Cambridge AS & A Level

CHEMISTRY

Paper 1

Topical Past Paper Questions

+ Answer Scheme

2015 - 2021

PapaCambridge

Chapter 1

Atomic structure

1.1 Particles in the atom and atomic radius

1. 9701_m20_qp_12 Q: 1

What number of protons, neutrons and electrons are present in the ion $^{54}Fe^{3+}$?

	protons	neutrons	electrons
A	26	28	23
B	26	28	29
C	29	25	23
D	29	25	26

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2. 9701_w20_qp_11 Q: 3

A single ^{32}P nucleus can be produced when a single ^{32}S nucleus joins with particle X. In the process a proton is emitted.

What is particle X?

A a deuteron, $^{2}_{1}H^{+}$

B an electron

C a neutron

D a proton

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3. 9701_m18_qp_12 Q: 3

Drinking water may contain dissolved calcium hydrogencarbonate, $Ca(HCO_3)_2$.

How many electrons are present in a hydrogencarbonate anion?

A 30 **B** 31 **C** 32 **D** 33

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4. 9701_s18_qp_13 Q: 2

Neutrons are passed through an electric field. The mass of one neutron relative to $\frac{1}{12}$ the mass of a ^{12}C atom and any deflection in the electric field is recorded.

Which row is correct?

	mass of neutron	behaviour of beam of neutrons in an electric field
A	0	deflected
B	1	deflected
C	0	not deflected
D	1	not deflected

---

5. 9701_w18_qp_12 Q: 2

Beams of charged particles are deflected by an electrical field. The angle of deflection of a particle is proportional to its charge / mass ratio.

In an experiment protons are deflected by an angle of +15°. In another experiment under identical conditions $^{2}H^{-}$ ions are deflected by an angle of Y°.

What is the value of Y?

A –30.0 **B** –7.5 **C** +7.5 **D** +30.0

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6. 9701_s17_qp_12 Q: 1

In which species are the numbers of protons, neutrons and electrons **all** different?

A $^{19}_{9}F^{-}$ **B** $^{23}_{11}Na^{+}$ **C** $^{31}_{15}P$ **D** $^{32}_{16}S^{2-}$

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7. 9701_s17_qp_13 Q: 1

The ion Y^{3-} contains 18 electrons and has a mass number of 31.

How many protons and neutrons does Y^{3-} contain?

	protons	neutrons
A	15	16
B	15	18
C	18	13
D	21	10

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8. 9701_w17_qp_12 Q: 1

In which pair do the atoms contain the same number of neutrons?

A ^{11}B and ^{12}C

B ^{7}Li and ^{9}Be

C ^{24}Mg and ^{28}Si

D ^{14}N and ^{16}O

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9. 9701_m16_qp_12 Q: 3

Which ion has both more electrons than protons and more protons than neutrons?
[H = $^{1}_{1}H$; D = $^{2}_{1}H$; O = $^{16}_{8}O$]

A D^- **B** H_3O^+ **C** OD^- **D** OH^-

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10. 9701_m16_qp_12 Q: 4

Which species contains the smallest number of electrons?

A B^{3+} **B** Be^{2+} **C** H^- **D** He^+

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11. 9701_w16_qp_11 Q: 4

Sodium azide, NaN_3 is an explosive used to inflate airbags in cars when they crash. It consists of positive sodium ions and negative azide ions.

What are the numbers of electrons in the sodium ion and the azide ion?

	sodium ion	azide ion
A	10	20
B	10	22
C	12	20
D	12	22

1.2 Isotopes

12. 9701_m21_qp_12 Q: 1

For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

The table shows the numbers of protons, neutrons and electrons in four different particles, W, X, Y, and Z.

	number of protons	number of neutrons	number of electrons
W	32	40	32
X	32	40	34
Y	32	42	32
Z	34	40	34

Which pair represents the atoms of two isotopes of the same element?

A W and Y **B** W and Z **C** X and Y **D** X and Z

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13. 9701_w21_qp_12 Q: 3

Technetium (Tc) is a second row transition element that does not occur naturally on Earth. One of its isotopes has 56 neutrons.

