CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



EXAM QUESTION PACK

1 ATOMIC STRUCTURE

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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

---

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

---

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

---

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** $^{32}_{16}S^{2-}$

---

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

---

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

---

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^-

---

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^+

---

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.

1 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

---

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

---

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.

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

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, ${}^{2}_{1}\mathrm{H}$. An isotope of a new element, **J**, is formed as well as two neutrons.

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

What is isotope **J**?

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

---

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

---

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

---

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^-

---

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

---

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 $[Ar]\,4s^2 3d^{10} 4p^6$

B $[Ar]\,4s^2 3d^{10} 4p^6 5s^2$

C $[Ar]\,4s^2 4d^{10} 4p^6$

D $[Ar]\,4s^2 4d^{10} 4p^6 5s^2$

---

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

---

22. 9701_s20_qp_11 Q: 10

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

A A*l* and Cu^{2+}

B Ca and Cr^{3+}

C Ca and Ni^{2+}

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

---

23. 9701_s20_qp_13 Q: 1

Which particle has equal numbers of protons and neutrons and an electronic structure of $1s^2 2s^2 2p^6 3s^2 3p^6$?

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

---

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

---

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

---

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

---

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.

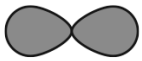
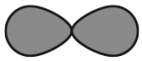
D It is occupied by one electron in an isolated phosphorus atom.

---

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	

---

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

---

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.

---

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

---

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

---

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

---

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+}

---

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

---

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

---

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.

---

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.

---

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

---

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

---

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

---

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

---

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+}

---

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

---

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.

---

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

---

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

Chapter 2

Atomic structure

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2.1 Particles in the atom

5. 9701_s17_qp_22 Q: 1

The composition of atoms and ions can be determined from knowledge of atomic number, nucleon number and charge.

(a) Complete the table.

atomic number	nucleon number	number of electrons	number of protons	number of neutrons	symbol
3		2			$^{6}_{3}Li^{+}$
		23	26	32	

[2]

(b) Boron occurs naturally as a mixture of two stable isotopes, ^{10}B and ^{11}B. The relative isotopic masses and percentage abundances are shown.

isotope	relative isotopic mass	abundance / %
^{10}B	10.0129	19.78
^{11}B	to be calculated	80.22

(i) Define the term *relative isotopic mass*.

.....

..... [2]

(ii) Calculate the relative isotopic mass of ^{11}B.

Give your answer to **six** significant figures. Show your working.

[2]

[Total: 6]

2.2 Electrons: energy levels, orbitals, ionisation, electron affinity

6. 9701_s20_qp_23 Q: 2

(a) Explain what is meant by the term *relative isotopic mass*.

.....

.....

..... [2]

(b) A sample of copper contains two isotopes, ^{63}Cu and ^{65}Cu. The relative atomic mass of the copper in this sample is 63.55.

Calculate the percentage abundance of each of these isotopes. Show your working.

percentage abundance of ^{63}Cu = ... %

percentage abundance of ^{65}Cu = ... %
[2]

(c) (i) Name the type of bonding within a sample of solid copper.

..... [1]

(ii) Draw a labelled diagram to show the bonding within a sample of solid copper.

[2]

(iii) State the electronic configuration of a copper atom.

$1s^2$ ..... [1]

(d) A student is provided with a sample of hydrated copper(II) sulfate, $CuSO_4 \cdot xH_2O$, and is asked to determine the value of x.
The student dissolves a sample of the hydrated copper(II) sulfate in water and adds it to an excess of aqueous potassium iodide to make a total volume of 250.0 cm^3 of solution.

$$2CuSO_4 + 4KI \rightarrow 2CuI + I_2 + K_2SO_4$$

The amount of iodine produced during this reaction is found by titrating a sample of this solution with sodium thiosulfate solution.

25.0 cm^3 of the iodine-containing solution requires 20.0 cm^3 of 0.10 mol dm^{-3} sodium thiosulfate solution.

$$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$$

(i) Calculate the amount, in mol, of copper(II) sulfate present in the original sample of hydrated copper(II) sulfate.

Show your working.

amount of copper(II) sulfate = ... mol [2]

(ii) A total of 7.98 g of $CuSO_4$ is present in 10.68 g of $CuSO_4 \cdot xH_2O$.

Complete each row of the table to calculate the value of x, where x is an integer.

[M_r: $CuSO_4$,159.6]

amount of $CuSO_4$ in 10.68 g of $CuSO_4 \cdot xH_2O$	..... mol
amount of H_2O in 10.68 g of $CuSO_4 \cdot xH_2O$	..... mol
value of x	x = ...

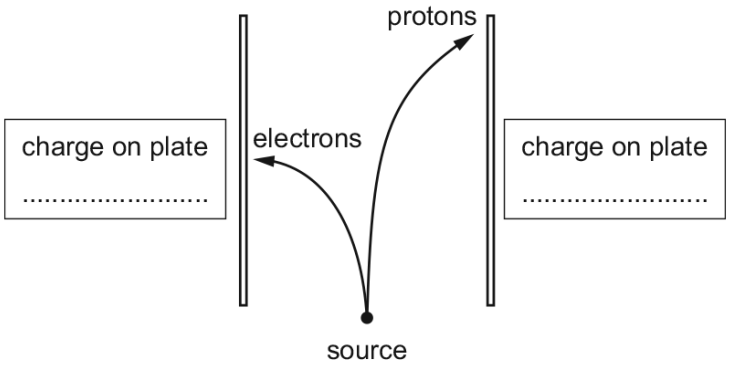
[3]

[Total: 13]

7. 9701_w20_qp_22 Q: 1

Atoms contain the subatomic particles electrons, protons and neutrons. Protons and electrons were discovered by observations of their behaviours in electric fields.

(a) The diagram shows the behaviour of separate beams of electrons and protons in an electric field.



(i) Complete the diagram with the relative charge of each of the electrically charged plates. [1]

(ii) On the diagram, draw a line to show how a separate beam of neutrons from the same source behaves in the same electric field. [1]

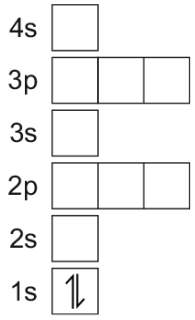
(b) Electrons in atoms up to $_{36}Kr$ are distributed in s, p and d orbitals.

(i) State the number of occupied orbitals in an isolated atom of $_{36}Kr$.

type of orbital	s	p	d
number of orbitals			

[3]

(ii) Complete the diagram to show the number and relative energies of the electrons in an isolated atom of $_{14}Si$.



[2]

(iii) The diagram shows a type of orbital.



State the total number of electrons that exist in all orbitals of this type in an atom of $_{9}F$.

..... [1]

(iv) The first ionisation energies of elements in the first row of the d block ($_{21}Sc$ to $_{29}Cu$) are very similar. For all these elements, it is a 4s electron that is lost during the first ionisation.

Suggest why the first ionisation energies of these elements are very similar.

.....

.....

.....

..... [3]

(c) *Hydron* is a general term used to represent the ions $^{1}_{1}H^{+}$, $^{2}_{1}H^{+}$ and $^{3}_{1}H^{+}$.

State, in terms of subatomic particles in the nucleus, what is the same about each of these ions and what is different.

same .....

different .....

[1]

[Total: 12]

8. 9701_s19_qp_23 Q: 1

(a) A sample contains three different types of atom: $^{40}_{18}Ar$, $^{40}_{19}K$ and $^{40}_{20}Ca$.

(i) State fully, in terms of the numbers of subatomic particles, what these three atoms have in common.

.....

..... [1]

(ii) State fully, in terms of the numbers of **all** subatomic particles, how these three atoms **differ** from each other.

