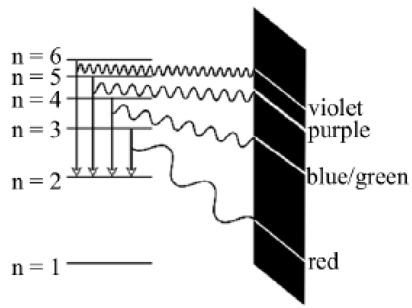
Arrangement of Electrons in the Atom

Question 1

5. (*a*) The diagram shows the relationship between the visible lines in the hydrogen spectrum and the corresponding energy levels in a hydrogen atom.



(*i*) Distinguish between the *ground state* and the *excited states* of the electron in a hydrogen atom.

(*ii*) How can the electron in a hydrogen atom become excited?

(*iii*) Explain the origin of the series of visible lines in the emission spectrum of hydrogen.

What name is given to this series?

(*iv*) Explain why there is no yellow line in the hydrogen emission spectrum. (24)

(*b*) Describe how to carry out a flame test to confirm the presence of lithium in a salt sample. (9)

(*c*) Atomic energy levels first described by Bohr are now known to contain energy sublevels and orbitals.

Define an atomic orbital.

Distinguish between a 2*p* orbital and a 2*p* sublevel.

Write the *s*, *p* electron configuration for a calcium atom.

Explain in terms of energy sublevels why the arrangement of electrons in the main energy levels in a calcium atom is 2, 8, 8, 2 and not 2, 8, 10. (17)

Question 2

(*d*) In 1913 Bohr proposed that electrons in an atom occupy certain stable states or *energy levels*.

Explain how the line emission spectrum of hydrogen arises and provides evidence for the existence of energy levels. (12)

(*e*) The colours produced by fireworks provide evidence for energy levels in atoms of other elements.

Suggest an element that gives a blue-green colour to a fireworks display. (3)

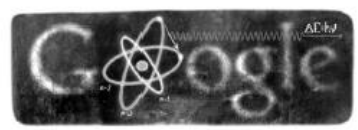
(*f*) Bohr's theory was later modified and we now understand that electrons in an atom occupy *atomic orbitals*.

Write the *s*, *p* electron configuration of a calcium atom in its ground state.

Give one significant difference between an electron in the 2*s* orbital and an electron in the 3*s* orbital of a calcium atom. (8)

Question 3

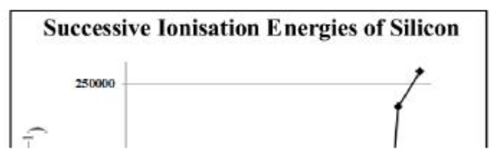
5. (*a*) Name the scientist whose work on energy levels in the hydrogen atom is depicted in the Google doodle reproduced on the right.



Distinguish between the terms *energy level* and *atomic orbital*. (14)

Write the electron configuration (*s*, *p*) of an atom of silicon showing the distribution of electrons in atomic orbitals in the ground state. (6)

Hence, state how many (*i*) main energy levels, (*ii*) atomic orbitals, are occupied in the silicon atom in its ground state. (6)



Question 4

(*a*) Write the electron configuration (*s*, *p*, *etc.*) of a zinc atom in its ground state.

Question 5

(*a*) State the number of (*i*) sub-levels (subshells), (*ii*) orbitals, occupied by electrons in an argon atom in its ground state.

Question 6

(*a*) Write the electron configuration (*s, p, etc.*) of the oxygen (oxide) ion ($\mathbf{O^{2-}}$).

Question 7

5. (*a*) State **two** assumptions of Dalton's atomic theory of 1808. (8)

(*b*) The electron was the first of the sub-atomic particles to be discovered. It was identified in experiments using cathode rays that were carried out in the late nineteenth century.

Name the scientist

(*i*) who, about 1897, measured the ratio of charge to mass of the electron, *e*/*m*,

(*ii*) who, about 1910, proved that the electrons in an atom reside in an electron cloud surrounding a small dense positive central nucleus,

(*iii*) who, about 1911, measured the charge on the electron, *e*. (9)

(*c*) The arrangement of the electrons in the electron cloud proposed in 1913 by Bohr, pictured on the right, was consistent with the hydrogen emission spectrum.

Outline Bohr's atomic theory based on the hydrogen emission spectrum. (15)

(*d*) State **two** limitations of Bohr's theory that led to its modification. (6)

(*e*) Define *atomic orbital*.

Draw the shape of the *p*-orbital.

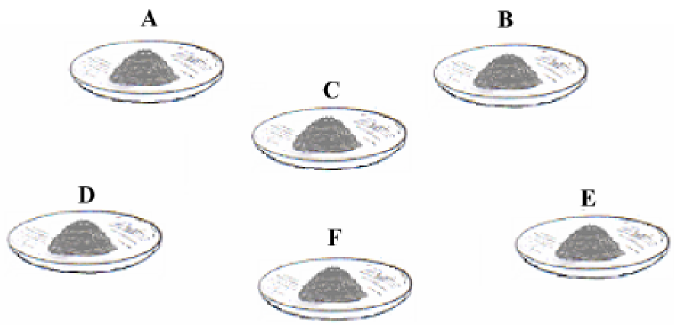
State the maximum number of electrons that can be accommodated in a *p*-orbital. (12)

Question 8

(*c*) State the *Heisenberg uncertainty principle*.

Question 9

3. The clock glasses shown in the diagram contained pure samples of the following salts: **KCl**, **KNO_3**, **$Na_2HPO_4.12H_2O$**, **$Na_2SO_3.7H_2O$**, **$NaHCO_3$** and **$Na_2SO_4.10H_2O$**. Each clock glass (**A – F**) contained a different salt. A student was provided with standard laboratory apparatus and reagents, and was asked to identify the six salts.



(*a*) Describe how the student could have distinguished between the samples that contained potassium ions and those that contained sodium ions using the flame test technique. (11)

(*b*) Which of the substances listed above was identified by the addition of silver nitrate, **$AgNO_3$**, solution to a solution of each sample in turn? What observation indicated a positive test result? (6)

(*c*) One of the samples gave a brown ring when a little concentrated sulfuric acid was carefully poured down the inside of a slanting test tube which contained a solution of the salt, together with another reagent. What was the other reagent? Which salt was identifiable by the appearance of a brown ring? (6)

(*d*) Describe how you would test the samples for the presence of the phosphate anion. (9)

(*e*) Having completed the tests referred to in (*a*) – (*d*) above the student should have positively identified three of the salts. A solution of barium chloride, **$BaCl_2$**, was then added to solutions of each of the three remaining samples in turn. A white precipitate was produced in two cases. Write a balanced equation for either **one** of the two reactions that occurred.

The student then added dilute hydrochloric acid to the precipitates.
What would the student have observed and what conclusion should have been drawn regarding the identities of the two salts? (12)

(*f*) The student was able to identify the last salt by a process of elimination. Suggest a way of confirming the identity of this salt. (6)