1. Atomic Structure

1.3 Electrons, energy levels and atomic orbitals

Paper 2

Question Paper

1 Cobalt, rhodium and iridium are metals in the same group of the Periodic Table.

(a) The shorthand electronic configuration of cobalt is $[Ar]3d^74s^2$.

(i) Identify what is meant by [Ar] by giving its full electronic configuration.

..... [1]

(ii) The lowest-energy electrons in cobalt are in the 1s orbital.

Draw the shape of a 1s orbital.

[1]

(iii) Deduce the number of unpaired electrons in a cobalt atom.

..... [1]

2 **(c)** Determine the full electronic configuration of Fe^{3+}.

..... [1]

3 Vanadium, niobium and tantalum are metals in the same group of the Periodic Table.

(a) The shorthand electronic configuration of vanadium in the ground state is $[Ar]3d^34s^2$.

(i) State what is meant by the term ground state.

..... [1]

(ii) Show the electronic configuration of vanadium using electrons in boxes notation.

[Ar] ☐ ☐ ☐ ☐ ☐ ☐

[1]

(iii) Deduce the total number of electrons in the p sub-shells of a vanadium atom.

..... [1]

4 Tellurium is an element in Group 16. The most common isotope of tellurium is ^{130}Te. Its electronic configuration is [Kr] $4d^{10}\ 5s^2\ 5p^4$.

(b) Identify the sub-shell in an atom of Te that contains electrons with the lowest energy.

..... [1]

5 The elements phosphorus, sulfur and chlorine are in Period 3 of the Periodic Table.

Table 1.1 shows some properties of the elements P to C*l*.

The first ionisation energy of S is **not** shown.

Table 1.1

property	P	S	C*l*
number of electrons in 3p subshell			
total number of unpaired electrons			
first ionisation energy /kJ mol^{-1}	1060		1260
formula of most common anion	P^{3-}	S^{2-}	Cl^-

(a) (i) Complete Table 1.1 to show the number of electrons in the 3p subshell and the total number of unpaired electrons in an atom of P, S and C*l*. [2]

(b) P^{3-}, S^{2-} and Cl^- have the same number of electrons.

(i) Give the full electronic configuration of P^{3-}.

..... [1]

6 The elements silicon, phosphorus and sulfur are in Period 3 of the Periodic Table.

(b) Table 1.1 shows some properties of the elements Si to S.

The first ionisation energy of P is **not** shown.

Table 1.1

property	Si	P	S
total number of electrons in s subshells			
total number of electrons in p subshells			
first ionisation energy / kJ mol^{-1}	786		1000
formula of most common chloride	$SiCl_4$	PCl_5	SCl_2

(i) Complete Table 1.1 to show the total number of s and p electrons in an atom of Si, P and S.

[2]

7 Calcium, magnesium and radium are Group 2 elements. Radium follows the same trends as the other members of Group 2.

(a) Identify the highest energy orbital which contains electrons in a calcium atom. Sketch the shape of this orbital.

identity of highest energy orbital in Ca .....

shape

[1]

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

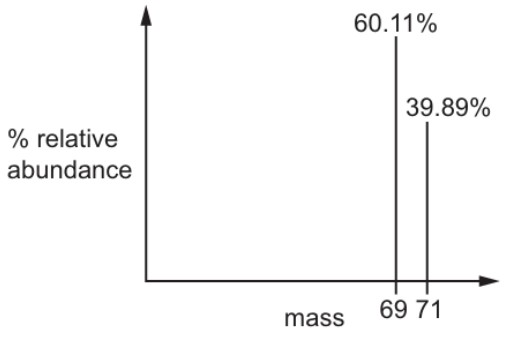
(b) Potassium also has two stable isotopes. Both isotopes have the same chemical properties.

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

..... [1]

9 Gallium is an element in Group 13.

A sample of gallium is analysed using a mass spectrometer. The mass spectrum produced is shown.



(c) Complete the table which describes a gaseous atom of gallium.

isotope	nucleon number	total number of electrons in **lowest** energy level	type of orbital which contains the electron in the **highest** energy level
^{71}Ga			

[3]

10 The reducing agent $LiAlH_4$ can be synthesised by reacting aluminium chloride with lithium hydride, LiH.

(a)(iii) Lithium hydride contains the ions Li^+ and H^-.

State the electronic configuration of these two ions.

Li^+ ..... H^- .....

[1]

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

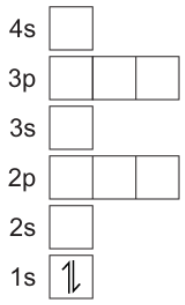
(b) Electrons in atoms up to $_{36}Kr$ are distributed in s, p and d orbitals.

(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 $_9F$.

..... [1]

12 **(c)** The energy value required to remove the first electron from an atom of argon is circled on the graph.

Sketch the shape of the orbital that contains this electron.

[1]

13 In the Periodic Table, the p block contains elements whose outer electrons are found in the p subshell.

(a) Elements in the p block show a general increase in first ionisation energy as the atomic number increases.

(i) Draw the shape of a p orbital.

[1]