.....

..... [1]

(b) A sample of sulfur contains only two isotopes, ^{32}S and ^{34}S. The relative atomic mass of this sample is 32.09.

isotope	isotopic mass
^{32}S	32.0
^{34}S	34.0

Calculate the percentage abundance of the isotopes present in this sample.

% abundance ^{32}S = ...

% abundance ^{34}S = ...
[3]

(c) The electronic configuration of a sulfur atom is $1s^2 2s^2 2p^6 3s^2 3p^4$.

(i) Identify which orbital in a sulfur atom has the lowest energy.

..... [1]

(ii) Sketch the shape of a p orbital.

[1]

(iii) During the process of ionisation a sulfur atom loses an electron.

$$S(g) \rightarrow S^+(g) + e^- \qquad \Delta H = 1000\,kJ\,mol^{-1}$$

Identify the orbital from which this electron is removed. Explain your answer.

orbital .....

explanation .....

.....

[2]

(d) (i) Complete the diagram to show the arrangement of electrons within the third shell of a phosphorus atom.



[1]

(ii) Explain why the first ionisation energy of sulfur is less than that of phosphorus.

.....

.....

.....

..... [2]

[Total: 12]

9. 9701_s16_qp_21 Q: 1

(a) Complete the table to show the composition and identity of some atoms and ions.

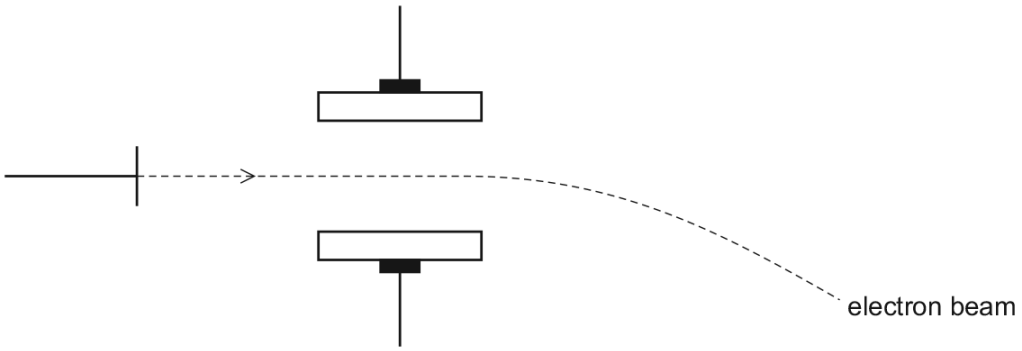
name of element	nucleon number	atomic number	number of protons	number of neutrons	number of electrons	overall charge
lithium	6	3	.....	.....	.....	+1
oxygen	.....	.....	.....	9	10	.....
.....	54	26	26	.....	24	.....
.....	.....	.....	17	18	.....	0

[4]

(b) Beams of protons, neutrons and electrons behave differently in an electric field due to their differing properties.

The diagram shows the path of a beam of electrons in an electric field.

Add and label lines to represent the paths of beams of protons and neutrons in the same field.



[3]

(c) The fifth to eighth ionisation energies of three elements in the third period of the Periodic Table are given. The symbols used for reference are **not** the actual symbols of the elements.

	ionisation energies, kJ mol^{-1}			
	fifth	sixth	seventh	eighth
X	6274	21269	25398	29855
Y	7012	8496	27107	31671
Z	6542	9362	11018	33606

(i) State and explain the group number of element **Y**.

group number .....

explanation .....

.....

[1]

(ii) State and explain the general trend in **first** ionisation energies across the third period.

.....

.....

..... [2]

(iii) Explain why the **first** ionisation energy of element **Y** is less than that of element **X**.

.....

.....

.....

..... [2]

(iv) Complete the electronic configuration of element **Z**.

1s^2 ..... [1]

(d) A sample of strontium exists as a mixture of four isotopes. Information about three of these isotopes is given in the table.

mass number	86	87	88
abundance	9.86%	7.00%	82.58%

(i) Calculate the abundance of the fourth isotope.

abundance = ... % [1]

(ii) The relative atomic mass of this sample of strontium is 87.71.

Calculate the mass number of the fourth isotope.

mass number = ... [2]

[Total: 16]

10. 9701_s16_qp_22 Q: 1

(a) Complete the table to show the composition and identity of some atoms and ions.

name of element	nucleon number	atomic number	number of protons	number of neutrons	number of electrons	overall charge
boron	10	5	.....	.....	.....	0
nitrogen	.....	.....	.....	8	10	.....
.....	208	82	82	.....	80	.....
.....	.....	.....	3	3	.....	+1

[4]

(b) The fifth to eighth ionisation energies of three elements in the third period of the Periodic Table are given. The symbols used for reference are **not** the actual symbols of the elements.

	ionisation energies, kJ mol^{-1}			
	fifth	sixth	seventh	eighth
X	7012	8496	27 107	31 671
Y	6542	9362	11 018	33 606
Z	7238	8781	11 996	13 842

(i) State and explain the group number of element **Y**.

group number .....

explanation .....

.....

[1]

(ii) State and explain the general trend in **first** ionisation energies across the third period.

.....

.....

..... [2]

(iii) Complete the electronic configuration of element **X**.

1s^2 ..... [1]

(c) A sample of oxygen exists as a mixture of three isotopes. Information about two of these isotopes is given in the table.

mass number	16	17
abundance	99.76%	0.04%

(i) Calculate the abundance of the third isotope.

abundance = ... % [1]

(ii) The relative atomic mass of this sample of oxygen is 16.0044.

Calculate the mass number of the third isotope. You **must** show your working.

mass number = ... [2]

[Total: 11]

Q1.

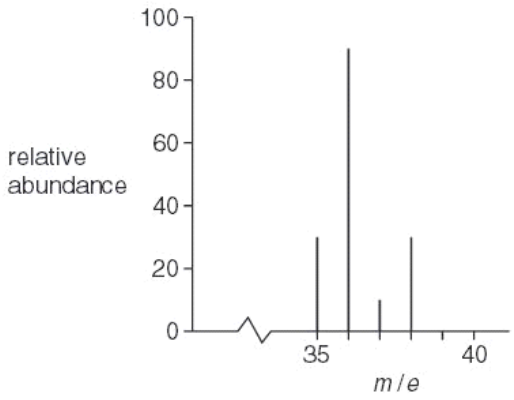
1 **(a)** Define *an isotope* in terms of its sub-atomic particles.

.....

.....

[1]

(b) In a mass spectrometer some hydrogen chloride molecules will split into atoms. The mass spectrum of HC*l* is given. Chlorine has two isotopes. The hydrogen involved here is the isotope $^{1}_{1}H$ only.



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(i) What particle is responsible for the peak at mass 35? .....

(ii) What particle is responsible for the peak at mass 38? .....
[2]

(c) Use the relative heights of the peaks to determine the proportions of the two isotopes of chlorine. Explain simply how you obtained your answer.

[2]

(d) Use your answer to **(c)** to explain why chlorine has a relative atomic mass of 35.5.

[1]

[Total : 6]

Q2.

1 Iron and cobalt are adjacent elements in the Periodic Table. Iron has three main naturally occurring isotopes, cobalt has one.

(a) Explain the meaning of the term *isotope*.

.....

.....

..... [2]

(b) The most common isotope of iron is ^{56}Fe; the only naturally occurring isotope of cobalt is ^{59}Co.

Use the *Data Booklet* to complete the table below to show the atomic structure of ^{56}Fe and of ^{59}Co.

	number of		
isotope	protons	neutrons	electrons
^{56}Fe			
^{59}Co			

[3]

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(c) A sample of iron has the following isotopic composition by mass.

isotope mass	54	56	57
% by mass	5.84	91.68	2.17

(i) Define the term *relative atomic mass*.

