02 Atomic Structure

Set A **Answer key**

A From the lesson

17 MARKS

1 **B** $^{12}_{6}C$ and $^{14}_{6}C$ [1]

Both have 6 protons and differ in neutrons (6 and 8), so they are isotopes of carbon.

Carbon and nitrogen are different elements. An atom and its ion have the same protons and neutrons and differ only in electrons.

2 **C** 35 [1]

Neutrons = nucleon number − proton number = 65 − 30 = 35.

The charge changes the number of electrons, not the number of neutrons.

3 **C** electrons [1]

Electrons have the largest charge-to-mass ratio, because their mass is so small.

Neutrons have no charge, so they are not deflected.

4 **A** [Ar] $3d^9$ [1]

Cu is [Ar] $3d^{10}$ $4s^1$, because a full 3d subshell is more stable.

Remove the 4s electron first, then one 3d electron: [Ar] $3d^9$. Option C forgets the copper exception and removes 3d before 4s.

5 **B** Al [1]

Al loses a 3p electron, which is higher in energy and less strongly attracted than the 3s electron lost by Mg, so less energy is needed.

Si and P are higher than the elements before them, as the general rise across the period predicts.

6

$^{23}Na^+$: 11 protons, 12 neutrons, 10 electrons.

$^{32}S^{2-}$: 16 protons, 16 neutrons, 18 electrons.

$^{65}Zn^{2+}$: 30 protons, 35 neutrons, 28 electrons. [3]

7

They have the same number of electrons, so they react in the same way.

They have different numbers of neutrons, so their masses, and so their densities, differ. [2]

8 +2°: the charge is the same and the mass doubles, so the angle halves. [1]

9 **(a)** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$ [1]

(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$ [1]

(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^5$ [1]

10 Group 15: the big jump is between the 5th and 6th ionisation energies, so J has 5 valence electrons. [1]

11 The first electron comes from the outer 3s subshell.

The second must be removed from the inner 2p subshell of Na^+, which is closer to the nucleus, so it is much more strongly attracted. [2]

B Practice

17 MARKS

12 **A** The relative charge of a proton is equal but opposite in sign to the relative charge of an electron. [1]

A proton has a relative charge of +1 and an electron −1: equal in size, opposite in sign.

A neutron has no charge. An electron has about 1/1836 of the mass of a proton or a neutron, so it is far lighter, not heavier.

13 **A** 26 neutrons, 22 protons [1]

A +4 charge means 4 more protons than electrons, so protons = 18 + 4 = 22.

The nucleus holds the protons and neutrons, so neutrons = 48 − 22 = 26.

14 **B** It contains 13 protons and 10 electrons. [1]

Only protons have a charge in the nucleus, so there are 13 protons and 27 − 13 = 14 neutrons. The ion has 13 − 3 = 10 electrons.

The ion has 13 protons, 14 neutrons and 10 electrons. Option A gives the wrong neutrons, C gives the electrons of the atom, and D gives the wrong electrons.

15 **A** 82 neutrons, 54 electrons [1]

Neutrons = nucleon number − proton number = 140 − 58 = 82.

The 4+ charge means 4 electrons were lost: 58 − 4 = 54 electrons.

16

B 1 and 3 only [1]

Isotopes have the same number of electrons, so the same outer shell and the same chemical reactions.

Statement 2 is wrong. The masses differ, so physical properties such as density differ.

17

C They have different mass numbers but undergo the same chemical reactions. [1]

Isotopes have the same proton number but different numbers of neutrons, so their mass numbers differ. The same electrons give the same chemical reactions.

Isotopes have the same number of electrons, they differ in neutrons, and they have the same proton number so they belong to the same element.

18

B 1 and 4 only [1]

Isotopes have the same proton (atomic) number and the same number of electrons, so they have the same chemical properties.

Their mass numbers differ, 35 and 37, and so do their physical properties, such as density.

19

B W and Z [1]

Isotopes have the same number of protons but different numbers of neutrons. W and Z both have 19 protons, with 20 and 22 neutrons.

X has the same protons and neutrons as W but one fewer electron: it is an ion of the same isotope, not another isotope. Y has 20 protons, so it is a different element.

20

A p, $n + 1$, $p + 1$ [1]

An isotope of Z has the same number of protons, p, but a different number of neutrons, such as $n + 1$.

A negative ion has gained electrons, so it has more electrons than protons, such as $p + 1$.

21

D $^{40}K^{+}$ [1]

Chlorine-37 has 17 protons, 20 neutrons and 17 electrons. R has 19 protons (potassium), 21 neutrons and 18 electrons.

The nucleon number is 19 + 21 = 40, and 19 protons with 18 electrons gives a charge of 1+.

22

C deflected more than the beam of protons, in the opposite direction [1]

Electrons have a much lower mass than protons, so they are deflected more.

Electrons are negative, so they bend towards the positive plate, opposite to the protons.

23 **C** 24 [1]

J^{3+} has lost 3 electrons, so the atom has 18 + 3 = 21 electrons and therefore 21 protons.

Neutrons = nucleon number − proton number = 45 − 21 = 24.

24 **D** $^{39}_{19}K^{+}$ [1]

K^{+} has 19 protons, 39 − 19 = 20 neutrons and 19 − 1 = 18 electrons, so all three numbers differ.

Al has 13 protons and 13 electrons. Cl^{-} has 18 neutrons and 18 electrons. S^{2-} has 16 protons and 16 neutrons.

25 **B** n − 2 protons, $m - (n - 2)$ neutrons [1]

X^{2-} has gained 2 electrons, so the number of protons is n − 2.

Neutrons = nucleons − protons = $m - (n - 2)$. Gaining electrons does not change the nucleus.

26 **C** It has a different electronic configuration from the other isotopes. [1]

Isotopes have the same number of protons and so the same number of electrons. All three carbon isotopes have the configuration 2.4.

Carbon-14 reacts like any carbon atom, so it forms carbon dioxide and carbon monoxide. It has 8 neutrons, more than carbon-12 (6) or carbon-13 (7).

27 **B** 1 and 2 only [1]

Atoms 1 and 2 each have 3 valence electrons, so both are in Group 13.

The ion in 3 came from an atom with 15 electrons, configuration 2.8.5, which is in Group 15.

28 **C** 20 [1]

Element 12 is 2.8.2 and element 20 is 2.8.8.2. Both have 2 valence electrons, so both are in Group 2 and have similar chemical properties.

Element 2 has a full first shell (Group 18), element 11 has 1 valence electron (Group 1) and element 24 is in Group 6.