Access Tuition

A-Level Chemistry

Ideal Gas Equation

Mark Scheme

Time available: 64 minutes
Marks available: 56 marks

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Mark schemes

1. (a) ***METHOD 1***

Stage 1

M1 $n = \frac{PV}{RT}$

1

M2 converting P to 51.0 x 10^3, V to 482 x 10^{-6}

1

M3 $\frac{51.0\,x\,10^3 \quad x \quad 482\,x\,10^{-6}}{8.31 \quad x \quad 297} \; (= \; 0.00996)$

1

Stage 2

M4 converting mass to 0.717

1

M5 $M_r \left(= \frac{mass}{moles}\right) = \frac{\mathbf{M4}}{\mathbf{M3}}$ = 72.0 (at least 2 sf)

1

METHOD 2

M1 $n = \frac{PV}{RT}$

M2 $M_r = \frac{mRT}{PV}$

M3 converting P to 51.0 x 10^3, V to 482 x 10^{-6}

M4 converting mass to 0.717

M5 $M_r = \left(\frac{0.717 \quad x \quad 8.31 \quad x \quad 297}{51.0\,x\,10^3 \quad x \quad 482\,x\,10^{-6}}\right)$ = 72.0 (at least 2 sf)

Both methods:

72.0 can be achieved with incorrect working and may not score because individual steps need to be assessed as correct

72.0 with no working scores no marks

*If expression not written out, **M1** could score from a substituted correct expression later on (even if any unit conversions are incorrect)*

METHOD 1

- *ECF from **M2** to **M3***
- *ECF from **M3** to **M4***
- *ECF from **M4** to **M5***
- *Ignore units for **M3***

METHOD 2

- *ECF from **M3** to **M4***
- *ECF from **M2** to **M4***
- *ECF from **M4** to **M5***

(b) **M1** amount of CO_2 formed in flask = 0.008 mol

*Allow ECF from **M1** to **M2***

1

M2 amount of gas in flask

= 0.0075 (O_2) + 0.0080 (**M1**) = 0.0155 mol

1

[7]

2. (a) **M1** n = pV / RT

***M1** for rearrangement*

M2 $n = \frac{100000 \times (178/1000000)}{8.31 \times (273 + 120)}$

***M2** for three unit conversions*

M3 n = 5.45×10^{-3} mol

M_r = mass/mol or $0.460 / 5.45 \times 10^{-3}$

***M3** for calculating the amount in moles of A*

M4 M_r = <u>84.4</u> Answer must be to 3 sig.fig.

***M4**: 0.460 / **M3** given to 3sf*

4

(b) Calculated *Mr* value would be greater than actual

Mr = mass / moles so dividing by too small a value of moles gives a larger Mr than expected.

1

A lower volume would have been recorded / mass evaporated less than mass of liquid / lower moles calculated / mass recorded higher than mass of gas / mass recorded would be too high

M2** dependent on correct **M1

1

(c) % uncertainty = (uncertainty / mass added) x 100

= ((2 x 0.001) / 0.460} x 100 = 0.435%

1

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3. (a) **M1** Amount of $S_2O_3^{2-}$ = $\frac{9.00 \times 0.0800}{1000}$ = 7.20×10^{-4} mol

1

(From equations mol $S_2O_3^{2-}$ = mol Cu^{2+})

M2 Amount of Cu^{2+} in 25 cm^3 = 7.20×10^{-4} mol

***M2** = answer to **M1** (1:1 ratio)*

1

M3 Amount of Cu^{2+} in 250 cm^3 = 7.20 v 10^{-4} **× 10** = 7.20×10^{-3} mol

***M3** = **M2** × 10*

1

M4 Mass of copper = 7.20×10^{-3} mol **× 63.5** = 0.457 g

***M4** = **M3** × 63.5*

1

M5 mass = 0.985 g

***M5** converting 985 mg to g*

1

M6 % Cu = $0.457 \times \frac{100}{0.985}$ = 46.4 %

M6** is for the answer to **3 sf

*Allow % Cu = $457 \times \frac{100}{985}$ = 46.4 % for **M5** and **M6***

*Allow (**M4** ×1000)/985 v 100 for **M5** and **M6***

1

(b) Use more of the alloy

1

Use a lower concentration of the thiosulfate solution/lower mass of $Na_2S_2O_3$ to make solution

1

(c) Oxidizing agent

Allow electron acceptor

1

(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$

Do not allow [Ar]3d ^{9}

1

(e) Full (3)d (sub)shell or $(3)d^{10}$

1

No (d-d) transitions possible/ cannot absorb visible/white light

M2** is dependent on **M1

Ignore reflects visible/white light

1

(f) **M1**: n = (5.00/253.8) = 0.0197 mol

Allow 254

*If 126.9 or 127 used lose **M1** only*

1

M2: T = 458 K and P = 100 000 Pa

1

M3 $V = \frac{nRT}{P}$ or $\frac{0.0197 \times 8.31 \times 458}{100\ 000}$ or 7.50×10^{-4} (m^3)

M3** If rearrangement incorrect can only score **M1** and **M2

1

M4: V = 750 (cm^3)

***M4**: Allow **M3** × 10^6*

***M4**: Allow 749*

1

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4.