.....

.....

.....

.....

(ii) By using the data above, calculate the relative atomic mass of iron to **three** significant figures.

[5]

[Total: 10]

Q3.

Hydrogen sulphide is a weak diprotic (dibasic) acid. Its solution in water contains HS^- and a few S^{2-} ions.

(e) **(i)** What is meant by the term *weak acid*?

.....

.....

(ii) Write an equation, with state symbols, for the **first** ionisation of H_2S when it dissolves in water.

..... [3]

Q4.

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3 This question is about the elements in Group II of the Periodic Table, magnesium to barium.

(a) Complete the table below to show the electronic configuration of calcium atoms and of strontium ions, Sr^{2+}.

	1s	2s	2p	3s	3p	3d	4s	4p	4d
Ca	2	2	6						
Sr^{2+}	2	2	6						

[2]

(b) Explain the following observations.

(i) The atomic radii of Group II elements increase down the Group.

.....

.....

(ii) The strontium ion is smaller than the strontium atom.

.....

.....

(iii) The first ionisation energies of the elements of Group II decrease with increasing proton number.

.....

.....

.....

.....

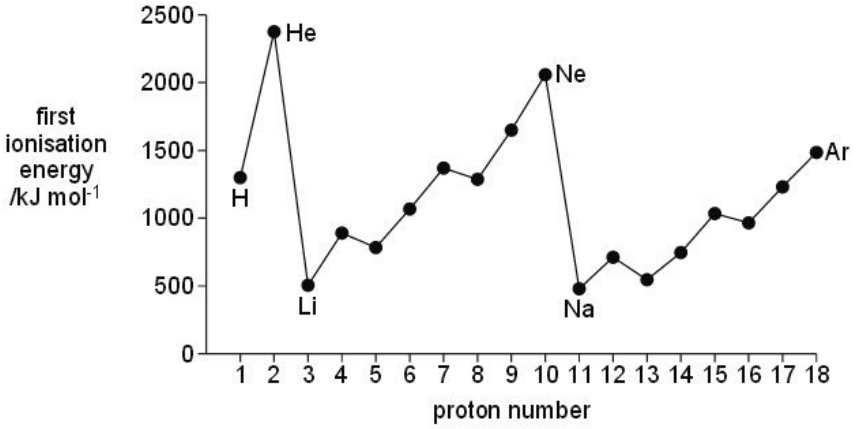
[4]

Q5.

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2 The Periodic Table we currently use is derived directly from that proposed by Mendeleev in 1869 after he had noticed patterns in the chemical properties of the elements he had studied.

The diagram below shows the first ionisation energies of the first 18 elements of the Periodic Table as we know it today.



(a) Give the equation, including state symbols, for the first ionisation energy of fluorine.

.....[2]

(b) Explain why there is a general increase in first ionisation energies from sodium to argon.

.....

.....

.....

.....[3]

(c) **(i)** Explain why the first ionisation energy of aluminium is less than that of magnesium.

.....

.....

.....

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(ii) Explain why the first ionisation energy of sulphur is less than that of phosphorus.

.....

.....

.....

[4]

Q6.

Copper and titanium are each used with aluminium to make alloys which are light, strong and resistant to corrosion.

Aluminium, *Al*, is in the third period of the Periodic Table; copper and titanium are both transition elements.

(a) Complete the electronic configuration of aluminium and of titanium, proton number 22.

Al	$1s^2$
Ti	$1s^2$

[1]

Phosphorus is a very reactive non-metallic element which readily forms ionic compounds with metals such as calcium and covalent compounds with non-metals such as chlorine and oxygen.

For Examiner Use

(a) (i) Write an equation, with state symbols, for the **second** ionisation energy of calcium.

.....

(ii) Use the *Data Booklet* to calculate the enthalpy change that occurs when one mole of gaseous calcium ions, Ca^{2+}, is formed from one mole of gaseous calcium atoms.
Include a sign in your answer.

enthalpy change = ... kJ mol^{-1} **[3]**

Q7.

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1 In the 19th and 20th centuries, experimental results showed scientists that atoms consist of a positive, heavy nucleus which is surrounded by electrons.

Then in the 20th century, theoretical scientists explained how electrons are arranged in orbitals around atoms.

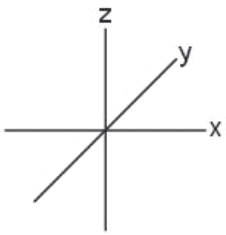
(a) The diagram below represents the energy levels of the orbitals present in atoms of the second period (Li to Ne).

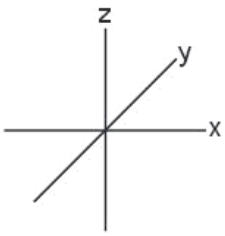
(i) Label the energy levels to indicate the principal quantum number **and** the type of orbital at each energy level.



(ii) On the axes below, draw a sketch diagram of **one** of each **different type (shape)** of orbital that is occupied by the electrons in a second-period element.

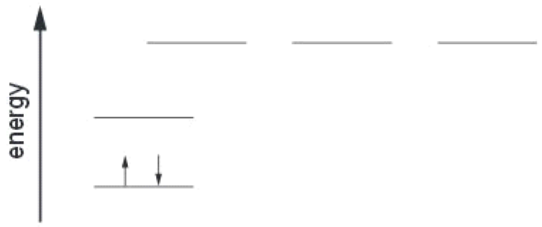
Label each type.



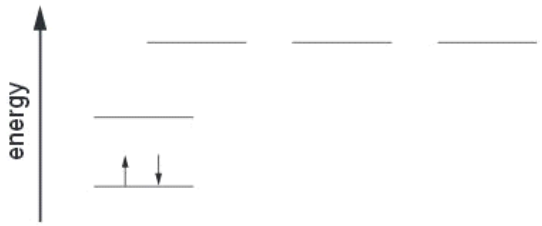


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(iii) Complete the electronic configurations of nitrogen atoms and oxygen atoms on the energy level diagrams below.
Use arrows to represent electrons.



nitrogen



oxygen

[6]

(b) **(i)** Use the *Data Booklet* to state the value of the first ionisation energy of nitrogen and of oxygen.

N ..... kJ mol^{-1} O ..... kJ mol^{-1}

(ii) Explain, with reference to your answer to **(a)(iii)**, the relative values of these two ionisation energies.

.....

.....

.....

[3]

[Total: 9]

Q8.

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2 The alkali metals are a series of six elements in Group I of the Periodic Table. The first ionisation energy of these elements shows a marked trend as the Group is descended.

For Examiner Use

(a) Define the term *first ionisation energy*.

.....

.....

..... [2]

(b) **(i)** State and explain the trend in first ionisation energy as Group I is descended.

.....

.....

.....

(ii) Suggest how this trend helps to explain the increase in the reactivity of the elements as the Group is descended.

.....

..... [3]

(c) In a redox reaction, 0.83 g of lithium reacted with water to form 0.50 dm^3 of aqueous lithium hydroxide.

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

(i) Calculate the amount, in moles, of lithium that reacted.

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(ii) Calculate the volume of hydrogen produced at room temperature and pressure.

(iii) Calculate the concentration, in mol dm^{-3}, of the LiOH(aq) formed.

[5]

(d) When heated in chlorine, all of the alkali metals react to form the corresponding chloride.

Describe what you see when sodium is heated in chlorine and write a balanced equation for the reaction.

description

.....

.....

.....

equation

.....

[2]

[Total: 12]

Q9.

