BioMedical Admissions Test (BMAT)

Section 2: Chemistry

Questions by Topic

C1 - Atomic Structure

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C1: Atomic Structure - Question by Topic

(Mark Scheme and explanations at the end)

1 The following statements are about the atomic structure.

1 Protons, electrons and neutrons are found in the atom.
2 A subatomic particle is found within an atom.
3 Protons, electrons and neutrons are nucleons.
4 An atom has very little empty space.
5 Electrons have a mass of 1.

Which of these statements are correct?

A 1, 2, 3 and 4
B 1, 2, 3 and 5
C 1, 2 and 4
D 1, 3 and 4
E 1, 2 and 5
F 2 and 4
G 1 and 2
H 2 and 5

2 The following statements are about the atomic structure.

1 The nucleus contains most of the mass of the atom.
2 Neutrons have no charge.
3 Protons and electrons have opposite charges.
4 The nucleus is negatively charged.
5 Atoms have no charge overall.

Which of these statements are correct?

A 1, 2, 3 and 4
B 1, 2, 3 and 5
C 1, 2 and 4
D 1, 3 and 4
E 1, 2 and 5
F 2 and 4
G 1 and 2
H 2 and 5

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3 The following statements are about the atomic structure.

1 The number of protons and electrons in an atom must be the same.
2 If the atom loses one or more electrons it becomes a positively charged ion.
3 If the atom gains electrons it becomes a negatively charged ion.
4 The mass number and the atomic number can be used to work out the number of neutrons.
5 The number of protons in an atom is called the mass number.

Which of these statements are correct?

A 1, 2, 3 and 4
B 1, 2, 3 and 5
C 1, 2 and 4
D 1, 3 and 4
E 1, 2 and 5
F 2 and 4
G 1 and 2
H 2 and 5

4 The following statements are about the atomic structure. Aluminium has an atomic number of 13 and an atomic mass of 27.

How many neutrons does an aluminium atom contain?

A 40
B 14
C 13
D 27

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5 The following statements are about the atomic structure. Chromium has an atomic number of 24 and an atomic mass of 52.

How many neutrons does a chromium atom contain?

A 24
B 52
C 76
D 28

6 The following statements are about the atomic structure. If the atomic number and the charge of the ion is known the number of electrons can be worked out. The atomic number of Na is 11 and the mass number of Na is 23.

How many electrons are present in a Na+ ion?

A 12
B 22
C 11
D 24
E 10

7 The following statements are about the atomic structure. If the atomic number and the charge of the ion is known the number of electrons can be worked out. The atomic number of sulfur (S) is 16 and the atomic mass of Na is 32.

How many electrons are present in a S^{2-} ion?

A 16
B 14
C 18
D 32

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8 The following statements are about the atomic structure.

1 Electrons are present in shells around the nucleus.
2 The maximum number of electrons present in the first shell is 8.
3 Electrons are removed from the lowest energy shell to form a positive ion.
4 Shells around a nucleus are filled from lowest to highest energy shells.
5 The number of electrons added to an atom is the charge of the ion.

Which of these statements are correct?

A 1, 2, 3 and 4
B 1, 2, 3 and 5
C 1, 2 and 4
D 1, 3 and 4
E 1, 4 and 5
F 2 and 4
G 1 and 2
H 2 and 5

9 The following statements are about the atomic structure. Phosphorus has an atomic number of 15 and an atomic mass number of 31.

What is the electron configuration of phosphorus?

A 8, 2, 5
B 2, 8, 6
C 2, 8, 5
D 2, 8, 8, 8, 5

10 The following statements are about the atomic structure. Iron has an atomic number of 26 and has an atomic mass number of 55.8.

What is the electron configuration of the Fe^{3+}?

A 2, 8, 8, 8
B 8, 2, 8, 5
C 2, 8, 8, 8, 3
D 2, 8, 8, 5

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11 When radioactive potassium 40 decays, the nucleus captures an electron and a proton changes into a neutron.

Which of the following is formed by this decay?

A Calcium 40
B Argon 40
C Calcium 39
D Argon 39

12 A mass spectrum reveals that:

Mass	Relative number of atoms
63	35
65	15

Which of the following is the correct relative atomic mass of copper based on this?

A 58.6
B 60.4
C 63.6
D 68.3

13 Sodium has an atomic number of 11.

What is the electronic configuration of a Na+ ion?

