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ELECTRONIC CONFIGURATION WS 1

1 Complete the electronic configurations of atoms of the following elements:

a) Phosphorus: [Ne].....

b) Cobalt: [Ar].....

2 Fill in the outer electrons of a phosphorus atom in the boxes below:

3s	3p

3 The successive ionisation energies of an element, X, are given in the table. To which group of the periodic table does element X belong?

Ionisation	Ionisation energy/ kJ mol^{-1}
1st	1 000
2nd	2 260
3rd	3 390
4th	4 540
5th	6 990
6th	8 490
7th	27 100
8th	31 700
9th	36 600
10th	43 100

.....

5 Write down the complete electronic configurations for the following elements:

a) Mn:

b) Mn^{2+} :

c) Cu^{2+} :

- 6 a) Explain what you understand by the word 'orbital' as applied to electrons.

.....

.....

- b) Draw an s- and a p- orbital.

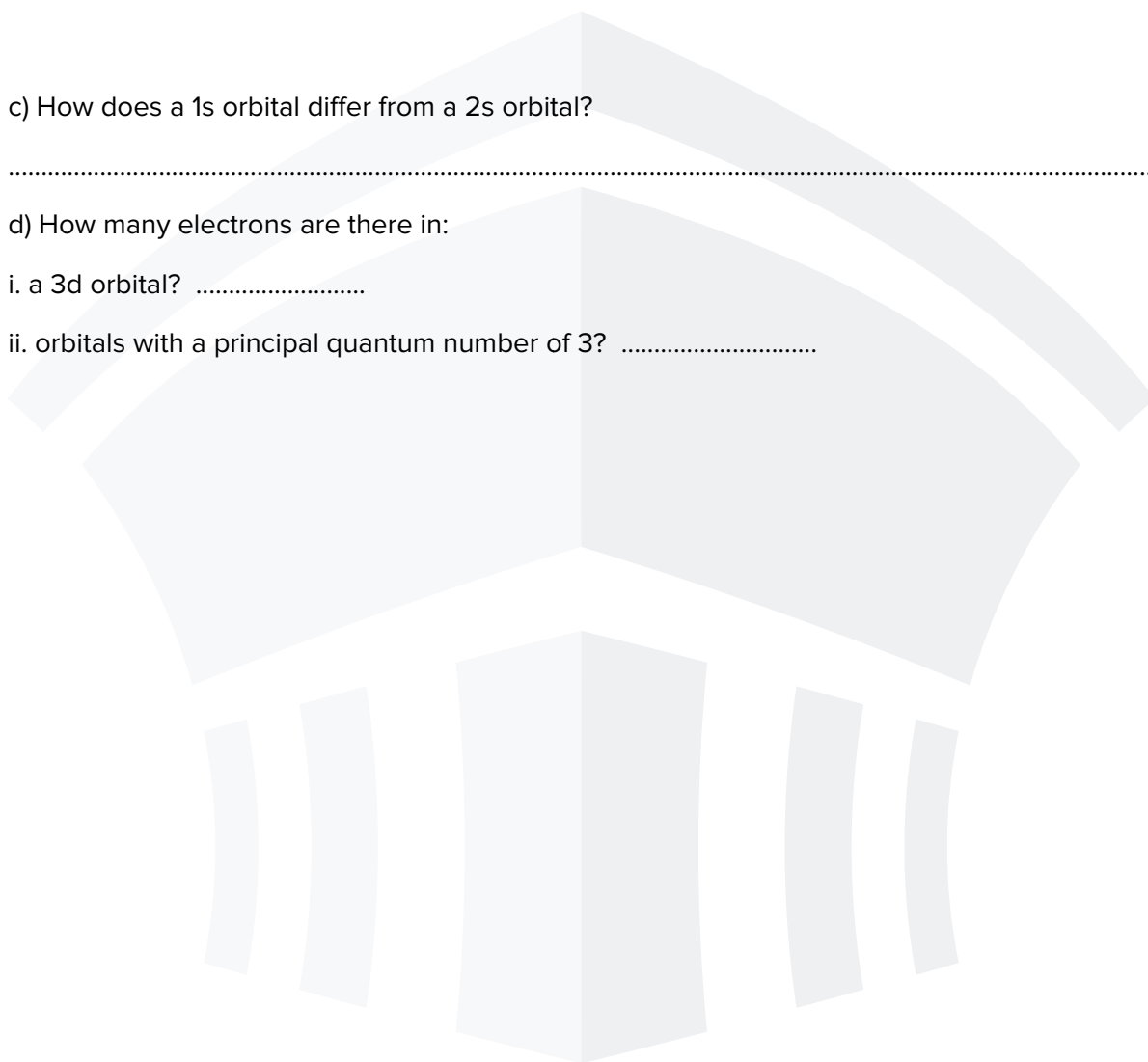
- c) How does a 1s orbital differ from a 2s orbital?

