A-Level Chemistry

The Mole and Avogadro's Constant

Mark Scheme

Time available: 52 minutes
Marks available: 48 marks

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Mark schemes

1. (a) **M1** $n(S_2O_3^{2-}) = 33.50 \times 0.100 \div 1000 = \underline{0.00335}$

1

M2 $n(I_2) = 0.00335 \div \mathbf{2} = 0.001675$ (from eqn 2)

M2 = M1÷2

1

M3 $n(ClO^-)$ in 25 cm^3 pipette = 0.001675 (from eqn 1)

M3 = M2

1

M4 $n(ClO^-)$ in 100 cm^3 flask = 0.001675 **x 4** = 0.00670 = n(NaClO) in original 10 cm^3 sample

M4 = M3 x 4

1

M5 mass (NaClO) = 0.00670 x 74.5 = 0.499 g

M5 = M4 x 74.5

1

M6 mass (bleach) = 10.0 x 1.20 = <u>12</u> g

M6 = mass of bleach

1

M7 % by mass of NaClO = $\dfrac{0.499}{12}$ = 4.16 %

M7 = (M5÷M6) x 100 to 3 significant figures
Allow 4.15% to 4.17%

1

(b) 0.45%

1

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2. (a) Selects correct titres

If 3 or more titres used them MAX 1 for conseq M3

1

mean titre = $\dfrac{9.75 + 9.65}{2}$

= 9.7(0) cm^3

Calculates mean

1

mol HCL = 0.102 × 9.70/1000 = 9.89 × 10^{-4}
(allow 9.9 × 10-4 for M3 but check not via 4 titres in which case only 1 mark)

Calculates mol (working or result gains credit)

9.92 × 10^{-4} scores 1 if all 4 titres used

9.83 × 10^{-4} scores 1 if titres 1,2, and 3 used

1

(b)   mol $MHCO_3$ = ANS 3.1 × 10 (= 9.89 × 10^{-3})

              Use ecf if wrong mean calculated above

1

$$Mr = \frac{1464/1000}{M1}$$

1

Mr = 148 (3sf)

              Allow ecf following wrong mass conversion

1

(c)   Suggestion: Use a larger mass of solid OR use a more
concentrated solution of $MHCO_3$ OR less concentrated / more dilute
solution of HCl OR more $MHCO_3$

1

              *Cannot score justification mark unless suggestion correct, but
suggestion could be after justification*

Justification: So a larger titre/reading will be needed OR larger volume of HCl

              Assume reference to the solution means the MHCO$_3$

1

(d)   This question is marked using levels of response.

Level 3
Must use volumetric flask to access level 3
Answer is communicated coherently and shows a logical
progression from stage 1 to stage 2 then stage 3.

All stages are covered and the description of each stage is complete

6 marks

All stages are covered but up to 2 omissions/errors from different
stages. If 2 omissions/errors from same stage only level 2 possible

5 marks

Level 2
Answer is mainly coherent and shows progression from stage 1 to
stage 3

All stages are covered but 3 omissions/errors

4 marks

All stages are attempted

3 marks

Level 1

Answer includes isolated statements but these are not presented in
a logical order or show confused reasoning.

2 stages attempted

2 marks

1 stage attempted

1 mark

Level 0

Insufficient correct chemistry to gain a mark.

0 marks

> *Indicative Chemistry content*
>
> *Stage 1: transfers known mass of solid*
>
> *a) Weigh the sample bottle containing the solid on a (2 dp) balance*
>
> *b) Transfer to beaker* and reweigh sample bottle*
>
> *c) Record the difference in mass*
>
> *Or*
>
> *d) Place beaker* on balance and tare*
>
> *e) Transfer solid into beaker*
>
> *f) Record mass*
>
> *Or*
>
> *g) Known mass provided*
>
> *h) Transfers (known) mass into beaker**
>
> *i) Wash all remaining solid from sample bottle into beaker*
>
> *Allow use of weighing boat*
>
> **Allow other suitable glassware including volumetric flask*
>
> *Stage 2: Dissolves in water*
>
> *a) Add distilled / deionised water*
>
> *b) Stir (with a glass rod) or swirl*
>
> *c) Until all solid has dissolved*
>
> *Stage 3: Transfer, washing and agitation*
>
> *a) Transfer to <u>volumetric / graduated</u> flask. Allow if a clear
> description/diagram given eg long necked flask with 250 cm^3 mark*
>
> *b) With washings*
>
> *c) Make up to 250 cm^3 / mark with water*
>
> *d) Shakes/inverts/mixes*