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1 The first six ionisation energies of an element X are given below.

ionisation energy / kJ mol^{-1}					
first	second	third	fourth	fifth	sixth
950	1800	2700	4800	6000	12300

(a) Define the term *first ionisation energy*.

.....

.....

.....

..... [3]

(b) Write an equation, with state symbols, for the **second** ionisation energy of element X.

..... [2]

(c) Use the data given above to deduce in which Group of the Periodic Table element X is placed. Explain your answer.

Group .....

explanation .....

.....

.....

..... [3]

The first ionisation energies (I.E.) for the elements of Group IV are given below.

element	C	Si	Ge	Sn	Pb
1st I.E. / kJ mol^{-1}	1090	786	762	707	716

(d) Explain the trend shown by these values in terms of the atomic structure of the elements.

.....

.....

.....

.....

..... [4]

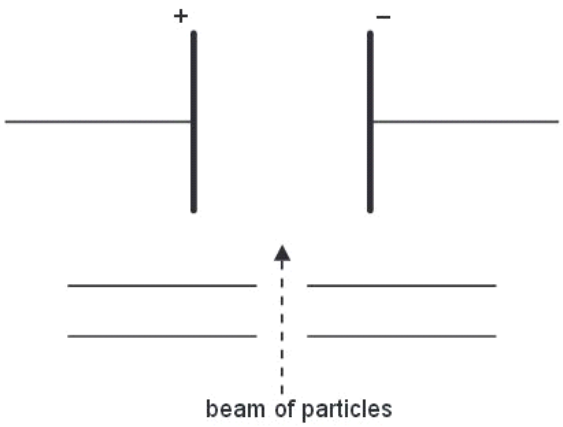
[Total: 12]

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Q10.

1 In the 19th and 20th centuries, scientists established the atomic theory and showed that three sub-atomic particles, electron, neutron and proton, exist. The masses and charges of these three particles were subsequently determined.

When separate beams of electrons, neutrons or protons are passed through an electric field in the apparatus below, they behave differently.



(a) (i) Which of these three particles will be deflected the most by the electric field?

.....

(ii) In which direction will this particle be deflected?

.....

(iii) Explain your answer.

.....

.....

[4]

(b) (i) Define the term *proton number*.

.....

.....

(ii) Why is the proton number of an atom of an element usually different from the nucleon number of an atom of the element?

.....

.....

[2]

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(c) Protons and neutrons have been used in nuclear reactions which result in the formation of artificial elements. In such processes, protons or neutrons are accelerated to high speeds and then fired like 'bullets' at the nucleus of an atom of an element.

Suggest why neutrons are more effective than protons as 'nuclear bullets'.

.....

..... [2]

(d) In some cases, when neutrons are fired at atoms of an element, the neutrons become part of the nucleus of those atoms.

What effect does the presence of an extra neutron have on the chemical properties of the new atoms formed? Explain your answer.

.....

.....

..... [2]

[Total: 10]

Q11.

1 Magnesium, Mg, and radium, Ra, are elements in Group II of the Periodic Table.

Magnesium has three isotopes.

(a) Explain the meaning of the term *isotope*.

.....

.....

..... [2]

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A sample of magnesium has the following isotopic composition by mass.

isotope mass	24	25	26
% by mass	78.60	10.11	11.29

(b) Calculate the relative atomic mass, A_r, of magnesium to **four** significant figures.

A_r = ...
[2]

For Examiner Use

Radium, proton number 88, and uranium, proton number 92, are radioactive elements.

The isotope ^{226}Ra is produced by the radioactive decay of the uranium isotope ^{238}U.

(c) Complete the table below to show the atomic structures of the isotopes ^{226}Ra and ^{238}U.

	number of		
isotopes	protons	neutrons	electrons
^{226}Ra			
^{238}U			

[3]

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(d) Radium, like other Group II elements, forms a number of ionic compounds.

(i) What is the formula of the radium cation?

……

(ii) Use the *Data Booklet* to suggest a value for the energy required to form one mole of the gaseous radium cation you have given in **(i)** from one mole of gaseous radium atoms. Explain your answer.

.....

.....

..... [3]

[Total: 10]

Q12.

1 The element magnesium, Mg, proton number 12, is a metal which is used in many alloys which are strong and light.

Magnesium has several naturally occurring isotopes.

(a) What is meant by the term *isotope*?

.....

.....

.....[2]

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(b) Complete the table below for two of the isotopes of magnesium.

isotope	number of protons	number of neutrons	number of electrons
^{24}Mg			
^{26}Mg			

[2]

A sample of magnesium had the following isotopic composition:
^{24}Mg, 78.60%; ^{25}Mg, 10.11%; ^{26}Mg, 11.29%.

(c) Calculate the relative atomic mass, A_r, of magnesium in the sample.
Express your answer to an appropriate number of significant figures.

[2]

Antimony, Sb, proton number 51, is another element which is used in alloys.

Magnesium and antimony each react when heated separately in chlorine.

(d) Construct a balanced equation for the reaction between magnesium and chlorine.

.....[1]

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When a 2.45 g sample of antimony was heated in chlorine under suitable conditions, 4.57 g of a chloride **A** were formed.

(e) **(i)** Calculate the amount, in moles, of antimony atoms that reacted.

(ii) Calculate the amount, in moles, of chlorine atoms that reacted.

(iii) Use your answers to **(i)** and **(ii)** to determine the empirical formula of **A**.

(iv) The empirical and molecular formulae of **A** are the same.

Construct a balanced equation for the reaction between antimony and chlorine.

.....[5]

(f) The chloride **A** melts at 73.4 °C while magnesium chloride melts at 714 °C.

(i) What type of bonding is present in magnesium chloride?

.....

(ii) Suggest what type of bonding is present in **A**.

.....[2]

[Total: 14]

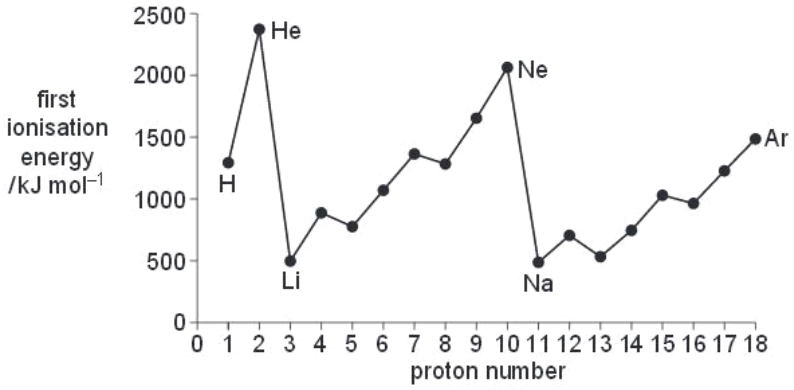
Q13.

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2 The Periodic Table we currently use is derived directly from that proposed in 1869 by Mendeleev who had noticed patterns in the physical and chemical properties of the elements he had studied.

For Examiner Use

The diagram below shows the first ionisation energies of the first 18 elements of the Periodic Table.



(a) Give the equation, including state symbols, for the first ionisation energy of sulfur.

..... [2]

(b) Explain why there is a **general** increase in first ionisation energies across the Period from sodium to argon.

.....

.....

.....

..... [3]

(c) **(i)** Explain why the first ionisation energy of magnesium is greater than that of aluminium.

.....

.....

.....

(ii) Explain why the first ionisation energy of phosphorus is greater than that of sulfur.

.....

.....

..... [4]

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Q14.

1 Sulfur, S, and polonium, Po, are both elements in Group VI of the Periodic Table.

Sulfur has three isotopes.

(a) Explain the meaning of the term *isotope*.

