Access Tuition

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}Ti	22	**24**	**22**
$^{49}Ti^{2+}$	22	**27**	**20**

Mark as rows

1
1

(c) Let ^{49}Ti be y

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

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

1

M2 5y = 20 OR y = 4

M2 0.2n =4 or n=20

1

M3 abundance of ^{46}Ti = 8%

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

1

[6]

2. (a) The average mass of an atom of an element

(Weighted) average mass of all isotopes of an element

1

Compared to 1/12th 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 x 10^{23} (= 1.395 x 10^{-25} kg)

Alternative method

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

M2 v^2 = 2ke/m = 2 x (4.83 × 10^{-16}) / (1.395 x 10^{-25})

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

M3 v = √(6924731183) = 83214.97

M3*:* d^2 *= 2 x (4.83 ×* 10^{-16}*) x (1.73 x* 10^{-5}*)*^{2} */ 1.395 x* 10^{-25} d^2 *= 2.07*

M4 d = v x t = 83214.97 x 1.72 × 10^{-5} = 1.43 (m)

M4 *= 1.44 (m)*

Allow answers in range 1.43 – 1.44 m

If m not converted to kg, then d = 0.045 m for max 3 4

[8]

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

1/12 mass of one atom of ^{12}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}C

OR

Average / mean mass of atoms of an element × 12
mass of one atom of ^{12}C

OR

(Average) mass of one mole of atoms
1/12 mass of one mole of ^{12}C

OR

(Weighted) average mass of all the isotopes
1/12 mass of one atom of ^{12}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}Cr and ^{53}Cr = 13.9%

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

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

*Alternative **M2***

Let % of ^{53}Cr = (13.9%-x)% and % of ^{50}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}Cr = 12.6%

1

M4 % of ^{50}Cr = 1.3%

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 <u>accelerated</u> (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 = $\underline{8.8. \times 10^{-26}}$ 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 = $\underline{8.8. \times 10}^{-26}$ 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 x 10−13

__M4__: Correct calculation to get t^2

1

M5 t = 7.9(0) x 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. x 10^{-23} , then t = 2.5 x 10^{-5} s (4 marks)

1

[15]

4. (a) = 79 / (1000 × 6.022 × 10^{23}) = 1.31 × 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 × 10^{-4}

= 1420 ms^{-1}

In method 1, M2 can be awarded in M3

1

KE = ½ mv^2

= ½ × 1.312 × 10^{-25} × $(1420)^2$

= 1.32 × 10^{-19} J

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

1

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

= √ 1.963 × 10^6

= 1.40 × 10^3 ms^{-1}

(allow 1.398 × 10^3 - 1.402 × 10^3)

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

1

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

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

Mark consequential to their M4

Accept 6.77 – 6.80 × 10^{-4} s

1

Method 2

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

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

Mark consequential to their M4

Accept 6.77 – 6.80 × 10^{-4} s

1

(b) ion hits the detector / negative plate <u>and</u> gains an electron

1

Not positive plate

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

1

[7]

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^+

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

(b) $C_3H_6O_2N^+$ / $C_3H_5O_2NH^+$

Must be charged

1

(c) $Ge(g) + e^- \rightarrow Ge^+(g) + 2\ e^-$

OR

$Ge(g) \rightarrow Ge^+(g) + e^-$

State symbols essential

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

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

$m = 2KE/v^2$

M1 *= working (or answer)*

1

M2 mass of one ion = 1.146×10^{-25} 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 kg)

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

1

M4 = 69(.01) g

M4 *=* ***M3*** *× 1000*

M3/M4 *could be in either order*

1

M5 mass number = 69

M5 *must have whole number for mass no*

1

[10]

6. (a) ^{24}Mg has 12n; ^{25}Mg has 13n; ^{26}Mg has 14n

OR They have different numbers of neutrons

1

(b) No difference in chemical properties

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 × 0.100) + 26(0.900 − x)

1

24.3 = 24x + 2.50 + 23.4 −26x

2x = 1.60

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

1

^{26}Mg = 0.900 − 0.800 = 0.100 ie percentage ^{26}Mg = 10.0(%)

1

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

1

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

1

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

1

D = vt =1.48 × 10^5 × 1.44 × 10^{-5}

D = 2.13 (m)

1

[11]