1. (i) ^{153}Eu has (2) more neutrons

OR

^{153}Eu has 90 neutrons **AND** ^{151}Eu has 88 neutrons ✓

> ***ALLOW*** *There are a different number of neutrons*
> ***IGNORE*** *Correct references to protons / electrons*
> ***DO NOT ALLOW*** *Incorrect references to protons / electrons*

    1

(ii)   (It has the) same number of protons **AND** electrons
OR
Both have 63 protons and 63 electrons ✓

> ***ALLOW*** *Same number of protons **AND** same electron configuration*
> ***DO NOT ALLOW*** *'Same number of protons' without reference to electrons (and vice versa)*

    1

    [2]

2. (a)   **Mass** of the **isotope** compared to 1/12th
OR
mass of the **atom** compared to 1/12th ✓

(the mass of a) carbon-12 **OR** ^{12}C (atom) ✓

> ***IGNORE*** *Reference to average **OR** weighted mean (i.e. correct definition of relative atomic mass will score both marks)*
>
> ***ALLOW*** *mass of a **mole** of the isotope/atom with 1/12th the mass of a **mole OR** 12 **g** of carbon-12 for two marks.*
>
> ***ALLOW 2 marks for:***
> *'**Mass** of the isotope **OR mass** of the atom compared to ^{12}C atom given a mass of 12.0'*
> *i.e. 'given a mass of 12' **OR** C12 is 12 communicates the same idea as 1/12th.'*
>
> ***ALLOW*** *12C **OR** C12*
>
> ***ALLOW 2 marks for:***
> $$\frac{mass\ of\ the\ isotope}{mass\ of\ 1/12th\ mass\ of\ carbon-12}$$
> *i.e. fraction is equivalent to 'compared to'*
>
> ***ALLOW 1 mark for*** *a mix of mass of atom and mass of mole of atoms, i.e. 'mass of the isotope/mass of an atom compared with 1/12th the mass of a **mole OR** 12 g of carbon-12.'*
>
> ***DO NOT ALLOW*** *mass of 'ions' **OR** mass of element*

    2

(b) $\dfrac{(151 \times 47.77) + (153 \times 52.23)}{100}$

OR

72.1327 + 79.9119
OR

152.0446 (calculator value) ✓

$A_r = 152.04$ ✓

> **ALLOW** *Correct answer for two marks*
>
> **ALLOW** *One mark for ECF from transcription error in first sum provided final answer is to 2 decimal points and is to between 151 and 153 and is a correct calculation of the transcription*

2

[4]

3.   (i)   (atoms of the) same element **OR** same atomic no.
OR no. of protons

AND

with different numbers of neutrons **OR** different masses ✓

> **IGNORE** *'same number of electrons'*
>
> **DO NOT ALLOW** *'different numbers of electrons'*
>
> **DO NOT ALLOW** *'different relative atomic masses'*
>
> **DO NOT ALLOW** *'elements with different numbers of neutrons'* **without** *mention of same protons* **OR** *same atomic number*

1

(ii)   **same** (number of) **electrons** (in the outer shell)

OR

same **electron** configuration **OR** structure ✓

> **DO NOT ALLOW** *different number of protons*
>
> **IGNORE** *'same number of protons'*
>
> **IGNORE** *'they are both carbon'* **OR** *'they are both the same element'*

1

(iii) **mass** of the isotope compared to 1/12th
OR
mass of the atom compared to 1/12th ✓

(the mass of a) carbon-12 **OR** ^{12}C (atom) ✓

> *IGNORE reference to average **OR** weighted mean*
> *(i.e. correct definition of relative atomic mass will score both marks)*
>
> ***ALLOW** mass of a **mole** of the isotope/atom with 1/12th the mass of a **mole OR** 12 g of* ✓
> *carbon –12* ✓
>
> ***ALLOW** 2 marks for:*
> *'**mass** of the isotope **OR mass** of the atom compared to ^{12}C atom given a mass of 12.0'*
> *i.e. 'given a mass of 12' communicates the same idea as 1/12th.'*
>
> ***ALLOW** 12C **OR** C12*
> ***ALLOW FOR 2 MARKS:***
>
> $$\frac{mass\ of\ the\ isotope}{mass\ of\ 1/12th\ mass\ of\ carbon-12}$$
>
> *i.e. fraction is equivalent to 'compared to'*
> ***ALLOW 1 MARK FOR** a mix of mass of atom and mass of mole of atoms, **i.e.:***
> *'mass of the isotope/mass of an atom compared with 1/12th the mass of a **mole OR** 12 g of carbon –12.'*

