) + e^-$ ✓

[1 mark]

IGNORE *state symbols on the electron*

16(b)(ii)

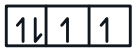
Paired electrons in (p-) orbital / sub shell (in S) ✓

Repulsion (between the paired electrons) ✓

ALLOW *if seen in a diagram*

i.e.

[2 marks]



ALLOW *2 electrons in an (p-) orbital*

DO NOT ALLOW *shell alone*

DO NOT ALLOW *s-orbital*

IGNORE *distance from nucleus*

16(c)

(aqueous bromine + sodium iodide)

(Orange solution) turns brown ✓

(aqueous bromine + sodium chloride)

Stays orange ✓

$Br_2 + 2I^- \rightarrow 2Br^- + I_2$ ✓

[3 marks]

ALLOW *one mark for only final colours*

ALLOW *shade of brown for dilute* I_2

DO NOT ALLOW *purple*

DO NOT ALLOW *incorrect colour for aqueous bromine*

ALLOW *shade of orange for dilute* Br_2

ALLOW *No colour change*

IGNORE *No reaction / No change*

DO NOT ALLOW *turns orange*

ALLOW *multiples, e.g.* $\frac{1}{2}Br_2 + I^- \rightarrow Br^- + \frac{1}{2}I_2$

IGNORE *state symbols*

IGNORE *half-equations, even if wrong*

16(d)

Level 3 (5–6 marks)

For all three molecules:

correct dot and cross diagrams drawn

AND correct shapes

AND correct trend of bond angles

AND an explanation of electron pair repulsion on shape

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

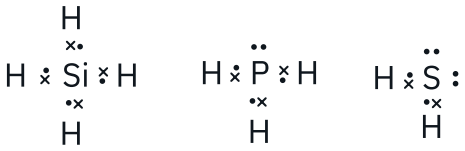
For two molecules:

correct dot and cross diagrams drawn

AND correct shapes

Indicative scientific points may include:

Dot and cross diagrams



Shapes

SiH_4 tetrahedral

PH_3 (trigonal) pyramidal

H_2S v-shaped / bent / angular / non-linear

IGNORE *planar / 'not straight'*

Trend of bond angles

AND correct trend of bond angles

AND an explanation of electron pair repulsion on shape

OR

For all three molecules:

One correct and three attempts from:

dot cross diagrams

shapes

trend in bond angles

explanation of electron pair repulsion on the shapes

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

For one molecule:

correct dot and cross diagram drawn

AND correct shape

AND an explanation of electron pair repulsion on shape or any molecule

OR

For two molecules:

correct dot and cross diagrams

OR correct shapes

OR an explanation of electron pair repulsion on shape

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

Bond angles in the order (numerical bond angles are not required)

$SiH_4 > PH_3 > H_2S$

$SiH_4 = 109.5° > PH_3$ (less than 109.5) > H_2S (less than PH_3) > 90°

Explanation of bond angles

SiH_4 Four bonding pairs (no lone pairs)

PH_3 Three bonding pairs one lone pair

H_2S Two bonding pairs two lone pairs

Electron pairs repel

Lone pairs repel more than bonding pairs

ALLOW *lp for lone pair (of electrons)*

ALLOW *bp for bonding pair (of electrons)*

ALLOW *regions for electron pairs (electron pairs seen in diagram)*

IGNORE *electron density*

IGNORE *'bonds' for 'bonded pair'*

IGNORE *'electrons repel'*

DO NOT ALLOW *'atoms repel'*

[6 marks]

Q211 · Electrons, bonding and structure · [1 mark]

Answer: **C**

The strength of the induced dipole–dipole interactions (London forces) increases.

Q212 · Electrons, bonding and structure · [1 mark]

Answer: **C**

NCl_3

Q213 · Electrons, bonding and structure · [1 mark]

Answer: **B**

Hydrogen bonds hold H_2O molecules apart in ice.

Q214 · Electrons, bonding and structure · [1 mark]

Answer: **A**

Al

Q215 · Electrons, bonding and structure · [19 marks]

OCR MARK SCHEME

16(a)

(The mean/average mass) taking into account the relative abundancies of the isotopes ✓

[1 mark]

EXAMINER GUIDANCE

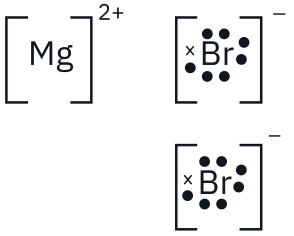
ALLOW

sum of (isotopic mass × %abundance)

sum of $\frac{\text{(isotopic mass} \times \text{abundance)}}{\text{total abundance}}$