.....

.....

.....[2]

(b) A sample of sulfur has the following isotopic composition by mass.

isotope mass	32	33	34
% by mass	95.00	0.77	4.23

Calculate the relative atomic mass, A_r, of sulfur to **two** decimal places.

A_r = ...

[2]

(c) Isotopes of polonium, proton number 84, are produced by the radioactive decay of several elements including thorium, Th, proton number 90.

The isotope ^{213}Po is produced from the thorium isotope ^{232}Th.

Complete the table below to show the atomic structures of the isotopes ^{213}Po and ^{232}Th.

	number of		
isotope	protons	neutrons	electrons
^{213}Po			
^{232}Th			

[3]

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Radiochemical reactions, such as nuclear fission and radioactive decay of isotopes, can be represented by equations in which the nucleon (mass) numbers must balance and the proton numbers must also balance.

For example, the nuclear fission of uranium-235, $^{235}_{92}U$, by collision with a neutron, $^{1}_{0}n$, produces strontium-90, xenon-143 and three neutrons.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{90}_{38}Sr + ^{143}_{54}Xe + 3\,^{1}_{0}n$$

In this equation, the nucleon (mass) numbers balance because: 235 + 1 = 90 + 143 + (3x1).

The proton numbers also balance because: 92 + 0 = 38 + 54 + (3x0).

(d) In the first stage of the radioactive decay of $^{232}_{90}Th$, the products are an isotope of element *E* and an alpha-particle, $^{4}_{2}He$.

(i) By considering nucleon and proton numbers only, construct a balanced equation for the formation of the isotope of *E* in this reaction.

$$^{232}_{90}Th \rightarrow \text{.....} + ^{4}_{2}He$$

Show clearly the nucleon number and proton number of the isotope of *E*.

nucleon number of the isotope of *E* .....

proton number of the isotope of *E* .....

(ii) Hence state the symbol of the element *E*.

.....

[3]

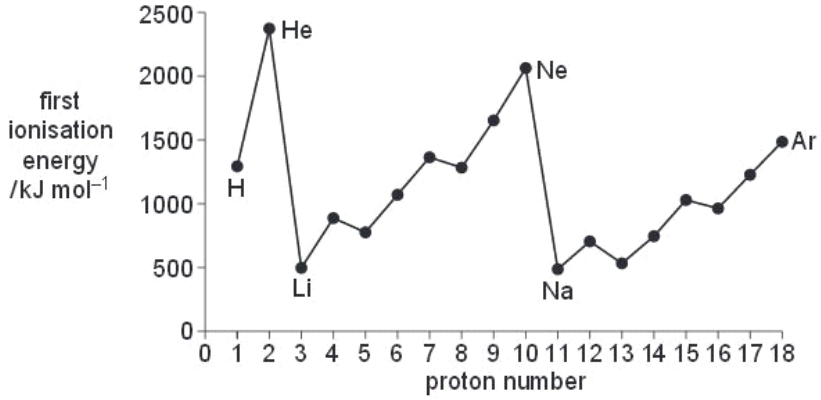
[Total: 10]

Q15.

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3 The Periodic Table we currently use is derived directly from that proposed in 1869 by Mendeleev who had noticed patterns in the physical and chemical properties of the elements he had studied.

The diagram below shows the first ionisation energies of the first 18 elements of the Periodic Table.



(a) Give the equation, including state symbols, for the first ionisation energy of carbon.

..... [2]

(b) **(i)** Explain why sodium has a lower first ionisation energy than magnesium.

.....

.....

(ii) Explain why magnesium has a higher first ionisation energy than aluminium.

.....

.....

(iii) Explain why helium, He, and neon, Ne, occupy the two highest positions on the diagram.

.....

.....

(iv) Explain why the first ionisation energy of argon, Ar, is lower than that of neon, which is lower than that of helium.

.....

.....

.....

[8]

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(c) (i) The first ionisation energies of the elements Na to Ar show a variation. Some physical properties show similar variations.

The atomic radius of the elements decreases from Na to Cl.

Give a brief explanation of this variation.

.....

.....

(ii) The cations formed by the elements Na to Al are smaller than the corresponding atoms.

Give a brief explanation of this change.

.....

.....

[3]

(d) The oxides of the elements of the third Period behave differently with NaOH(aq) and HCl (aq). In some cases, no reaction occurs.

Complete the table below by writing a balanced equation for any reaction that occurs, with heating if necessary. If you think no reaction takes place write 'no reaction'.

You do not need to include state symbols in your answers.

.....MgO(s) + ...NaOH (aq) →
.....MgO(s) + ...HCl (aq) →
.....Al_2O_3(s) + ...NaOH (aq) + ...H_2O (l) →
.....Al_2O_3(s) + ...HCl (aq) →
.....SO_2(g) + ...NaOH (aq) →
.....SO_2(g) + ...HCl (aq) →

[6]

[Total: 19]

Q16.

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1 Although the actual size of an atom cannot be measured exactly, it is possible to measure the distance between the nuclei of two atoms. For example, the 'covalent radius' of the Cl atom is assumed to be half of the distance between the nuclei in a Cl_2 molecule. Similarly, the 'metallic radius' is half of the distance between two metal atoms in the crystal lattice of a metal. These two types of radius are generally known as 'atomic radii'.
The table below contains the resulting atomic radii for the elements of period three of the Periodic Table, Na to Cl.

element	Na	Mg	Al	Si	P	S	Cl
atomic radius / nm	0.186	0.160	0.143	0.117	0.110	0.104	0.099

(a) (i) Explain qualitatively this variation in atomic radius.

.....

.....

.....

.....

.....

(ii) Suggest why it is not possible to use the same type of measurement for argon, Ar.

.....

.....

[4]

(b) (i) Use the *Data Booklet* to complete the following table of radii of the cations and anions formed by some of the period three elements.

radius of cation / nm			radius of anion / nm		
Na^+	Mg^{2+}	Al^{3+}	P^{3-}	S^{2-}	Cl^-

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(ii) Explain the differences in size between the cations and the corresponding atoms.

Exa

.....

.....

.....

(iii) Explain the differences in size between the anions and the corresponding atoms.

.....

.....

.....

[5]

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One of the most important chemical species responsible for the removal of ozone from the stratosphere is a free radical of chlorine, $^{35}Cl^{\bullet}$.

What does $^{35}Cl^{\bullet}$ contain?

	protons	neutrons	electrons
A	17	18	16
B	17	18	17
C	18	17	17
D	18	17	18

[2002 O/N (2)]

Unnilpentium is an artificial element. One of its isotopes is $^{262}_{105}Unp$.

Which of the following statements is correct?

A $^{262}_{105}Unp$ has a nucleon number of 105.

B The atom $^{260}_{105}X$ is an isotope of $^{262}_{105}Unp$.

C There are 262 neutrons in $^{262}_{105}Unp$.

D The proton number of $^{262}_{105}Unp$ is 262.

[2003 O/N (4)]

What is the order of increasing energy of the listed orbitals in the atom of titanium?

A 3s 3p 3d 4s

B 3s 3p 4s 3d

C 3s 4s 3p 3d

D 4s 3s 3p 3d

[2004 M/J (4)]

Which of the following particles would, on losing an electron, have a half-filled set of p orbitals?

A C^- **B** N **C** N^- **D** O^+

[2004 M/J (5)]

The isotope cobalt-60 ($^{60}_{27}Co$) is used to destroy cancer cells in the human body.

Which statements about an atom of cobalt-60 are correct?

1 It contains 33 neutrons.

2 Its nucleus has a relative charge of 27+.

3 It has a different number of neutrons from the atoms of other isotopes of cobalt.

[2004 M/J (31)]

Use of the Data Booklet is relevant to this question.