6

[14]

3. (a)

Method 1   Method 2

Mass of H_2O = 4.38−2.46   Percentage of H_2O = 44%

(= 1.92 g)

If there is an AE in M1 then can score M2 and M3

If M_r incorrect can only score M1

1

| ZnSO$_4$ | H$_2$O | | ZnSO4 | H2O |

ZnSO$_4$ H$_2$O   ZnSO4   H2O

2.46   1.92   56   44

161.5   18   161.5   18

1

(0.0152   0.107)   (0.347   2.444)

(1   :   7)   (1   :   7)

x = 7   x = 7

If x = 7 with working then award 3 marks.

Allow alternative methods.

If M1 incorrect due to AE, M3 must be an integer.

1

(b)   Moles HCl = 0.12(0)

1

mol ZnCl$_2$ = 0.06(0) **OR** 0.12 / 2

1

If M2 incorrect then CE and cannot score M2, M3 and M4.

mass ZnCl$_2$ = 0.06 × 136.4

Allow 65.4 + (2 × 35.5) for 136.4

1

= 8.18(4) (g) **OR** 8.2 (g)

Must be to 2 significant figures or more.

Ignore units.

1

(c)   Moles ZnCl$_2$ = $\dfrac{10.7}{136.4}$ (= 0.0784)

1

OR moles Zn = 0.0784

Mass Zn reacting = 0.0784 × 65.4 = (5.13 g)

M2 is for their M1 × 65.4

1

$$\% \text{ purity of } Zn = \frac{5.13}{5.68} \times 100$$

M3 is M2 × 100 / 5.68 provided M2 is < 5.68

1

= <u>90.2</u>% **OR** <u>90.3</u>%

Allow alternative methods.

M1 = Moles $ZnCl_2$ = <u>10.7</u> (= 0.0784)
             136.4

M2 = Theoretical moles Zn = <u>5.68</u> (= 0.0869)
                  65.4

M3 = M1 × 100 / M2 = (0.0784 × 100 / 0.0869)

*M4 = <u>90.2%</u> **OR** <u>90.3%</u>*

1

(d)   Ionic

If not ionic CE = 0/3

1

<u>Strong</u> (electrostatic) <u>attraction</u> (between ions)

1

between oppositely charged ions / + and − ions / F^- and Zn^{2+} ions

If IMF, molecules, metallic bonding implied CE = 0/3

1

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4.   (a)   (i)   <u>0.0212</u>

Need 3 sig figs

Allow correct answer to 3 sig figs eg 2.12×10^{-2}

1

(ii)   0.0106

Mark is for (a)(i) divided by 2 leading to correct answer 2 sig figs

1

(iii) M_r = <u>100.1</u>

1.06 g

Allow 100.1 as 'string'

Need 3 sig figs or more

Consequential on (a)(ii) x 100(.1)

2

(iv)   Neutralisation or acid / base reaction

Allow acid / alkali reaction

Apply list principle

1

(b) (i)   T = 304(K) and P = 100 000 (Pa)

Only T and P correctly converted

1

$$\frac{100\,000 \times 3.50 \times 10^{-3}}{8.31 \times 304} \quad OR \quad n = \frac{PV}{RT}$$

1

0.139 (mol)
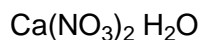
Allow 0.138 – 0.139

1

(ii)   0.0276 – 0.0278(mol)

Allow answer to (b)(i) divided by 5 leading to a correct answer

Allow 0.028

1

(c)   4.20 g $Ca(NO_3)_2$

1

$Ca(NO_3)_2$ H_2O

$$\frac{4.20}{164(.1)} \qquad \frac{1.84}{18}$$

Mark is for dividing by the correct Mr values

M2 and M3 dependent on correct M1

0.0256   0.102

M2 can be awarded here instead

1   :   3.98

$x = 4$

If $Ca(NO_3)_2.4H_2O$ seen with working then award 3 marks

Credit alternative method which gives $x = 4$

1

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