A 2, 8, 1
B 2, 7
C 2, 8, 2
D 2, 8

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14 Mg has several naturally occurring isotopes. There abundance is as follows:

79% ^{24}Mg 10% ^{25}Mg 11% ^{26}Mg

Using this information, which of the following is the correct relative atomic mass of Mg?

A 23.4
B 24.0
C 24.3
D 26.5

15 Lithium has a relative atomic mass of 6.941 and has 2 naturally occurring isotopes: ^{6}Li and ^{7}Li.

Which of the following rows correctly estimates the natural abundances of these isotopes?

	^{6}Li	**^{7}Li**
A	91.5	12.5
B	79.5	20.5
C	29.5	70.5
D	7.5	92.5

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Answers and Explanations

1 **The correct answer is G**

1. **is correct** - it is true that **electrons, protons and neutrons** are **found in the atom.**
2. **is correct** - it is true that particles that are found in the atom are called **subatomic particles.** The **3 main subatomic particles** in an atom, as stated above, are **electrons, protons and neutrons.**
3. is incorrect - **nucleons are particles that are found in the nucleus.** The subatomic particles that are found in the nucleus of the atom are: **protons and neutrons.** Electrons are not nucleons as they are not found in the nucleus.
4. is incorrect - this is because an **atom is mostly empty space.** The nucleus (containing protons and neutrons) and electrons are really small, with the nucleus being less than 1/2000 the size of the atom.
5. is incorrect - this is because **electrons have a negligible mass**, not a mass of 1. It is protons and neutrons that have a mass of 1.

Since **1** and **2** are the only correct statements, **G** must be the correct answer.

2 **The correct answer is B**

1. **is correct** - it is true that the **nucleus contains most of the mass of an atom.** This is because the only subatomic particles that have a mass are **protons and neutrons (mass = 1)** and these are **present in the nucleus.**
2. **is correct** - it is true that **neutrons have no charge.**
3. **is correct** - it is true that protons and electrons have **opposite charges.** Protons have a positive charge and electrons have a negative charge.
4. is incorrect - the nucleus is charged however it has a **positive charge**, not a negative charge. The nucleus has a positive charge because the nucleus **contains protons and neutrons**, neutrons do not have a charge but protons have a positive charge, this gives the nucleus a positive charge.
5. **is correct** - it is true that an **atom has no charge over all.** This is because an atom has the **same number of electrons and protons.** As protons have a positive charge and electrons have a negative charge, the **charges are cancelled out**, which makes the atom **neutral.**

Since **1, 2, 3** and **5** are the only correct statements, **B** must be the correct answer.

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3 **The correct answer is A**

1 **is correct** - it is true that an atom contains the **same number of protons and electrons.**

2 **is correct** - it is true that if an **atom loses one or more electrons** it becomes a **positively charged ion.** This is because initially the atom will have the same number of protons and electrons, when electrons are lost this means **more protons are present.** As protons are positively charged and electrons are negatively charged, when electrons are lost there is a **greater positive charge present,** therefore a positively charged ion is formed.

3 **is correct** - it is true that if an **atom gains one or more electrons** it **forms a negatively charged ion.** This is because initially the atom will have the same number of protons and electrons, when electrons are gained this means **more electrons are present.** As protons are positively charged and electrons are negatively charged, when electrons are gained there is a **greater negative charge present,** therefore a negatively charged ion is formed.

4 **is correct** - it is true that the atomic number and atomic mass can be used to work out the number of neutrons. The equation to work out the number of neutrons is $atomic\ mass\ number - atomic\ number = number\ of\ neutrons.$

5 is incorrect - this is because the **mass number** is the **number of protons and neutrons** that are present in the atom. The **atomic number** is the **number of protons** present.

Since **1, 2, 3** and **4** are the only correct statements, **A** must be the correct answer.

4 **The correct answer is B**

A is incorrect - this is because 40 comes from adding the mass number and atomic number together (13 + 27). This is not how you work out the number of neutrons.

B **is correct** - this is because you can work out the number of neutrons using the following equation: $atomic\ mass\ number - atomic\ number = number\ of\ neutrons.$ We know the atomic mass number is 27 and the atomic number is 13. $27 - 13 = 14$ therefore the number of neutrons in the aluminium atom is 14.

C is incorrect - this is because **13 is the atomic number**, this is the **number of protons** in the aluminium atom not the number of neutrons.

D is incorrect - this is because **27 is the atomic mass number**, this is the **number of protons and neutrons** in the aluminium atom, not the number of neutrons.