DO NOT ALLOW *average mass of the isotopes*

16(b)(i)



Mg with no (or 8) outer electrons

AND

2 × Br with '*dot-and-cross*' outer octet ✓

Correct charges ✓

[2 marks]

ALLOW *8 electrons in Mg^{2+} BUT 'extra' electron in Br^- must match symbol for electrons in Mg^{2+}*

IGNORE *inner shells and circles*

ALLOW *1 mark if both electron arrangements and charges are correct but only one Br is drawn.*

ALLOW *$2[Br^-]$, $2[Br]^-$ (brackets not required)*

16(b)(ii)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 1.71×10^{22} award 3 marks

$n(MgBr_2) = \frac{1.74}{184.1} = 0.00945.....$ mol ✓

Moles of ions = 0.00945.... × 3 = 0.0283.... mol ✓

Number of ions = 0.0283... × 6.02×10^{23} = 1.71×10^{22} ✓

ALLOW ECF

Calculator answer = $9.451385117 \times 10^{-3}$

ALLOW ECF *from incorrect moles of ions.*

e.g. 0.00945

Common error

3SF required

[3 marks]

5.69×10^{21}	no × 3	2 marks

16(c)

Level 3 (5–6 marks)

Explains all three melting point values and conductivities in terms of structure, bonding, particles and relative strengths of the forces.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Attempts to explain all three melting point values and conductivities in terms of the structure, bonding, particles of all three substances, but explanations may be incomplete or may contain only some correct statements or comparisons.

OR

Correctly explains two of the melting point values and conductivities in terms of the structure, bonding, particles.

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Identifies only some of the structures, forces and particles

AND

Attempts to explain the melting point values **OR** conductivities in terms of the structure, bonding, particles

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

Indicative scientific points may include:

Structure and bonding

Magnesium

- Structure: giant lattice
- Metallic bonding
- Delocalised electrons

Bromine

- Structure: simple molecular
- induced dipole dipole forces (London forces)
- (Between) molecules

DO NOT ALLOW *(between) atoms*

Magnesium bromide

- Structure: giant lattice
- Ionic bonding
- (Between) oppositely charged ions

Comparison of bond strengths

- Metallic and ionic bonds are stronger than London forces

OR Metallic and Ionic bonds need more energy to break than London forces

Conductivity

- Magnesium: conducts due to delocalised electrons can move/mobile.

IGNORE *'Carry' charge for movement*

- Magnesium bromide: In solid IONS cannot move; in solution IONS can move.

DO NOT ALLOW *electrons.*

- Bromine: Does not conduct as no mobile charge carriers.

16(d)(i)

$Mg^{2+}(g) + 2Br(g) + 2e^{-}$ ✓

$Mg(s) + Br_2(l)$ ✓

State symbols required.

CARE: Liquid state symbol for Br_2

[2 marks]

16(d)(ii)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = –346.5 award 2 marks

$2\Delta H$ hyd =

–525 – 186 – (2 x 112) – 148 – 736 – 1450 + (2 x -325) + 1926

OR

–525 – 186 – 224 – 148 – 736 – 1450 + 650 + 1926

OR

= –693 ✓

ΔH hyd = –346.5 (kJ mol^{-1}) ✓

ALLOW -347 *(kJ mol^{-1}) for 2 marks.*

ALLOW *for 1 mark ONE error with sign* ***OR*** *use of 2:*

–693 (not divided by 2 at the end)

346.5 (wrong sign on answer)

Common errors for 1 mark

–2272.5 (–1926 instead of 1926)

-1386 (2 x -693 instead of -693)

–996.5 (–650 instead of 650)

–509 (2 × 325 not used)

–290.5 (2 × 112 not used)

–198.5 (148 instead of –148)

–160.5 (186 instead of –186)

–122.5 (224 instead of –224)

178.5 (525 instead of –525)

389.5 (736 instead of –736)

1103.5 (1450 instead of –1450)

For other answers, check for a single transcription error or calculation error which could merit 1 mark

DO NOT ALLOW *any answer which involves two errors*

e.g. –453 (2 × 325 not used **AND 2 x** 112 not used)

[2 marks]

16(d)(iii)

Equation: $Mg^{2+}(g) + 2Br^{-}(g) \rightarrow MgBr_2(s)$ ✓

CHECK THE ANSWER ON ANSWER LINE

If answer = –2433 award 2 marks

State symbols required

For other answers, check for a single transcription error or calculation error which could merit 1 mark

Lattice enthalpy =

$\Delta_{hy}H(Mg^{2+}) + 2 \times \Delta_{hy}H(Br^{-}) - \Delta_{sol}H(MgBr_2)$ **OR**