It is now thought that where an element exists as several isotopes, the stable ones usually contain a 'magic number' of neutrons. One of these magic numbers is 126.

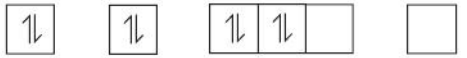
Which isotope is unstable?

A ^{209}Bi **B** ^{208}Pb **C** ^{210}Po **D** ^{208}Tl

[2004 O/N (4)]

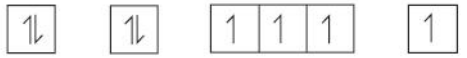
An atom has eight electrons.

Which diagram shows the electronic configuration of this atom in its lowest energy state?

A 

B 

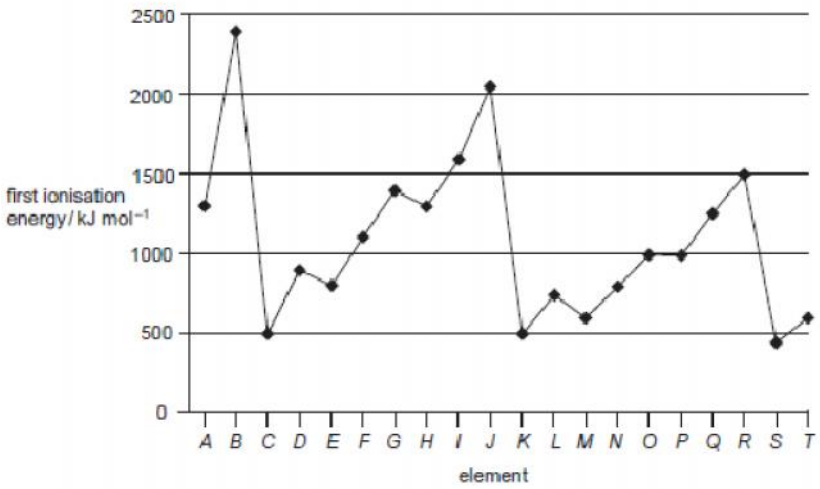
C 

D 

[2004 O/N (5)]

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The first ionisation energies of successive elements in the Periodic Table are represented in the graph.



Which of these statements about this graph are correct?

1 Elements *B*, *J* and *R* are in Group 0 of the Periodic Table.

2 Atoms of elements *D* and *L* contain 2 electrons in their outer shells.

3 Atoms of elements *G* and *O* contain half-filled p orbitals.

[2004 O/N (34)]

The first six ionisation energies of four elements, **A** to **D**, are given.

Which element is most likely to be in Group IV of the Periodic Table?

ionisation energy / kJ mol $^{-1}$	1st	2nd	3rd	4th	5th	6th
A	494	4560	6940	9540	13400	16600
B	736	1450	7740	10500	13600	18000
C	1090	2350	4610	6220	37800	47000
D	1400	2860	4590	7480	9400	53200

[2005 M/J (3)]

In which species are the numbers of electrons and neutrons equal?

A $^{9}_{4}Be$ **B** $^{19}_{9}F$ **C** $^{23}_{11}Na^{+}$ **D** $^{18}_{8}O^{2}$

[2005 M/J (4)]

The following species contain the same number of electrons.

In which order do their radii increase?

	smallest radius →		largest radius
A	Ar	K^+	Ca^{2+}
B	Ca^{2+}	Ar	K^+
C	Ca^{2+}	K^+	Ar
D	K^+	Ar	Ca^{2+}

[2005 M/J (12)]

Which ion has 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

[2005 O/N (2)]

Gallium nitride, GaN, could revolutionise the design of electric light bulbs because only a small length used as a filament gives excellent light at low cost.

Gallium nitride is an ionic compound containing the Ga^{3+} ion.

What is the electron arrangement of the nitrogen ion in gallium nitride?

A $1s^2\ 2s^2$

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

C $1s^2\ 2s^2\ 2p^4$

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

[2006 M/J (3)]

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A radioactive isotope of thallium, $^{201}_{81}Tl$, is used to assess damage in heart muscles after a heart attack.

Which statement about $^{201}_{81}Tl$ is correct?

A This isotope has a nucleon number of 120.

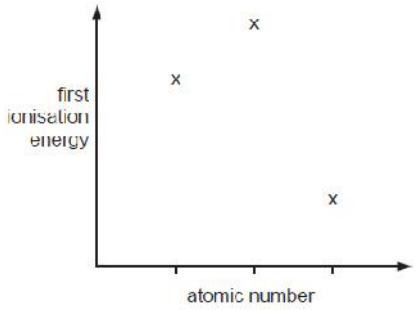
B The number of electrons in one atom of this isotope is 81.

C The number of neutrons in one atom of this isotope is 201.

D $^{201}_{82}X$ is an isotope of $^{201}_{81}Tl$.

[2006 M/J (4)]

Three successive elements in the Periodic Table have first ionisation energies which have the pattern shown in the diagram.



What could be the first element of this sequence?

A C **B** N **C** F **D** Na

[2006 O/N (2)]

Use of the Data Booklet is relevant to this question.

The electronic structures of calcium, krypton, phosphorus and an element **X** are shown.

Which electronic structure is that of element **X**?

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

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

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

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

[2006 O/N (3)]

John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

A Atoms are very small in size.

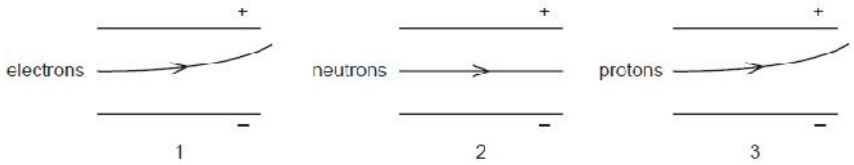
B No atom can be split into simpler parts.

C All the atoms of a particular element have the same mass.

D All the atoms of one element are different in mass from all the atoms of other elements.

[2007 M/J (3)]

The diagrams show the possible paths of subatomic particles moving in an electric field in a vacuum.



Which diagrams are correct?

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

[2007 M/J (4)]

Use of the Data Booklet is relevant to this question.

The technetium–99 isotope (^{99}Tc) is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc?

1 It has 13 more neutrons than protons.

2 It has 43 protons.

3 It has 99 nucleons.

[2007 M/J (31)]

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Use of the Data Booklet is relevant to this question.

In forming ionic compounds, elements generally form an ion with the electronic structure of a noble gas.

Which ion does **not** have a noble gas electronic structure?

A I^- **B** Rb^+ **C** Sn^{2+} **D** Sr^{2+}

[2007 O/N (2)]

Skin cancer can be treated using a radioactive isotope of phosphorus, $^{32}_{15}P$. A compound containing the phosphide ion $^{32}_{15}P^{3-}$, wrapped in a plastic sheet, is strapped to the affected area.

What is the composition of the phosphide ion, $^{32}_{15}P^{3-}$?

	protons	neutrons	electrons
A	15	17	18
B	15	17	32
C	17	15	17
D	32	17	15

[2008 M/J (3)]

In which pair do both atoms have one electron only in an s orbital in their ground states?

A Ca, Sc **B** Cu, Be **C** H, He **D** Li, Cr

[2008 O/N (3)]

The first seven ionisation energies of an element between lithium and neon in the Periodic Table are as follows.