What is the nucleon number of this isotope?

A 43 **B** 56 **C** 99 **D** 112

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14. 9701_s16_qp_11 Q: 4

When nuclear reactions take place, the elements produced are different from the elements that reacted. Nuclear equations, such as the one below, are used to represent the changes that occur.

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{144}_{56}\text{Ba} + {}^{89}_{36}\text{Kr} + 3\,{}^{1}_{0}\text{n}$$

The nucleon (mass) number total is constant at 236 and the proton number total is constant at 92.

In another nuclear reaction, uranium-238 is reacted with deuterium atoms, $^{2}_{1}\text{H}$. An isotope of a new element, **J**, is formed as well as two neutrons.

$$^{238}_{92}\text{U} + {}^{2}_{1}\text{H} \rightarrow \mathbf{J} + 2\,{}^{1}_{0}\text{n}$$

What is isotope **J**?

A ^{238}Np **B** ^{238}Pu **C** ^{240}Np **D** ^{240}Pu

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15. 9701_w16_qp_11 Q: 5

The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give an isotope of a different element, ^{68}X, which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus and changes a proton into a neutron.

Which statement about the composition of an atom of ^{68}X is correct?

A It has 4 electrons in its outer p orbitals.

B It has 13 electrons in its outer shell.

C It has 37 neutrons.

D Its proton number is 32.

1.3 Electrons, energy levels and atomic orbitals

16. 9701_m22_qp_12 Q: 2

What is the electronic configuration of Mg^{2+}?

A $1s^2\ 2s^2\ 2p^6$

B $1s^2\ 2s^2\ 2p^6\ 3s^2$

C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$

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17. 9701_m21_qp_12 Q: 2

Where in the Periodic Table is the element that has an outer electron shell arrangement of $4s^24p^3$?

	Group	Period
A	13	3
B	13	4
C	15	3
D	15	4

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18. 9701_s21_qp_11 Q: 2

In which pair of species do both species have only one unpaired p electron?

A Ar^+ and C^- **B** B and Ti^+ **C** F and Ga **D** Se^- and Si^-

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19. 9701_s21_qp_13 Q: 3

Which atom has the same number of electrons as an ammonium ion?

A Mg **B** Na **C** Ne **D** O

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20. 9701_w21_qp_11 Q: 4

The ion X^{2+} has the same electronic configuration as the atom Kr.

What is the electronic configuration of an atom of X?

A $[Ar]4s^23d^{10}4p^6$

B $[Ar]4s^23d^{10}4p^65s^2$

C $[Ar]4s^24d^{10}4p^6$

D $[Ar]4s^24d^{10}4p^65s^2$

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21. 9701_w21_qp_12 Q: 4

Which atom has more unpaired electrons than paired electrons in orbitals of principal quantum number 2?

A carbon

B nitrogen

C oxygen

D fluorine

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22. 9701_s20_qp_11 Q: 10

In which pair does each species have the same number of unpaired electrons?

A Al and Cu^{2+}

B Ca and Cr^{3+}

C Ca and Ni^{2+}

D Fe^{3+} and O^{2-}

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23. 9701_s20_qp_13 Q: 1

Which particle has equal numbers of protons and neutrons and an electronic structure of $1s^22s^22p^63s^23p^6$?

A $^{39}_{18}Ar$ **B** $^{40}_{20}Ca^{2+}$ **C** $^{16}_{8}O^{2-}$ **D** $^{32}_{16}S$

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24. 9701_s20_qp_13 Q: 8

What is the electronic configuration of an isolated Ni^{2+} ion?

A $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^1$

C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

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25. 9701_w20_qp_11 Q: 14

The electronic arrangement for atoms of four elements is given.

Which element is the strongest oxidising agent?

A $1s^2 2s^2 2p^5$

B $1s^2 2s^2 2p^6 3s^2$

C $1s^2 2s^2 2p^6 3s^2 3p^5$

D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

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26. 9701_w20_qp_12 Q: 3

Which atomic orbitals are occupied in an atom of phosphorus?

