



# **A-Level Chemistry**

## **Mass Number and Isotopes**

### **Mark Scheme**

**Time available: 63 minutes**

**Marks available: 57 marks**

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## Mark schemes

1.

- (a) Number of protons + neutrons (in the nucleus of the atom)

*Do not allow reference to mass or average*

*Ignore references to C-12 being 12*

1

- (b)

	Number of protons	Number of neutrons	Number of electrons
$^{46}\text{Ti}$	22	24	22
$^{49}\text{Ti}^{2+}$	22	27	20

*Mark as rows*

1

1

- (c) Let  $^{49}\text{Ti}$  be y

$$\text{M1 } 47.8 = \frac{(46 \times 2y) + (47 \times 2y) + (48 \times (100 - 5y)) + (49 \times y)}{100}$$

$$47.8 = \frac{235y + 4800 - 240y}{100}$$

*Allow*

$$\text{M1 } 47.8 = \frac{(46 \times 2) + (47 \times 2) + (48 \times n) + 49}{(5 + n)}$$

1

$$\text{M2 } 5y = 20 \text{ OR } y = 4$$

$$\text{M2 } 0.2n = 4 \text{ or } n = 20$$

1

$$\text{M3 abundance of } ^{46}\text{Ti} = 8\%$$

$$\text{M3 } \% ^{46}\text{Ti} = \frac{2}{25} \times 100 = 8\%$$

1

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2.

- (a) The average mass of an atom of an element

*(Weighted) average mass of all isotopes of an element*

1

Compared to  $1/12^{\text{th}}$  the mass of an atom of carbon-12

1

(b) R.A.M. =  $\frac{(82 \times 6) + (83 \times 1) + (84 \times 28) + (86 \times 8)}{43}$

**M1** for working

1

$$= 3615 / 43$$

$$= 84.1$$

**M2** for answer to 1 decimal place 36.2 scores 1/2

1

(c) **M1**  $m = (84/1000)/6.02 \times 10^{23} (= 1.395 \times 10^{-25} \text{ kg})$

Alternative method

**M1:**  $m = (84/1000)/6.02 \times 10^{23} (= 1.395 \times 10^{-25} \text{ kg})$

**M2**  $v^2 = 2ke/m = 2 \times (4.83 \times 10^{-16}) / (1.395 \times 10^{-25})$

**M2:**  $d^2 = 2 ke t^2/m$

**M3**  $v = \sqrt{(6924731183)} = 83214.97$

**M3:**  $d^2 = 2 \times (4.83 \times 10^{-16}) \times (1.73 \times 10^{-5})^2 / 1.395 \times 10^{-25} \quad d^2 = 2.07$

**M4**  $d = v \times t = 83214.97 \times 1.72 \times 10^{-5} = 1.43 \text{ (m)}$

**M4**  $= 1.44 \text{ (m)}$

Allow answers in range 1.43 – 1.44 m

If m not converted to kg, then  $d = 0.045 \text{ m}$  for max 3

4

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3.

(a) Average / mean mass of 1 atom (of an element)

1

1/12 mass of one atom of  $^{12}\text{C}$

1

If moles and atoms mixed, max = 1

Mark top and bottom line independently. All key terms must be present for each mark.

OR

Average / mean mass of atoms of an element

1/12 mass of one atom of  $^{12}\text{C}$

OR

Average / mean mass of atoms of an element  $\times 12$

mass of one atom of  $^{12}\text{C}$

OR

(Average) mass of one mole of atoms

1/12 mass of one mole of  $^{12}\text{C}$

OR

(Weighted) average mass of all the isotopes

1/12 mass of one atom of  $^{12}\text{C}$

OR

Average mass of an atom/isotope compared to/relative to C-12 on a scale in which an atom of C-12 has a mass of 12

*This expression = 2 marks*

(b) **M1** % of  $^{50}\text{Cr}$  and  $^{53}\text{Cr}$  = 13.9%

Let % of  $^{53}\text{Cr}$  = x% and Let % of  $^{50}\text{Cr}$  = (13.9 - x)%

*If x used for  $^{50}\text{Cr}$  and  $^{53}\text{Cr}$  or x and y, max 2 marks = **M1** and **M4***