2

[4]

4. (i)

	protons	neutrons	electrons
^{24}Mg	12	12	12
^{25}Mg	12	13	12

^{24}Mg line correct ✓
^{25}Mg line correct ✓

> *mark by **row***

2

(ii) $$\frac{24 \times 78.60 + 25 \times 10.11 + 26 \times 11.29}{100}$$

OR 18.8640 + 2.5275 + 2.9354

OR 24.3269 ✓

A_r = 24.33 (to 4 sig figs) ✓

      ALLOW two marks for A_r = 24.33 with no working out

      ALLOW one mark for ecf from incorrect sum provided final answer is between 24 and 26 and is to 4 significant figures, e.g. 24.3235 ✘ gives ecf of 24.32 ✓

2

(iii) The (weighted) mean **mass** of an **atom**
OR (weighted) average **mass** of an **atom** ✓

relative to 1/12th (the mass) ✓

of (one atom of) ^{12}C ✓

      ALLOW The (weighted) mean mass
      OR (weighted) average mass of an atom
      OR average atomic mass ✓
      compared with (the mass of) carbon-12 ✓
      which is 12 ✓

      *For 1st marking point, **ALLOW** mean mass of the isotopes*
      OR average mass of the isotopes
      *Do **NOT ALLOW** the singular: isotope*
      *ALLOW mass of **one mole** of **atoms** ✓*
      compared to 1/12th ✓
      *(the mass) of **one mole** / 12 g of carbon-12 ✓*

         <u>mass of one mole of atoms</u>✓
      1/12th✓ the mass of one mole / 12 g of carbon-12 ✓

3

[7]

5. (i) atoms of the same element with different numbers of neutrons/different masses **(1)**

    1

(ii) ^{79}Br 35 protons, 44 neutrons, 35 electrons **(1)**
^{81}Br 35 protons, 46 neutrons, 35 electrons **(1)**

    2

(iii) $(1s^2)2s^22p^63s^23p^63d^{10}4s^24p^5$ **(1)**

    1

[4]

6. Molar mass of anhydrous calcium nitrate = 164.1 g mol^{-1} **(1)**
Ratio Ca(NO$_3$)$_2$: H$_2$O = 69.50/164.1 : 30.50/18
or 0.4235 : 1.694 or 1 : 4 **(1)**
Formula = Ca(NO$_3$)$_2$•4H$_2$O **(1)**

[3]

7. (a) (atoms of) **same element/same atomic number**….. with

   different numbers of neutrons/different masses ✓   1

   (b)   3

isotope	percentage composition	number of		
		protons	neutrons	electrons
^{85}Rb	71 to 73	37	48	37
^{87}Rb	27 to 29	37	50	37

   mark   must add
               up to 100 ✓

   ie 1 mark for each atomic structure; 1 for % compositions.

   $$A_r = \frac{(85 \times 72) + (87 \times 28)}{100} / 85.56 \ ✓$$

   = 85.6 ✓ 2nd mark for significant figures   2
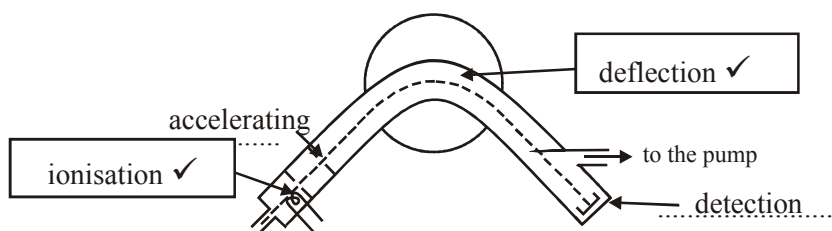   71/29: 85.58 = 85.6
   73/27: 85.54 = 85.5

   (c) carbon-12/^{12}C ✓   1

[7]