A 1p 2s 2p **B** 2s 2p 2d **C** 2s 2p 3s **D** 2p 3s 3d

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27. 9701_m19_qp_12 Q: 3

Which statement about a 3p orbital is correct?

A It can hold a maximum of 6 electrons.

B It has the highest energy of the orbitals with principal quantum number 3.

C It is at a higher energy level than a 3s orbital but has the same shape.

D It is occupied by one electron in an isolated phosphorus atom.

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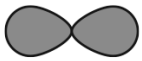
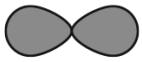
28. 9701_s19_qp_11 Q: 4

The outermost electron in an atom of neon occupies a particular orbital.

Which row shows the relative energy and shape of this orbital?

	energy of orbital relative to other occupied orbitals	shape of orbital
A	higher or equal	
B	higher or equal	
C	lower or equal	
D	lower or equal	

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29. 9701_s19_qp_13 Q: 3

Which atom has exactly three unpaired electrons?

A an isolated gaseous aluminium atom

B an isolated gaseous carbon atom

C an isolated gaseous chromium atom

D an isolated gaseous phosphorus atom

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30. 9701_w19_qp_12 Q: 4

Which statement about the electrons in a ground state carbon atom is correct?

A Electrons are present in four different energy levels.

B There are more electrons in p orbitals than there are in s orbitals.

C The occupied orbital of highest energy is spherical.

D The occupied orbital of lowest energy is spherical.

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31. 9701_m18_qp_12 Q: 4

Which molecule contains a nitrogen atom with sp hybridised orbitals?

A $CH_3CH_2NH_2$ **B** HNO_3 **C** HCN **D** NH_3

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32. 9701_s18_qp_11 Q: 1

This question refers to isolated gaseous atoms.

In which atom are all electrons paired?

A Ba **B** Br **C** S **D** Si

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33. 9701_s18_qp_12 Q: 2

The electronic configuration of an atom of sulfur is $1s^2 2s^2 2p^6 3s^2 3p^4$.

How many valence shell and unpaired electrons are present in one sulfur atom?

	valence shell electrons	unpaired electrons
A	2	1
B	4	2
C	6	0
D	6	2

---

34. 9701_s18_qp_13 Q: 3

The table refers to the electron distribution in the second shell of an atom with eight protons.

Which row is correct for this atom?

	orbital shape 		orbital shape 	
	orbital type	number of electrons	orbital type	number of electrons
A	p	2	s	4
B	p	4	s	2
C	s	2	p	4
D	s	4	p	2

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35. 9701_m17_qp_12 Q: 1

Which ion has the same electronic configuration as Cl^-?

A F^- **B** P^+ **C** Sc^{3+} **D** Si^{4+}

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36. 9701_s16_qp_12 Q: 2

Four electronic configurations are shown below. Three of these configurations belong to atoms of the elements chlorine, sodium and vanadium.

Which electronic configuration belongs to an atom of another element?

A $1s^2 2s^2 2p^6 3s^1$

B $1s^2 2s^2 2p^6 3s^2 3p^5$

C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

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37. 9701_s16_qp_13 Q: 5

Which isolated gaseous atom has a total of five electrons occupying spherically shaped orbitals?

A boron

B fluorine

C sodium

D potassium

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38. 9701_s15_qp_12 Q: 1

Use of the Data Booklet is relevant to this question.

In which option do all three particles have the same electronic configuration **and** the same number of neutrons?

A $^{15}N^{3-}$ $^{16}O^{2-}$ $^{19}F^{-}$

B $^{18}O^{2-}$ $^{19}F^{-}$ ^{20}Ne

C $^{19}F^{-}$ ^{20}Ne $^{23}Na^{+}$

D ^{22}Ne ^{23}Na $^{24}Mg^{2+}$

1.4 Ionisation energy

39. 9701_m22_qp_12 Q: 1

The first ionisation energy of potassium, K, is 418 kJ mol^{-1}. The first ionisation energy of strontium, Sr, is 548 kJ mol^{-1}.