.....

- d) How many electrons are there in:

i. a 3d orbital?

ii. orbitals with a principal quantum number of 3?



ELECTRONIC CONFIGURATION WS 2

- 1 Successive ionisation energies of an element X in kJ/mol are as follows:

578	1817	2745	11578	14831	18378
-----	------	------	-------	-------	-------

Which one of the following is X?

- A boron
B carbon
C aluminium
D silicon

- 2 Which one of the rows giving information about the fourth period of the periodic table is correct?

	Total number of orbitals	The number of different types of orbital	Maximum number of electrons in the shell
A	4	2	8
B	9	2	18
C	9	3	8
D	9	3	18

- 3 What is the order of increasing energy of the orbitals within a single energy level?

- A $d > s < f < p$
B $s < p < d < f$
C $p < s < f < d$
D $f < d < p < s$

- 4 What is the condensed electronic configuration for Co^{3+} ?

- A $[\text{Ar}]4s^23d^5$
B $[\text{Ar}]4s^23d^4$
C $[\text{Ar}]3d^6$
D $[\text{Ar}]4s^13d^5$

- 5 Which are the values of the successive ionisation energies for an element in Group 14 of the periodic table?

- A 496, 738, 578, 789, 1012, 1000
B 578, 1817, 2745, 11578, 14831, 18378
C 1086, 2353, 4621, 6223, 37832, 47278
D 1314, 1000, 941, 869, 812

- 6 Which are the values for the first ionisation energies of consecutive elements in the same period?
- A 496, 738, 578, 789, 1012, 1000 C 1086, 2353, 4621, 6223, 37832, 47278
- B 578, 1817, 2745, 11578, 14831, 18378 D 1314, 1000, 941, 869, 812

- 7 Use of the Data Booklet is relevant to this question.

In the gas phase, aluminium and a transition element require the same amount of energy to form one mole of an ion with a 2+ charge.

What is the transition element?

- A Co
B Cr
C Cu
D Ni

[W'02 3]

- 8 The successive ionisation energies, in kJ mol^{-1} , of an element X are given below.

870 1800 3000 3600 5800 7000 13 200

What is X?

- A ${}_{33}\text{As}$ B ${}_{40}\text{Zr}$ C ${}_{52}\text{Te}$ D ${}_{53}\text{I}$

[S'03 4]

- 9 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^+

[S'04 5]

- 10 The table gives the successive ionisation energies for an element X.

	1st	2nd	3rd	4th	5th	6th
ionisation energy / kJ mol^{-1}	950	1800	2700	4800	6000	12300

What could be the formula of the chloride of X?

- A XCl B XCl_2 C XCl_3 D XCl_4

[W'03 5]

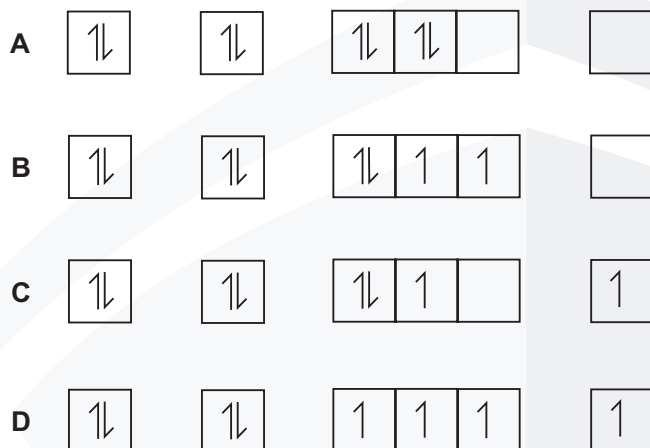
11 What is the order of increasing energy of the listed orbitals in the atom of titanium?