Since **A, C** and **D** are incorrect statements, **B** must be the correct answer.

5 **The correct answer is D**

A is incorrect - this is because 24 is the **atomic number** of chromium. This means chromium has **24 protons**, not neutrons.

B is incorrect - this is because 52 is the **atomic mass number** of chromium. This means chromium has **52 protons and neutrons together,** this is not the number of just the neutrons.

C is incorrect - this is because 76 is the number you get when you add the atomic number (24) and the atomic mass number (52). This is not how you work out the number of neutrons.

D **is correct** - this is because you can work out the number of neutrons using the following equation: $atomic\ mass\ number - atomic\ number = number\ of\ neutrons.$ We know the atomic mass number is 52 and the atomic number is 24. $52 - 24 = 28$ therefore the number of neutrons in the aluminium atom is 28.

Since **A, B** and **C** are incorrect statements, **D** must be the correct answer.

6 **The correct answer is E**

A is incorrect - this is because 12 is the number you get when you subtract 11 from 23 $(23 - 11 = 12)$. This is the number of neutrons present in Na+.

B is incorrect - this is because 22 is the number you get when you subtract 1 from 23 (the atomic mass number). This is not how you work out the number of electrons present in an ion.

C is incorrect - this is the number of electrons in a Na ion.

D is incorrect - this is because **23 is the atomic mass number**, which is the **number of protons and neutrons present** in the sodium ion, not the number of electrons.

E **is correct** - this is because you can work you the number of electrons present in a positive ion by **subtracting the number of electrons lost from the number of electrons present in the atom.** The **number of electrons lost is equal to the charge.** E.g. if two electrons are lost the charge will be 2+. The sodium ion has a **1+ charge (Na+)** therefore **one electron has been lost.** We can work out the number of electrons that would be present in the sodium atom, as this is the same as the number of protons (atomic number), which is 11. Therefore to work out the number of electrons present in the Na+ ion, 1 (the number of electrons lost) must be subtracted from 11 (number of electrons present in the atom). $11 - 1 = 10.$

Since **A, B, C** and **D** are incorrect statements, **E** must be the correct answer.

7 **The correct answer is C**

A is incorrect - this is because 16 is the **atomic number**, this is the **number of protons** that are present in the sulfur ion, not the number of electrons.

B is incorrect - this is because 14 is the number you get when you subtract the number of electrons gained (2), to form the sulfur ion, from the number of electrons present in the sulfur. However as it is a **negative ion** you do not subtract the number of electrons, you **add them**, as **electrons have been gained.**

C **is correct** - this is because you can work you the number of electrons present in a negative ion by **adding the number of electrons gained to the number of electrons present in the atom.** The **number of electrons gained is equal to the charge.** E.g. if two electrons are gained the charge will be 2-. The sulfur ion has a **2- charge (S^{2-})** therefore **two electrons have been gained.** We can work out the number of electrons that would be present in the sulfur atom, as this is the same as the number of protons (atomic number), which is 16. Therefore to work out the number of electrons present in the S^{2-} ion, 2 (the number of electrons gained) must be added to 16 (number of electrons present in the atom). $16 + 2 = 18$.

D is incorrect - this is because **32 is the atomic mass number**, which is the **number of protons and neutrons present** in the sulfur ion, not the number of electrons.

Since **A, B** and **D** are incorrect statements, **C** must be the correct answer.

8 **The correct answer is E.**

1 **is correct** - it is true that electrons are present in **energy shells**, and move around the nucleus in these shells.

2 is incorrect - this is because the **maximum number of electrons** that can be present in the **first shell** around the nucleus is **2**, not 8.

3 is incorrect - this is because **electrons are removed from the highest energy shell**, not the lowest, to form a **positive ion.**

4 **is correct** - it is true that shells around a nucleus are **filled from the lowest energy shell to the next highest energy shell.**

5 **is correct** - it is true that the **number of electrons that are added to an atom** to form a negative ion, is **equal to the charge of the ion.** E.g. S^{2-} has a -2 charge, this means two electrons have been added to the sulfur atom. S^{2-}

Since **1, 4** and **5** are the only correct statements, **E** must be the correct answer.

9 **The correct answer is C.**

A is incorrect - this is because the **first shell around the nucleus**, can only contain a **maximum number of 2 electrons**, not 8. Therefore the electron configuration cannot start with 8.