Which statement helps to explain why Sr has a greater first ionisation energy than K?

A The charge on a Sr nucleus is greater than the charge on a K nucleus.

B The outer electron in a Sr atom experiences greater shielding than the outer electron in a K atom.

C The outer electron in a Sr atom experiences spin-pair repulsion.

D The outer electron in a Sr atom is further from the nucleus than the outer electron in a K atom.

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40. 9701_s21_qp_11 Q: 7

Why is the first ionisation energy of oxygen less than that of nitrogen?

A The nitrogen atom has its outer electron in a different subshell.

B The nuclear charge on the oxygen atom is greater than that on the nitrogen atom.

C The oxygen atom has a pair of electrons in one p orbital that repel one another.

D There is more shielding in an oxygen atom.

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41. 9701_s21_qp_12 Q: 2

Which equation represents the first ionisation energy of iodine?

A $\frac{1}{2}I_2(g) + e^- \rightarrow I^-(g)$

B $I(g) + e^- \rightarrow I^-(g)$

C $\frac{1}{2}I_2(g) \rightarrow I^+(g) + e^-$

D $I(g) \rightarrow I^+(g) + e^-$

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42. 9701_w21_qp_11 Q: 3

Which of these elements has the highest fifth ionisation energy?

A C **B** N **C** P **D** Si

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43. 9701_s20_qp_12 Q: 12

The fifth to eighth ionisation energies of four elements in Period 3 of the Periodic Table are shown.

Which row refers to chlorine?

	ionisation energies / kJ mol^{-1}			
	fifth	sixth	seventh	eighth
A	6280	21 200	25 900	30 500
B	6990	8 490	27 100	31 700
C	6540	9 330	11 000	33 600
D	7240	8 790	12 000	13 800

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44. 9701_s19_qp_12 Q: 13

The eight elements sodium to argon are in the same period of the Periodic Table.

The equation corresponding to the first ionisation energy is shown.

$$X(g) \rightarrow X^{+}(g) + e^{-}$$

For which of these eight elements is the electron in this equation removed from a filled orbital?

A Mg, A*l*, Si, P, S, C*l* and Ar

B A*l*, Si, P, S, C*l* and Ar only

C Mg, S, C*l* and Ar only

D S, C*l* and Ar only

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45. 9701_w18_qp_11 Q: 1

The first four ionisation energies for element X are shown in the table.

ionisation energy	1st	2nd	3rd	4th
value / kJ mol^{-1}	577	1980	2960	6190

Which ion of X is produced by removing an electron from a filled shell?

A X^{+} **B** X^{2+} **C** X^{3+} **D** X^{4+}

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46. 9701_s17_qp_11 Q: 4

Which property of an atom does **not** affect its first ionisation energy?

A the atomic radius

B the number of electron shells

C the number of neutrons

D the number of protons

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47. 9701_s17_qp_11 Q: 12

Why is the second ionisation energy of sodium larger than the second ionisation energy of magnesium?

A The attraction between the nucleus and the outer electron is greater in Na^+ than in Mg^+.

B The nuclear charge of Na^+ is greater than that of Mg^+.

C The outer electron of Na^+ is more shielded than the outer electron of Mg^+.

D The outer electron of Na is in the same orbital as the outer electron of Mg.

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48. 9701_m16_qp_12 Q: 2

For the element sulfur, which pair of ionisation energies has the largest difference between them?

A third and fourth ionisation energies

B fourth and fifth ionisation energies

C fifth and sixth ionisation energies

D sixth and seventh ionisation energies

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49. 9701_s16_qp_12 Q: 3

Elements X and Y are in the same group of the Periodic Table.

The table shows the first six ionisation energies of X and Y in $kJ\,mol^{-1}$.

	1st	2nd	3rd	4th	5th	6th
X	800	1600	2400	4300	5400	10400
Y	1000	1800	2700	4800	6000	12300

What could be the identities of X and Y?

	X	Y
A	antimony, Sb	arsenic, As
B	arsenic, As	antimony, Sb
C	selenium, Se	tellurium, Te
D	tellurium, Te	selenium, Se