- A 3s 3p 3d 4s
 B 3s 3p 4s 3d
 C 3s 4s 3p 3d
 D 4s 3s 3p 3d

[S'04 4]

12 An atom has eight electrons.

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



[W'04 5]

13 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

[S'05 3]

14 What is the electronic configuration of an element with a **second** ionisation energy higher than that of each of its neighbours in the Periodic Table?

- A $1s^2 2s^2 2p^6 3s^2$
 B $1s^2 2s^2 2p^6 3s^2 3p^1$
 C $1s^2 2s^2 2p^6 3s^2 3p^2$
 D $1s^2 2s^2 2p^6 3s^2 3p^3$

[S'05 3]

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



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

- A II B IV C VI D 0

[S'11 2 13]

- 16 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 $1s^2 2s^2 2p^6$

[S'06 3]

- 17 *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 $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

[W'06 3]

- 18 *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+}

[W'07 2]

- 19 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

[W'08 3]

- 20 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 kJ mol^{-1}

What is the outer electronic configuration of the element?

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

[S'09 13]

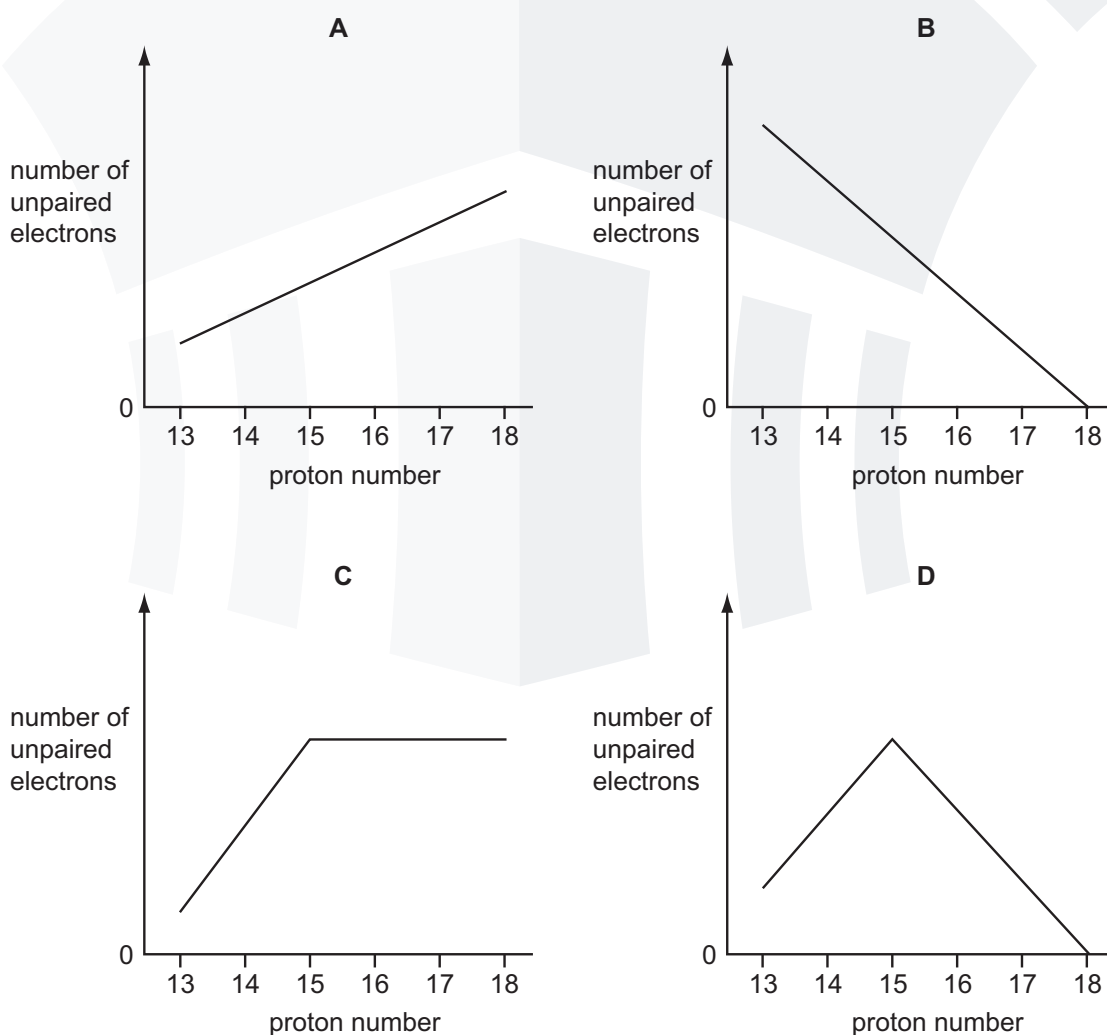
- 21 Which element has an equal number of electron pairs and of unpaired electrons within orbitals of principal quantum number 2?