B is incorrect - this is because the electron configuration 2,8,6 adds up to 16. 16 is the **number of neutrons that are present in the phosphorus atom**, and there are not 16 electrons in the atom, therefore the electron configuration cannot add up to 16.

C **is correct** - it is true that the electron configuration for phosphorus is 2,8,5. This is because the **atomic number of phosphorus is 15**, therefore the number of electrons in phosphorus is 15. The **first energy shell can have a maximum of 2 electrons** and the **second energy shell will have a maximum of 8 electrons.** The electron configuration 2,8,5 adds up to 15.

D is incorrect - this is because the electron configuration 2,8,8,8,5 adds up to 31, this adds up to the **atomic mass number which is the number of protons and neutrons in the phosphorus atom**, therefore the electron configuration for phosphorus cannot add up to 31.

Since **A, B** and **D** are incorrect statements, **C** must be the correct answer.

10 **The correct answer is D**

A is incorrect - this is because the electron configuration 2,8,8,8 is for an **iron atom**, not the Fe^{3+} ion. This is because the iron atom has an **atomic number of 26**, which means there are **26 electrons in the iron atom.**

B is incorrect - this is because the **first energy shell** can only have a **maximum of two electrons**, therefore the electron configuration cannot start with 8.

C is incorrect - this is because Fe^{3+} is a **positive ion**, therefore the iron atom has **lost three electrons.** The electron configuration 2,8,8,8,3 shows that **three electrons have been added on.**

D **is correct** - this is because **Fe^{3+} is a positive iron**, therefore the iron atom ion has **lost electrons in order to become a positive ion.** As Fe^{3+} has **3+ charge** therefore **3 electrons** have been lost from the iron atom. This means there are three less electrons present in Fe^{3+} compared to the iron atom. The iron atom has 26 electrons, therefore the Fe^{3+} has 23 electrons $(26 - 3 = 23)$. Therefore the Fe^{3+} has an electron configuration of 2,8,8,5.

Since **A, B** and **C** are incorrect statements, **D** must be the correct answer.

Exam Tip - it is essential to know the rules for electron configuration which apply to the first 20 elements in the periodic table.

- 1st shell maximum number of electrons: 2
- 2nd shell maximum number of electrons: 8
- 3rd shell maximum number of electrons: 8
- Commas are used to separate the number of electrons in each shell, when writing the electron configuration.

11 **The correct answer is B**

The atomic number is the number of protons found in the nucleus, so this number decreases by 1 when the proton changes into a neutron. Potassium had an atomic number of 19 so this will change to 18, making the new element argon.
The mass number does not change as the number of the number of neutrons and protons altogether remains the same.

12 **The correct answer is C**

Total number of atoms = 35 + 15 = 50

$$\text{Ar (Cu)} = \left(\frac{35}{50} \times 63\right) + \left(\frac{15}{50} \times 65\right) = \frac{2205}{50} + \frac{975}{50} = 63.6$$

13 **The correct answer is D**

The first shell can contain a maximum of 2 electrons, the second shell a maximum of 8. Sodium has an atomic number of 11, meaning 11 protons and 11 electrons to balance them, but the Na+ ion has lost an electron, so there are only 10 electrons - enough to fill the first two shells.

14 **The correct answer is C**

$$A_r \text{ (Mg)} = \frac{(79 \times 24) + (10 \times 25) + (11 \times 26)}{100} = 24.32$$

Exam Tip - the general formula for calculating relative atomic mass is:

$$A_r \text{ (X)} = \frac{(a \times b) + (c \times d) + (e \times f) + \ldots}{100}$$

when there is a% of ^{b}X, c% of ^{d}X, e% of ^{f}X ...

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15 **The correct answer is D**

Since we do not know what the percentages of these two isotopes are, we can give them algebraic letters for now: X% of ^{6}Li and Y% of ^{7}Li.

Rearranging the equation in the previous question we can see that:

$6.941 = \frac{6X + 7Y}{100}$ and so $6X + 7Y = 694.1$

Substituting row A in roughly gives: (6x92) + (8x5) = 552 + 40 = 594 - too small!

Substituting row B in roughly gives: (6x80) + (7x20) = 480 + 140 = 620- too small!

Substituting row C in roughly gives: (6x29) + (7x70) = 174 + 490 = 664 - too small!

Substituting row D in roughly gives: (6x7) + (7x93) = 42 + 651 = 693 - closest

Exam Tip - in questions like this, it can be better to work backwards and use estimates instead of spending valuable time working out precise numbers!

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