1310 3390 5320 7450 11 000 13 300 71 000 $kJmol^{-1}$

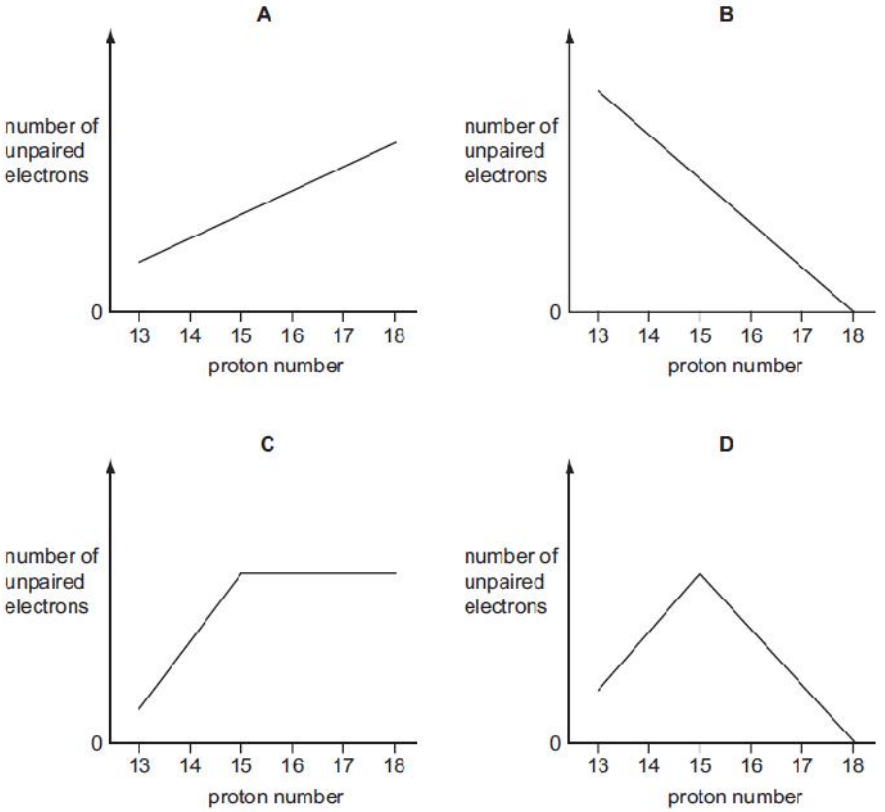
What is the outer electronic configuration of the element?

A $2s^2$ **B** $2s^22p^1$ **C** $2s^22p^4$ **D** $2s^22p^6$

[2009 M/J (3)]

Use of the Data Booklet is relevant to this question.

Which graph represents the number of unpaired p orbital electrons for atoms with proton numbers 13 to 18?



[2009 M/J (4)]

Use of the Data Booklet is relevant to this question.

What could be the proton number of an element that has three unpaired electrons in each of its atoms?

A 5 **B** 13 **C** 15 **D** 21

[2010 M/J – 11(1)]

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Use of the Data Booklet is relevant to this question.

The elements radon (Rn), francium (Fr) and radium (Ra) have consecutive proton numbers in the Periodic Table.

What is the order of their first ionisation energies?

	least endothermic →		most endothermic
A	Fr	Ra	Rn
B	Fr	Rn	Ra
C	Ra	Fr	Rn
D	Rn	Ra	Fr

[2010 M/J - 11(2)]

A simple ion X^+ contains eight protons.

What is the electronic configuration of X^+?

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

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

C $1s^2\ 2s^2\ 2p^5$

D $1s^2\ 2s^2\ 2p^7$

[2010 O/N - 13(1)]

Which ion has more electrons than protons and more protons than neutrons?
[H = ^1_1H ; D = ^2_1H ; O = $^{16}_8O$]

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

[2010 O/N - 13(3)]

Which equation represents the second ionisation energy of an element X?

A $X(g) \rightarrow X^{2+}(g) + 2e^-$

B $X^+(g) \rightarrow X^{2+}(g) + e^-$

C $X(g) + 2e^- \rightarrow X^{2-}(g)$

D $X^-(g) + e^- \rightarrow X^{2-}(g)$

[2011 M/J – 11(1)]

Helium, He, is the second element in the Periodic Table.

Tritium is the isotope of hydrogen ^3H.

What is the same in an atom of ^4He and an atom of ^3H?

A the number of electrons

B the number of neutrons

C the number of protons

D the relative atomic mass

[2011 M/J – 12(1)]

In 1999, researchers working in the USA believed that they had made a new element and that it had the following electronic configuration.

$$[Rn]\ 5f^{14}6d^{10}7s^27p^6$$

In which Group of the Periodic Table would you expect to find this element?

A II **B** IV **C** VI **D** 0

[2011 M/J – 12(13)]

Which element has an equal number of electron pairs and of unpaired electrons within orbitals of principal quantum number 2?

A beryllium

B carbon

C nitrogen

D oxygen

[2011 O/N – 11(1)]

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Use of the Data Booklet is relevant to this question.

From which particle is the removal of an electron the most difficult?

A $Cl^-(g)$ **B** $F^-(g)$ **C** $K^+(g)$ **D** $Na^+(g)$

[2011 O/N – 12(3)]

In which species does the underlined atom have an incomplete outer shell?

A $\underline{B}F_3$ **B** $\underline{C}H_3^-$ **C** $F_2\underline{O}$ **D** $H_3\underline{O}^+$

[2012 M/J – 11(1)]

Use of the Data Booklet is relevant to this question.

In which pairs do both species have the same number of unpaired p electrons?

1 O and Cl^+

2 F^+ and Ga^-

3 P and Ne^+

[2012 M/J – 11(32)]

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

A $^{11}_{5}B$ **B** $^{19}_{9}F^-$ **C** $^{23}_{11}Na^+$ **D** $^{24}_{12}Mg^{2+}$

[2012 M/J – 12(2)]

In which species does the underlined atom have an incomplete outer shell?

A $\underline{Al_2Cl_6}$ **B** $\underline{C}H_3^+$ **C** $Cl_2\underline{O}$ **D** $H_2\underline{C}lC\bullet$

[2012 M/J – 12(4)]

Use of the Data Booklet is relevant to this question.

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

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

A It has 4 electrons in its outer p subshell.

B It has 13 electrons in its outer shell.

C It has 37 neutrons.

D Its proton number is 32.

[2012 O/N – 11(2)]

John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

A All atoms are very small in size.

B All the atoms of a particular element have the same mass.

C All the atoms of one element are different in mass from all the atoms of other elements.

D No atom can be split into simpler parts.

[2012 O/N – 11(9)]

Use of the Data Booklet is relevant to this question.

The isotope ^{99}Tc is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc?

1 It has 13 more neutrons than protons.

2 It has 43 protons.

3 It has 99 nucleons.

[2012 O/N – 11(32)]

The phosphide ion $^{31}_{15}P^{3-}$ and sulfide ion $^{32}_{16}S^{2-}$ have the same number of which sub-atomic particles?

1 neutrons

2 electrons

3 protons

[2012 O/N – 13(32)]

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

A $^{27}_{13}Al$ **B** $^{35}_{17}Cl^-$ **C** $^{32}_{16}S^{2-}$ **D** $^{39}_{19}K^+$

[2013 M/J – 11(5)]

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Which ion has 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^-

[2013 M/J – 12(3)]

Use of the Data Booklet is relevant to this question.

In which pairs do both species have the same number of unpaired p electrons?

1 Al^{2-} and O^+

2 N and Cl^{2+}

3 C and Cl^+

[2013 M/J – 12(31)]

Use of the Data Booklet is relevant to this question.

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** $^{32}_{16}S^{2-}$

[2013 M/J – 13(2)]

Use of the Data Booklet is relevant to this question.

Which statements are correct when referring to the atoms ^{23}Na and ^{24}Mg?

