

Unit 1

Atoms, bonds and groups

Chapter 1 Atoms, isotopes and electrons

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- a** (i) 8p, 8n, 8e
(ii) 8p, 8n, 10e
- b** (i) 11p, 12n, 11e
(ii) 11p, 12n, 10e
- c** (i) 9p, 10n, 9e
(ii) 9p, 10n, 10e
- d** (i) 20p, 20n, 20e
(ii) 20p, 20n, 18e

e These questions should cause little difficulty, but note that it is always the electrons that are lost to create a positive ion. If protons were gained in a reaction, the element would be changed: 11p, 12n, 11e is a sodium atom, but 12p, 12n, 11e would be Mg^+ .

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1

$$\text{weighted mean relative atomic mass} = \frac{(72.2 \times 85)}{100} + \frac{(27.8 \times 87)}{100}$$
$$= 61.37 + 24.19 = 85.6$$

e A useful cross-check is that the answer must be somewhere between the masses of the two isotopes (i.e. between 85 and 87) and because the percentage abundance of Rb-85 is greater than that of Rb-87, the final value has to be below 86. You should try to estimate answers first in order to avoid giving silly calculator values.

2

$$\text{weighted mean relative atomic mass} = \frac{(90.48 \times 20)}{100} + \frac{(0.27 \times 21)}{100} + \frac{(9.25 \times 22)}{100}$$
$$= 18.096 + 0.0567 + 2.035 = 20.19$$

e A quick inspection shows that the answer has to be between 20 and 22. Ne-20 is the most abundant isotope, so the final value must be close to 20.

- 3** abundance of unknown isotope = $100 - 69 = 31\%$
Let m equal the mass of the unknown isotope:

$$\frac{69 \times 63}{100} + \frac{31 \times m}{100} = 63.6$$

$$43.47 + 0.31m = 63.6$$

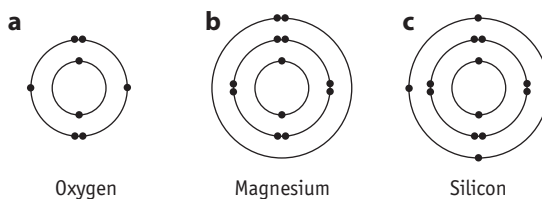
$$0.31m = 63.6 - 43.47 = 20.13$$

$$m = \frac{20.13}{0.31} = 64.9$$

Hence, $m = 65$ (since the isotope must have a mass number that is a whole number).

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- a Na $1s^2 2s^2 2p^6 3s^1$
b K $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
c N $1s^2 2s^2 2p^3$ or $1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$
d O^{2-} $1s^2 2s^2 2p^6$
e Ca^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6$
f Al^{3+} $1s^2 2s^2 2p^6$
g Cl^- $1s^2 2s^2 2p^6 3s^2 3p^6$
h P^{3-} $1s^2 2s^2 2p^6 3s^2 3p^6$

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Extension question

- a The number of electrons is $2n^2$, where n is the level.
For $n = 4$, the number of electrons is 32.
For $n = 5$, the number of electrons is 50.
- b Level 3 holds 18 electrons, so the number of electrons in level 4 that are f -electrons is $32 - 18 = 14$. Orbitals contain a maximum of two electrons, so there must be seven f -orbitals.
The number of electrons in level 5 that are g -electrons is $50 - 32 = 18$, so there must be nine g -orbitals.
- e The answers could also be obtained, perhaps more simply, by noting that the number of electrons held by each type of orbital increases by 4. Thus, an s -orbital holds 2 electrons, the p -orbitals hold 6 electrons, the d -orbitals 10 etc.
- c Einsteinium-253 has 99 protons, 99 electrons and hence $253 - 99 = 154$ neutrons.
d Einsteinium-254 has 99 protons, 99 electrons and hence $254 - 99 = 155$ neutrons.
e The orbitals are filled according to the sequence given in the textbook (see Figure 1.6 on p. 13) *but*, because einsteinium is in the seventh period, students have to realise that the sequence has to be extended to include the $7s$ -orbital, which will then be followed by $5f$, $6d$, $5g$ orbitals.
Einsteinium is in the final (seventh) period and therefore the first six levels are full. Radon is the final element in the sixth period and hence radon has the outer configuration $6p^6$. Radon is element 86 and einsteinium is element 99, so einsteinium has 13 more electrons than radon. The additional 13 electrons fill up the $7s$ -orbital followed by $5f$, such that the electronic configuration of einsteinium is $[_{86}\text{Rn}]7s^2 5f^{11}$. Hence there are 11 f -electrons in $_{99}\text{Es}$.
- e The complexity of working out this answer indicates the limitation of using the concept of shells or the old idea of orbits. For the first ten elements it is helpful because the electrons do fill the first orbit first (i.e. $1s^2$) and the second orbit second (i.e. $2s^2 2p^6$). However, two electrons — the $4s^2$ -electrons — are placed in the fourth orbit before the third orbit is completed with the $3d$ -electrons. Once the fifth orbit is filled with the 14 $5f$ -electrons, there are eight electrons in the sixth orbit and two in the seventh.

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- f** On losing an alpha particle an einsteinium atom loses two protons and two neutrons, so the number of protons becomes 97 and the number of neutrons becomes 152 or 153, depending on which isotope is considered. Thus, it becomes element 97, berkelium (Bk).
- e** This is just one step in the decay of an einsteinium atom and it proceeds through several other steps before ending up as a lead atom. Einsteinium exists with isotopes of every mass number from 241 to 257, all of which are radioactive. The extent of their radioactivity can be measured by their half-lives, which is the time taken for half the atoms to decay. The half-lives of einsteinium-253 and einsteinium-254 are 20.5 days and 275.7 days respectively.