*Alternative **M2***

*Let % of  $^{53}\text{Cr}$  = (13.9%-x)% and % of  $^{50}\text{Cr}$  = x%*

1

**M2**  $52.1 = \frac{50(13.9 - x) + (52 \times 86.1) + 53(x)}{100}$

OR

$$3x = 37.8$$

**M2**  $52.1 = \frac{53(13.9 - x) + (52 \times 86.1) + 50x}{100}$

OR

$$3x = 3.9$$

1

**M3** x = % of  $^{53}\text{Cr}$  = 12.6%

1

**M4** % of  $^{50}\text{Cr}$  = 1.3%

$$\mathbf{M4 = M1 - M3}$$

1

(c) **M1** (Same) number of protons OR electrons

*Do not allow same electronic configuration for **M1***

1

**M2** (Different) number of neutrons

1

- (d) **M1** (Ions will interact with and) be accelerated (by an electric field)

*Allow (ions) accelerated to a negative plate*

*Do not allow magnetic field*

1

- M2** Ions create a current when hitting the detector OR ions create a current in the detector/electron multiplier.

*Allow (ions) can be detected*

1

- (e) **M1** Mass of ion =  $8.8. \times 10^{-26}$  kg

**M1** Mass of ion in kg

1

**M2**  $v^2 = \frac{2KE}{m} = v^2 = \frac{2 \times 1.102 \times 10^{-13}}{8.8. \times 10^{-26}} (= 2.504 \times 10^{12})$

**M2** Rearrangement

Alternative **M2**  $v = \sqrt{\frac{2KE}{m}}$

1

**M3**  $v = \sqrt{\left( \frac{2 \times 1.102 \times 10^{-13}}{8.8. \times 10^{-26}} \right)} = 1.58 \times 10^6 (\text{ms}^{-1})$

**M3:** Calculating  $v$  by taking  $\sqrt{v}$

1

**M4**  $v = \frac{d}{t}$

**M4:** Recall of  $v = d/t$

1

**M5**  $t = 7.9(0) \times 10^{-7}$  (s) (2sf or more)

**M5:** Calculating  $t$

1

Alternative

**M1** Mass of ion =  $8.8. \times 10^{-26}$  kg

*Alternative*

**M1** Mass of ion in kg

1

**M2**  $KE = \frac{md^2}{2t^2}$  or  $v = \frac{d}{t}$

**M2** Recall of  $v = d/t$

1

**M3**  $t^2 = \frac{md^2}{2KE}$  OR  $\frac{8.8. \times 10^{-26} \times 1.25^2}{2 \times 1.102 \times 10^{-13}}$

**M3** Rearrangement

1

**M4**  $t^2 = 6.24 \times 10^{-13}$

**M4:** Correct calculation to get  $t^2$

1

**M5**  $t = 7.9(0) \times 10^{-7}$  (s) (2sf or more)

**M5:** Calculating  $t$  by taking square root of **M4**

Allow answers consequential on incorrect **M1** If mass in g calculated =  $8.8 \times 10^{-23}$ , then  $t = 2.5 \times 10^{-5}$  s (4 marks)

1

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4.

(a)  $= 79 / (1000 \times 6.022 \times 10^{23}) = 1.31 \times 10^{-25}$  kg

1

Then either follow **method 1** (or **method 2** below)