1 They have the same number of full electron orbitals.

2 They have the same number of neutrons.

3 They are both reducing agents.

[2013 M/J – 13(32)]

X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?

1 $^{38}_{18}Ar$

2 $^{40}_{20}Ca^{2+}$

3 $^{39}_{19}K^+$

[2013 O/N – 11(31)]

Use of the Data Booklet is relevant to this question.

In which set do all species contain the same number of electrons?

A Co^{2+}, Co^{3+}, Co^{4+}

B F^-, Br^-, Cl^-

C Na^+, Mg^{2+}, Al^{3+}

D K_2SO_4, K_2SeO_4, K_2TeO_4

[2013 O/N – 12(4)]

X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?

1 $^{38}_{18}Ar$

2 $^{40}_{20}Ca^{2+}$

3 $^{39}_{19}K^+$

[2013 O/N – 12(31)]

The $^{1}H_3^+$ ion was first characterised by J. J. Thomson over a century ago. ^{6}Li is a rare isotope of lithium which forms the $^{6}Li^+$ ion.

Which statements are correct?

1 Both ions contain the same number of protons.

2 Both ions contain the same number of electrons.

3 Both ions contain the same number of neutrons.

[2013 O/N – 13(31)]

Use of the Data Booklet is relevant to this question.

Atoms of element X have six unpaired electrons.

What could be element X?

A carbon

B chromium

C iron

D selenium

[2014 M/J – 11(1)]

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Use of the Data Booklet is relevant to this question.

The most common ion-molecule reaction in gas clouds of the Universe is as shown.

$$H_2(g) + H_2^+(g) \rightarrow H(g) + H_3^+(g)$$

What could be the composition of an H_3^+ ion?

	protons	neutrons	electrons
A	2	1	1
B	2	1	2
C	3	0	1
D	3	0	2

[2014 M/J – 13(4)]

In 2011 an international group of scientists agreed to add two new elements to the Periodic Table. Both elements had been made artificially and were called ununquadium (Uuq) and ununhexium (Uuh).

	Uuq	Uuh
proton number	114	116
nucleon number	289	292

Which statements about these elements are correct?

1 One atom of Uuh has one more neutron than one atom of Uuq.

2 One Uuq^{2-} ion has the same number of electrons as one atom of Uuh.

3 One Uuh^+ ion has the same number of electrons as one Uuq^- ion.

[2014 M/J – 13(31)]

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Atomic structure – 2022 June AS Chemistry 9701

1. June/2022/Paper_11/No.1

Which atom has its outermost electron in an orbital of the shape shown, with principal quantum number 3?



A sodium

B chlorine

C calcium

D bromine

2. June/2022/Paper_11/No.2

Which atom has the same number of electrons as the hydroxide ion, OH^-?

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

3. June/2022/Paper_12/No.1

Equations involving four enthalpy changes are shown.

$Na(g) \rightarrow Na^+(g) + e^-$ $\Delta H = W$

$Na(g) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = X$

$Na(s) \rightarrow Na(g)$ $\Delta H = Y$

$Na(s) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = Z$

Which equation represents the second ionisation energy of sodium?

A X **B** X + Y – W **C** X – W **D** Z – W

4. June/2022/Paper_12/No.2

This question refers to isolated gaseous atoms in the ground state.

In which atom are all electrons paired?

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

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5. June/2022/Paper_12/No.6

Elements J and L are both in Group 15.

J and L each form a gaseous covalent hydride in which their oxidation number is –3.

In the liquefied forms of these hydrides, significant hydrogen bonding occurs only in the hydride of L.

Which row about J and L could be correct?

	identity of J	identity of L	outer shell electron configuration
A	As	N	p^5
B	As	N	s^2p^3
C	N	As	p^5
D	N	As	s^2p^3

6. June/2022/Paper_13/No.1

Which atom has exactly three unpaired electrons in the ground state?

A an isolated gaseous aluminium atom

B an isolated gaseous carbon atom

C an isolated gaseous chromium atom

D an isolated gaseous phosphorus atom

7. June/2022/Paper_13/No.2

Which element has the **second** smallest atomic radius in its group and the **second** highest electrical conductivity in its period?

A boron

B calcium

C magnesium

D sodium

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8. June/2022/Paper_13/No.39

A sample of sulfur consists mostly of ^{32}S. It also contains 4.2% ^{34}S and 2.8% ^{36}S. No other isotopes of sulfur are present.

What is the relative atomic mass, A_r, of **this** sample of sulfur?

A 32.1 **B** 32.2 **C** 34.0 **D** 34.3

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9. June/2022/Paper_21/No.1(e)

(e) A sample of magnesium contains three isotopes, ^{25}Mg, ^{26}Mg and **X**.

The percentage abundance of the three isotopes is shown in Table 1.1.

Table 1.1

isotope of Mg	mass / a.m.u.	percentage abundance / %
X		78.99
^{25}Mg	24.99	10.00
^{26}Mg	25.98	11.01

(i) The relative atomic mass, A_r, is calculated by comparing the average mass of the isotopes of an element to the unified atomic mass unit.

Define the unified atomic mass unit.

..... [1]

(ii) Calculate the mass of **X**. Use data from Table 1.1 and A_r (magnesium) = 24.31 in your calculation. Show your working.

mass of **X** = ...
[2]

(iii) State **one** similarity and **one** difference in the properties of these isotopes of magnesium. Explain your answer.

.....

.....

..... [2]

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10. June/2022/Paper_23/No.1(a, b)

(a) Define first ionisation energy.

.....

.....

..... [2]

(b) Successive ionisation energies for element **A** are shown in Table 1.1.

Table 1.1

ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
ionisation energy / kJ mol^{-1}	1310	3390	5320	7450	11 000	13 300	71 000	84 100

Use Table 1.1 to deduce the group of the Periodic Table that **A** belongs to. Explain your answer.

Group .....

.....

[1]

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Atomic structure – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.3

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.

2. Nov/2022/Paper_11/No.4

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

3. Nov/2022/Paper_12/No.1

Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?

A A phosphorus atom has one more proton in its nucleus.

B The atomic radius of a phosphorus atom is greater.

C The outer electron in a phosphorus atom is more shielded.

D The outer electron in a phosphorus atom is paired.

4. Nov/2022/Paper_21/No.1

Atoms with nuclei containing an odd number of protons tend to have fewer isotopes than those with an even number of protons.

(a) Gallium has two stable isotopes, ^{69}Ga and ^{71}Ga.

(i) Complete Table 1.1 to show the numbers of protons, neutrons and electrons in the two stable isotopes of gallium.

Table 1.1

isotope	number of protons	number of neutrons	number of electrons
^{69}Ga			
^{71}Ga			

[2]

(ii) Define relative atomic mass.

.....

.....

..... [2]

(iii) The relative atomic mass of gallium, A_r, is 69.723.
The relative isotopic masses of ^{69}Ga and ^{71}Ga are:

^{69}Ga, 68.926; ^{71}Ga, 70.925.

Use this information to calculate the percentage abundance of ^{69}Ga in elemental gallium.
Show your working.
Assume that the element contains only the ^{69}Ga and ^{71}Ga isotopes.
Give your answer to **four** significant figures.

percentage abundance of ^{69}Ga = ... %
[2]

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(b) Potassium also has two stable isotopes. Both isotopes have the same chemical properties.

(i) Explain why both isotopes of potassium have the same chemical properties.

.....

..... [1]

(ii) State the full electronic configuration of an atom of potassium.

..... [1]

(iii) The first, second and third ionisation energies of potassium are 418, 3070 and 4600 kJ mol^{-1}, respectively.

Use this information to explain why potassium is in Group 1.

.....

.....

.....

..... [2]

[Total: 10]

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