- A beryllium
B carbon
C nitrogen
D oxygen

[W'11 13]

- 22 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?



[S'09 14]

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ELECTRONIC CONFIGURATION WS 2

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23 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

[W'13 2 4]

24 Element X forms X^- ions that can be oxidised to element X by acidified potassium manganate(VII).

What could be the values of the first four ionisation energies of X?

	1st	2nd	3rd	4th
A	418	3070	4600	5860
B	577	1820	2740	11 600
C	590	1150	4940	6480
D	1010	1840	2040	4030

[W'13 3 4]

25 Atoms of element X have six unpaired electrons.

What could be element X?

- A carbon
- B chromium
- C iron
- D selenium

[S'14 1 1]

26 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

[M'16 2 2]

- 27 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	10 400
Y	1000	1800	2700	4800	6000	12 300

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

[S'16 2 3]

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

- A** boron
B fluorine
C sodium
D potassium

[S'16 2 5]

- 30 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

- 31 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 $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$
C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

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

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

- 33 This question refers to isolated gaseous atoms.

In which atom are all electrons paired?

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

[S'18 1 Q1]

- 34 Element X has a higher first ionisation energy than element Y.

Two students state what they believe is one factor that helps to explain this.

student 1 "X has a higher first ionisation energy than Y because an atom of X has more protons in its nucleus than an atom of Y."

student 2 "X has a higher first ionisation energy than Y because X has a smaller atomic radius than Y."

Only **one** of the two students is correct.

What could X and Y be?

	X	Y
A	carbon	boron
B	magnesium	aluminium
C	oxygen	nitrogen
D	oxygen	sulfur

[S'18 1 Q10]

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

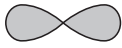
How many valence shell and unpaired electrons are present in one sulfur atom?

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

[S'18 2 Q2]

36 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

[S'18 3 Q3]

SECTION B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

1 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^+

[S'12 3 32]

2 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.

[S'07 31]

3 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.

[S'13 3 32]

4 Carbon and nitrogen are adjacent in the Periodic Table.

Which properties do they both have?

- 1 There is an empty 2p orbital in one atom of the element.
- 2 The principal quantum number of the highest occupied orbital is 2.
- 3 They form compounds in which their atoms form bonds with four other atoms.

[S'13 1 32]



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ELECTRONIC CONFIGURATION WS 3

1 Electrons are arranged in energy levels.

(a) An orbital is a region in which an electron may be found.

Draw diagrams to show the shape of an s orbital and of a p orbital.

s orbital	p orbital
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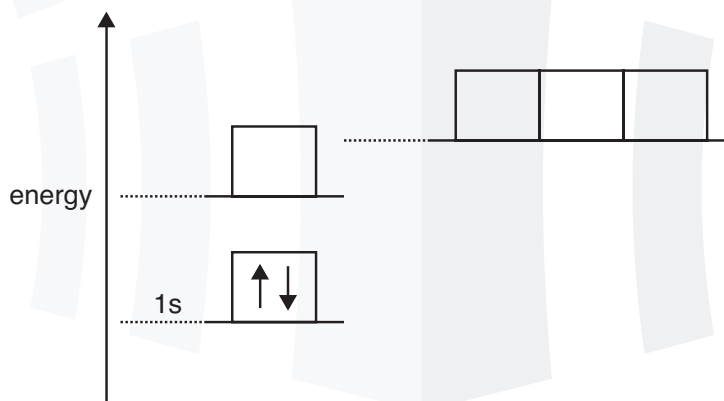
[2]