This question is marked using Levels of Response. Examiners should apply a 'best-fit' approach to the marking.	
Level 3 5-6 marks	All stages are covered and the explanation of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and then stage 3. Coherent communication requires that there is a comparison between the types of bonding and that the bonding is correct for each substance.
Level 2 3-4 marks	All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete. Answer is mainly coherent and shows some progression from stage 1 to stage 2 and then stage 3.
Level 1 1-2 marks	Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR only one stage is covered but the explanation is generally correct and virtually complete. Answer shows some progression between two stages
Level 0 0 marks	Insufficient correct chemistry to gain a mark.

Indicative chemistry content. Contradictions (eg molecules, IMFs, covalent bonding,) negate statements.

Stage 1 - **Na**
1a) Na has metallic bonding
1b) there is attraction/ bonding between the positive nucleus/ ion and the delocalised electrons in Na
1c) Na has a giant/lattice structure

Stage 2 – **NaBr or NaI**
2a) Ionic bonding in NaBr and/or NaI
2b) There is attraction/ bonding between the + and – ions in NaBr and/or NaI
2c) NaBr and/or NaI have a giant/lattice structure

Stage 2 – **comparison of bonding**
3a) The ionic bonds are stronger (or wtte) than the metallic bonds
3b) there is stronger attraction (or wtte) between the + and – ions in NaBr than in NaI
3c) since the Br^- ion is smaller than the I– ion

6

(b) **M1** $Na + H_2O \rightarrow NaOH + ½ H_2$

Allow multiples

1

M2 (Mass Na = 0.250 g so moles Na = 0.250/23.0) = 0.0109

CE: If not divided by 23, max 3/5 calculation marks – M3, M4 and M5

AE: If not divided by 1000 and final answer is 1.33×10^5 cm^3 4/5

1

M3 moles $H_2 = 5.43 \times 10^{-3}$ to 5.45×10^{-3}

M3 = M2 /2

CE: If incorrect ratio used max 3/5 calculation marks – M2, M4 and M5

1

M4 T = 298 (K) and P = 101000 (Pa)

1

M5 V = nRT/P or $(5.435 \times 10^{-3} \times 8.31 \times 298)/101000$ or 1.33×10^{-4} (m^3)

1

M6 V = 133 – 134 cm^3

Allow to 2 significant figures or more

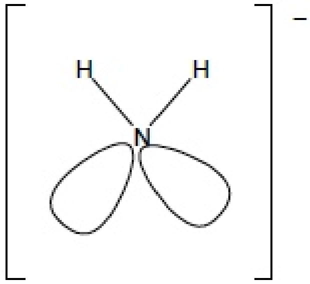
1

(c) Conc = $0.0109/ 500 \times 10^{-3}$ = 0.0217-0.022 (mol dm^{-3})

Allow M2 from question (b)

1

(d) **M1**



Ignore charge and brackets

1

M2 104.5°

Allow 104-106

1

M3 (4) electron pairs repel to be as far apart as possible

1

M4 lp/lp repulsion> lp/bp repulsion (> bp/bp repulsion)

For M4 allow lone pairs repel more than bonding pairs

Mark independently

1

[16]

5. (a) **Stage 1**

M1 $n = \frac{PV}{RT}$

1

M2 $= \frac{102 \times 10^3 \times 72 \times 10^{-6}}{8.31 \times 373}$

1

M3 = 0.0024 / 0.00237 / 0.002369 / 0.0023693 ..

1

Stage 2

M4 $M_r (= \frac{\text{mass}}{\text{moles}}) = \frac{0.194}{\textbf{M3}}$

1

M5 = 82 (**<u>2sf only</u>**)

1

*As this is an extended response question, each separate step of correct working is required in **M1–M5***

Correct answer with no working scores 2 marks

***M1** – If expression not written out, **M1** could score from a correct expression for **M2** (even if unit conversions are not correct for **M2**)*

M2** – allow an expression that gives correct value for **M3

***M3** should be <u>at least</u> 2sf (do not allow 0.0023 but do allow 0.00236)*

***M4** must show 0.194 or 194 × 10^{-3} in working to score*

***M5** must be 2sf*

ECF:

- *No ECF within either stage 1 or stage 2 (except for transcription errors)*
- *Allow ECF from stage 1 into stage 2, i.e for **M4** and **M5** based on incorrect **M3**, (but if expression for **M4** is inverted, cannot score **M5**)*
- *(Note that if 72 × 10^{-3} used in **M2**, then **M3** = 2.4, **M5** = 0.082)*

*Ignore units for **M3** and **M5***
*Note that if T = 273 + 373 = 646, **M5** = 140 (2sf)*

(b) **M1** dividing %s by relative atomic masses
C = 83.7/12(.0), H = 16.3/1(.0) **1**

M2 converting (C : H 6.975 : 16.3) to 3 : 7 **1**

M3 empirical formula = C_3H_7 **1**

M4 molecular formula = C_6H_{14} **1**

***M1** & **M2** are for working*

***M3** for C_3H_7 only, marked independently*

***M4** for C_6H_{14} only, marked independently (ignore additional correct structures)*

*Formulae with no working cannot score **M1** or **M2***

Alternative method:
***M1** working that shows 83.7% of 86 is 72*
***M2** idea of 72/12 gives 6 C atoms*

Alternative method:
*working that shows that C_6H_{14} (or C_3H_7) contains 83.7% C scores **M1** & **M2***

[9]