*Do not mix and match methods*

**Method 1**

$$V_{79} = \frac{d}{t} = 0.950 / 6.69 \times 10^{-4}$$

$$= 1420 \text{ ms}^{-1}$$

*In method 1, M2 can be awarded in M3*

1

$$\text{KE} = \frac{1}{2} mv^2$$

$$= \frac{1}{2} \times 1.312 \times 10^{-25} \times (1420)^2$$

$$= 1.32 \times 10^{-19} \text{ J}$$

*Mark consequential to their velocity and mass. Allow mass of 79 etc.*

1

$$V_{81} = \sqrt{\left(\frac{2\text{KE}}{m}\right)}$$

$$= \sqrt{1.963 \times 10^6}$$

$$= 1.40 \times 10^3 \text{ ms}^{-1}$$

$$(\text{allow } 1.398 \times 10^3 - 1.402 \times 10^3)$$

*Mark consequential to their velocity and mass. Allow mass of 81 etc.*

1

$$t = \frac{d}{v} = \frac{0.950}{v_{81}}$$

$$= 6.80 \times 10^{-4} \text{ s}$$

*Mark consequential to their M4*

*Accept 6.77 – 6.80 × 10<sup>-4</sup> s*

1

## Method 2

$$m_1(d/t_1)^2 = m_2(d/t_2)^2$$

or

$$m_1 / t_1^2 = m_2 / t_2^2$$

1

$$t_2^2 = t_1^2 (m_2/m_1)$$

Or

$$t_2^2 = (6.69 \times 10^{-4})^2 \times (81/79)$$

1

$$t_2^2 = 4.59 \times 10^{-7}$$

*Mark consequential to their M3*

1

$$t = 6.77 \times 10^{-4} \text{ s}$$

*Mark consequential to their M4*

*Accept 6.77 – 6.80 × 10<sup>-4</sup> s*

1

- (b) ion hits the detector / negative plate and gains an electron

1

*Not positive plate*

(relative) abundance is proportional to (the size of) the current

1

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5.

- (a) (Sample is) dissolved (in a volatile solvent)

*Allow named solvent (eg water/methanol)*

1

(Injected through) needle/nozzle/capillary at high voltage/positively charged

*Ignore pressure*

1

Each molecule/particle gains a proton/H<sup>+</sup>

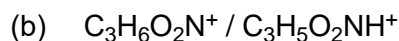
*Allow M3 from a suitable equation (ignore state symbols)*

*Do not allow atoms gain a proton for M3*

*Ignore references to electron gun ionisation*

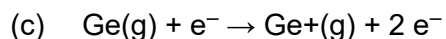
*Mark each point independently*

1



*Must be charged*

1



OR



*State symbols essential*

(d) **M1**  $v = \text{length}/t = 0.96 / 4.654 \times 10^{-6}$

$v = 206274 \text{ m s}^{-1}$

$m = 2KE/v^2$

**M1** = working (or answer)

1

**M2** mass of one ion =  $1.146 \times 10^{-25} \text{ kg}$

**M2** = answer conseq on **M1**

1

**M3** mass of 1 mole ions =  $1.146 \times 10^{-25} \times 6.022 \times 10^{23} = (0.06901 \text{ kg})$

**M3** = **M2**  $\times 6.022 \times 10^{23}$

1

**M4** =  $69(.01) \text{ g}$

**M4** = **M3**  $\times 1000$

**M3/M4** could be in either order

1

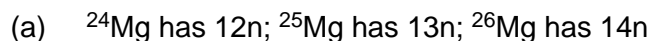
**M5** mass number = 69

**M5** must have whole number for mass no

1

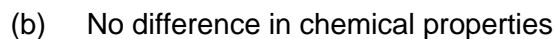
[10]

6.



OR They have different numbers of neutrons

1



1

Because all have the same electronic structure (configuration)

OR they have the same number of outer electrons

1



(c) If fraction with mass 24 = x

Fraction with mass 26 = 0.900 - x

Fraction with mass 25 = 0.100

1

$$A_r = 24x + (25 \times 0.100) + 26(0.900 - x)$$

1

$$24.3 = 24x + 2.50 + 23.4 - 26x$$

$$2x = 1.60$$

$$x = 0.800 \text{ i.e. percentage } ^{24}\text{Mg} = 80.0(\%) \text{ (80.0\% 3sf)}$$

1

$$^{26}\text{Mg} = 0.900 - 0.800 = 0.100 \text{ ie percentage } ^{26}\text{Mg} = 10.0(\%)$$

1

(d)  $m = \frac{25/1000}{6.022 \times 10^{23}}$

1

$$v^2 = 2ke/m \text{ or } v^2 = \frac{2 \times (4.52 \times 10^{-16}) \times (6.022 \times 10^{23})}{25/1000}$$

1

$$V = \sqrt{2.18 \times 10^{10}} = 1.48 \times 10^5 \text{ (ms}^{-1}\text{)}$$

1

$$D = vt = 1.48 \times 10^5 \times 1.44 \times 10^{-5}$$

$$D = 2.13 \text{ (m)}$$

1

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