-1926 + (2 x -346.5) – (-186)

OR

$\Delta_fH(MgBr_2) - 2\Delta_{at}H(Br) - \Delta_{at}H(Mg) - 1st\ IE(Mg) - 2nd\ IE(Mg) - 2\Delta_{ea}H(Br)$ **OR**

-525 – (2 x 112) – 148 – 736 – 1450 – (2 x -325) ✓

Lattice enthalpy = –2433 kJ mol^{-1} ✓

[3 marks]

DO NOT ALLOW *any answer which involves two errors*

ALLOW ECF *from incorrect answer to d(ii)*

Q216 · Electrons, bonding and structure · [1 mark]

Answer: **A**

Cr atoms have the electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$.

Q217 · Electrons, bonding and structure · [1 mark]

Answer: **C**

sodium chloride

Q218 · Electrons, bonding and structure · [1 mark]

Answer: **B**

ethanol

Q219 · Electrons, bonding and structure · [1 mark]

Answer: **A**

δ^- N—I δ^+

Q220 · Electrons, bonding and structure · [1 mark]

Answer: **D**

phosphorus

Q221 · Electrons, bonding and structure · [11 marks]

OCR MARK SCHEME

1(a)(i)

(Electrostatic) attraction between oppositely charged ions ✓

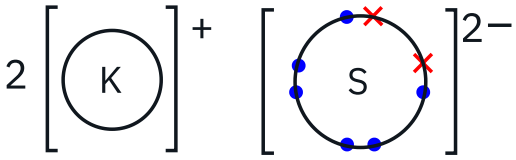
[1 mark]

EXAMINER GUIDANCE

IGNORE *force*

IGNORE *references to transfer of electrons*

1(a)(ii)



Dot and cross

2 × K shown with either 8 or 0 electrons

AND

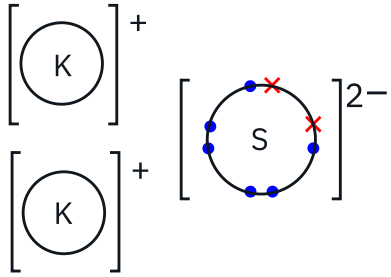
S shown with 8 electrons with 2 crosses and 6 dots (or vice versa) ✓

Charges

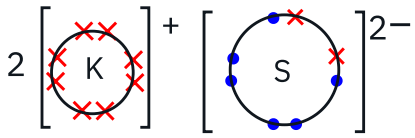
Correct charges on K^+ **AND** S^{2-} ions ✓

[2 marks]

ALLOW *separate* K^+ *ions, i.e.*



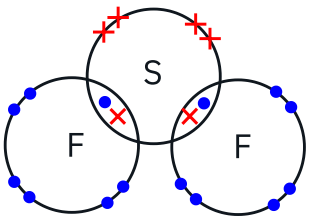
If 8 electrons are shown around K, 'extra electrons' around S must match symbol chosen for electrons around K, e.g.



Shell circles **NOT** needed

IGNORE *inner shell electrons*

1(b)



Bonded pairs

Electron pairs in covalent bonds shown correctly using dots and crosses in SF_2 molecule ✓

Lone pairs

Lone pairs correct on S and 2 F atoms ✓

[2 marks]

Shell circles **NOT** needed

IGNORE *inner shells*

ALLOW *Non-bonding electrons shown as unpaired*

1(c)

ALLOW *induced* ***OR*** *permanent dipole interactions*

K_2S: ionic bonds are strong

OR has a giant ionic lattice ✓

SF_2: London forces/ dipole-dipole forces are weak ✓

between molecules ✓

ALLOW *intermolecular forces are weak for 2 marks for* SF_2

IGNORE *van der Waals forces, vdW*

[3 marks]

1(d)(i)

Octahedral ✓

90° ✓

[2 marks]

1(d)(ii)

SF_6 has no overall dipole **OR** is non polar

OR S–F bonds are strong

OR SF_6 has no lone pairs ✓

[1 mark]

Q222 · Electrons, bonding and structure · [1 mark]

Answer: **C**

The attraction of a bonded atom for the electrons in a covalent bond.

Q223 · Electrons, bonding and structure · [1 mark]

Answer: **D**

OCR MARK SCHEME

Only 1

EXAMINER GUIDANCE

Accept 1

Q224 · Electrons, bonding and structure · [1 mark]

Answer: **B**

Only 1 and 2

Q225 · Electrons, bonding and structure · [1 mark]

Answer: **C**

$CH_3COOCH_2CH_2CH_3$

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