01 Atomic Structure

Set A Answer key

A From the lesson

16 MARKS

1

species	protons	neutrons	electrons	
$^{23}Na^{+}$	11	12	10	[1]
$^{32}S^{2-}$	16	16	18	[1]
$^{56}Fe^{3+}$	26	30	23	[1]

EXAM TIP Charge changes only the electrons: number of electrons = proton number − charge. Protons and neutrons never change in chemical reactions.

2

Angle of deflection = $k \times \frac{\text{charge}}{\text{mass}}$

For $^{1}H^{+}$: $+12 = k \times \frac{+1}{1}$, so $k = 12$

(a) $^{2}H^{+}$: $12 \times \frac{+1}{2} = \mathbf{+6°}$ [1]

(b) $^{4}He^{2+}$: $12 \times \frac{+2}{4} = \mathbf{+6°}$ [1]

(c) $^{16}O^{2-}$: $12 \times \frac{-2}{16} = \mathbf{-1.5°}$ [1]

NOTE $^{2}H^{+}$ and $^{4}He^{2+}$ have the same charge to mass ratio, so they are deflected by the same angle.

3

% $^{26}Mg = 100 - 79.0 - x = 21.0 - x$

$A_r = \frac{24(79.0) + 25x + 26(21.0 - x)}{100} = 24.32$ [1]

$1896 + 25x + 546 - 26x = 2432$

$x = \mathbf{10.0}$ [1]

4

Each atom is ^{35}Cl with probability 0.75 and ^{37}Cl with probability 0.25.

Mass 70 (^{35}Cl–^{35}Cl): $0.75 \times 0.75 = 0.5625$

Mass 72 (^{35}Cl–^{37}Cl or ^{37}Cl–^{35}Cl): $2 \times 0.75 \times 0.25 = 0.375$

Mass 74 (^{37}Cl–^{37}Cl): $0.25 \times 0.25 = 0.0625$ [1]

Relative abundances 70 : 72 : 74 = **9 : 6 : 1** [1]

5 **(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]

6 The large jump is between the 3rd and 4th ionisation energies, so Y has 3 electrons in its outermost shell. **Group 13**, and in Period 3, **Y is aluminium**. [1]

7 **Group 1**: the large jump is after the 1st ionisation energy. [1]

The 2nd electron is removed from an inner principal quantum shell, nearer the nucleus and less shielded, so it is much more strongly attracted. [1]

B Practice

22 MARKS

8 **B** They have 10 neutrons in their nuclei. [1]

$^{18}O^{2-}$: 8 protons, 10 neutrons, 10 electrons. $^{19}F^{-}$: 9 protons, 10 neutrons, 10 electrons.

A Wrong: each has as many electrons as neutrons (10).

C Wrong: both have an outer configuration of $2s^2\ 2p^6$.

D Wrong: the nucleon numbers are 18 and 19.

9 **C** Cu^+ [1]

particle	electronic configuration	unpaired electrons
Fe^{3+}	[Ar] $3d^5$	5
Ge^+	[Ar] $3d^{10}\ 4s^2\ 4p^1$	1
Cu^+	[Ar] $3d^{10}$	0
Ti^{3+}	[Ar] $3d^1$	1

NOTE Transition metal ions lose their 4s electrons before their 3d electrons.

10 **B** N^- [1]

particle	before losing an electron	after losing an electron
C^-	$1s^2\ 2s^2\ 2p^3$	$1s^2\ 2s^2\ 2p^2$
N^-	$1s^2\ 2s^2\ 2p^4$	$1s^2\ 2s^2\ 2p^3$ (half-filled)
O^+	$1s^2\ 2s^2\ 2p^3$	$1s^2\ 2s^2\ 2p^2$
P^+	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

11

species	protons	neutrons	electrons	explanation (not required)
^{2}H	1	1	1	each ^{2}H atom has 1 electron, 1 proton and 1 neutron
$^{1}H_{2}^{+}$	2	0	1	each ^{1}H atom has 1 electron, 1 proton and 0 neutrons
$^{3}H_{3}^{+}$	3	3 × 2 = 6	2	each ^{3}H atom has 1 electron, 1 proton and 2 neutrons

[1] for any 3 boxes correct **[3]**

12

(a)

Si: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ **[1]**

(b)

Similarity (one of the following): **[1]**

The 3s and 3p orbital both belong to the third principal quantum shell *or* the 3s and 3p orbital can each hold a maximum of two electrons (of opposite spins).

Difference (one of the following): **[1]**

The 3s orbital is spherical while the 3p orbital has a dumb-bell shape *or* the 3s orbital is lower in energy than the 3p orbital.

NOTE Vague answers ("both hold electrons", "different energy") were rejected. Compare one 3s orbital with one 3p orbital, not the number of orbitals in each subshell.

(c)

Difference (any one of the following): the 3p orbital is higher in energy than the 2p orbital *or* the 3p orbital is larger (in size) than the 2p orbital *or* the 3p orbital belongs to the third quantum shell, while the 2p orbital belongs to the second quantum shell. **[1]**

13

(a)

Let the nucleon number of X be m.

$$\frac{1/28}{1/m} = \frac{5.6}{2.0}$$ **[1]**

m = 78.4, so **X is Br**. **[1]**

(b)

Isotopes of bromine with a lower charge/mass ratio. **[1]**

14

(a)

Across the period from sodium to argon, nuclear charge increases. There is the same number of inner shell electrons, so the shielding effect is approximately constant. **[1]**

Effective nuclear charge increases, so the electrostatic forces of attraction between the nucleus and the valence electron increase. More energy is needed to remove the valence electron. **[1]**

(b)

Mg: $1s^2\ 2s^2\ 2p^6\ 3s^2$ Al: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ **[1]**

The 3p electron removed from Al is at a higher energy level than the 3s electron removed from Mg, so less energy is required to remove it. **[1]**

(c)

P: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ S: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$ **[1]**

In S, two electrons are paired in the same 3p orbital, so there is inter-electronic repulsion. Less energy is required to remove a 3p electron from S than from P. **[1]**

15 **(a)**

$B^{3+}(g) \rightarrow B^{4+}(g) + e^-$ **[1]**

(b)

B^{3+}: $1s^2$ C^{3+}: $1s^2\ 2s^1$

C^{3+} has one more electron shell than B^{3+}: the 2s electron in C^{3+} is further from the nucleus and more shielded than the 1s electron in B^{3+}. **[1]**

Despite the greater nuclear charge of C^{3+}, the electrostatic attraction between the nucleus and its 2s electron is weaker. Less energy is required to remove the 2s electron from C^{3+} than the 1s electron from B^{3+}, so B has the higher fourth ionisation energy. **[1]**