(b) Complete the table below to show how many electrons **completely** fill each of the following.

	number of electrons
a d orbital	
a p sub-shell	
the third shell ($n = 3$)	

[3]

(c) The energy diagram below is for the eight electrons in an oxygen atom. The diagram is incomplete as it only shows the two electrons in the 1s level.



Complete the diagram for the oxygen atom by:

(i) adding labels for the other sub-shell levels,

[1]

(ii) adding arrows to show how the other electrons are arranged.

[1]

- (d) Successive ionisation energies provide evidence for the arrangement of electrons in atoms. **Table 1.1** shows the eight successive ionisation energies of oxygen.

Table 1.1

ionisation number	1st	2nd	3rd	4th	5th	6th	7th	8th
ionisation energy / kJ mol ⁻¹	1314	3388	5301	7469	10989	13 327	71 337	84 080

- (i) Define the term **first ionisation energy**.

.....
.....
.....
..... [3]

- (ii) Write an equation, with state symbols, to represent the **third** ionisation energy of oxygen.

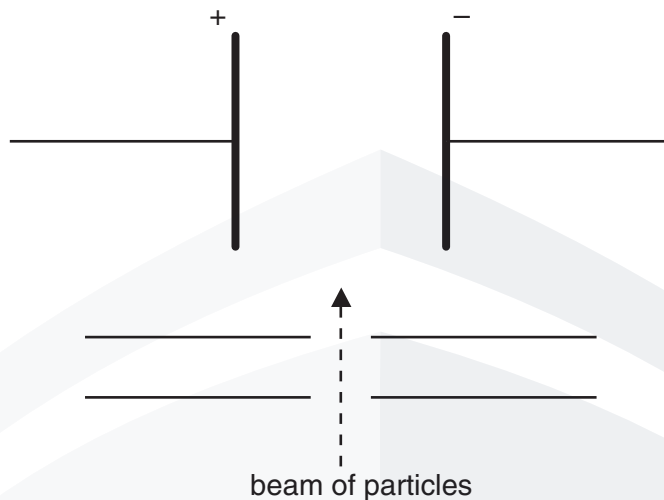
..... [2]

- (iii) Explain how the information in **Table 1.1** provides evidence for two electron shells in oxygen.

.....
.....
.....
..... [2]

- 3 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]

- (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]

- 4 The first six successive ionisation energies of an element **D** are shown in Table 4.1 below.

Table 4.1

element	ionisation energy / kJ mol ⁻¹					
	1st	2nd	3rd	4th	5th	6th
D	1086	2353	4621	6223	37832	47278

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

.....
.....
.....
..... [3]

- (b) Write an equation, with state symbols, to represent the **third** ionisation energy of element **D**.

..... [2]

- (c) Use Table 4.1 to deduce which group of the Periodic Table contains element **D**. Explain your answer.

group

explanation

.....
..... [3]

- 5 (a) Explain what is meant by the term *ionisation energy*.

.....

.....

..... [3]

- (b) The first seven ionisation energies of an element, **A**, in kJ mol^{-1} , are

1012 1903 2912 4957 6274 21 269 25 398.

- (i) State the group of the Periodic Table to which **A** is most likely to belong. Explain your answer.

.....

.....

..... [2]

- (ii) Complete the electronic configuration of the element in Period 2 that is in the same group as **A**.

$1s^2$ [1]

- (c) Another element, **Z**, in the same period of the Periodic Table as **A**, reacts with chlorine to form a compound with empirical formula ZCl_2 . The percentage composition by mass of ZCl_2 is **Z**, 31.13; **Cl**, 68.87.

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

.....

.....

..... [2]

- (ii) Calculate the relative atomic mass, A_r , of **Z**.
Give your answer to **three** significant figures.

A_r of **Z** = [2]