8. (i)

	protons	neutrons	electrons		
^{25}Mg	12	13	12	✓	
^{26}Mg	12	14	12	✓	2

(ii) $1s^2 2s^2 2p^6 3s^2$ ✓

$24 \times 78.60/100 + 25 \times 10.11/100 + 26 \times 11.29/100$ ✓   1

(iii)   = 24.33 ✓ (calc value: 24.3269. This scores one mark)
24.32 with no working, award 1 mark only.
24.3 with no working, no marks (Periodic Table value)   2

[5]

9. (i)   (atoms of) same element/same atomic number/number of protons with
different numbers of neutrons/diff masses ✓   1

(ii)

	proton	neutron	electron	
relative mass 1	1	$\frac{1}{1840}$ /	negligible ✓	
relative charge	+1	0	−1	✓

i.e. 1 mark for each correct row
for electron, accept 1/1500 – 1/2000
for charges, accept +; 0; –

2

[3]

10. (i) average **atomic** mass/weighted mean/average mass ✓

    compared with carbon-12 ✓

    1/12th of mass of carbon-12/on a scale where carbon-12 is 12 ✓

    $\qquad\qquad$ *OR*

    (ii) The mass of 1 mole of **atoms** of an element

    compared with 12 g ✓ of carbon-12 ✓ $\qquad\qquad$ 3

    $$A_r = \frac{(121 \times 57.21) + (123 \times 42.79)}{100} \;/\; 121.8558 \;✓$$

    = 121.9 ✓ $\qquad\qquad$ 2

    $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ **[5]**

11.

isotope	protons	neutrons	electrons	
^{12}C	6	6	6	✓
^{13}C	6	7	6	✓

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ **[2]**

12. (i) mass spectrometry ✓ $\qquad\qquad$ 1

    (ii) mass of an isotope compared with carbon-12 ✓
    1/12th of mass of carbon-12/on a scale where carbon-12 is
    12 ✓ $\qquad\qquad$ 2

    *mass of 1 mole of the isotope/mass of 1 mole of carbon-12
    is equivalent to the first mark
    "mass of the isotope that contains the same number of
    atoms as are in 1 mole of carbon-12" → 1 mark (mark
    lost because of mass units)*

    (iii) $12 \times 95/100 + 13 \times 5/100$ OR 12.05 ✓
    = 12.1 (mark for significant figures) ✓
    (12.1 scores both marks) $\qquad\qquad$ 2

    $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ **[5]**

13. (a) (i) atoms of same element/same atomic number….. with
    different numbers of neutrons/different masses ✓ $\qquad\qquad$ 1

    (ii)

isotope	protons	neutrons	electrons	
^{46}Ti	22	24	22	✓
^{47}Ti	22	25	22	✓

    $\qquad$ 2

(b) $A_r = \dfrac{(46 \times 8.9) + (47 \times 9.8) + (48 \times 81.3)}{100} / 47.724$ ✓

      $= 47.7$ ✓   2

[5]

14. (i) ^{79}Br has two ✓ less neutrons than ^{81}Br ✓   2

    (ii) ^{79}Br have same numbers of protons ✓
        and same number of electrons ✓   2

[4]

15.

isotope	protons	neutrons	electrons
nickel-58	28	30	28
nickel-60	28	32	28
nickel-62	28	34	28
	✓	✓	✓

    For ecf, 3rd column same as first column.

[3]

16. (i) mass spectrometry ✓
       mass spec… /mass spectrometer should also be credited   1

    (ii) average mass/weighted mean mass **of an atom** ✓
       compared with carbon-12 ✓
       1/12th of mass of carbon-12/on a scale where carbon-12 is 12 ✓
       *mass of 1 mole **of atoms** (of an element) mass of 1 mole of*   3
       carbon-12 is equivalent to first two marks
       "mass of the element that contains the same number of
       atoms as are in 1 mole of carbon-12" $\rightarrow$ *2 marks (mark lost*
       because of mass units)

    (iii) $63.0 \times 77.2/100 + 65.0 \times 22.8/100 / 63.456$ ✓   2

       $= 63.5$ (mark for significant figures) ✓

    (iv) copper/ Cu ✓   1

[7]