Multiple Choice Questions (Type-1)

1. Which of the following conclusions could not be derived from Rutherford's α -particle scattering experiment?
(i) Most of the space in the atom is empty.
(ii) The radius of the atom is about 10–10 m while that of a nucleus is 10–15 m.
(iii) Electrons move in a circular path of fixed energy called orbits.
(iv) Electrons and the nucleus are held together by electrostatic forces of attraction.
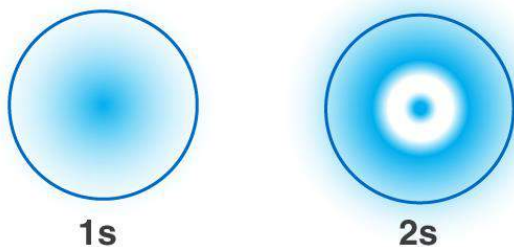**Solution:**
Option (iii) is the answer.

2. Which of the following options does not represent ground state electronic configuration of an atom?
(i) 1s2 2s2 2p6 3s2 3p6 3d8 4s2
(ii) 1s2 2s2 2p6 3s2 3p6 3d9 4s2
(iii) 1s2 2s2 2p6 3s2 3p6 3d10 4s1
(iv) 1s2 2s2 2p6 3s2 3p6 3d5 4s1
Solution:
Option (ii) is the answer.

3. The probability density plots of 1s and 2s orbitals are given in Fig. 2.1:

1s   2s

The density of dots in a region represents the probability density of finding electrons in the region.
Based on the above diagram which of the following statements is incorrect?
(i) 1s and 2s orbitals are spherical.
(ii) The probability of finding the electron is maximum near the nucleus.
(iii) The probability of finding the electron at a given distance is equal in all directions.
(iv) The probability density of electrons for 2s orbital decreases uniformly as the distance from the nucleus increases.
Solution:
Option (iv) is the answer.

4. Which of the following statement is not correct about the characteristics of cathode rays?
(i) They start from the cathode and move towards the anode.
(ii) They travel in a straight line in the absence of an external electrical or magnetic field.
(iii) Characteristics of cathode rays do not depend upon the material of electrodes in a cathode ray tube.
(iv) Characteristics of cathode rays depend upon the nature of gas present in the cathode ray tube.
Solution:
Option (iv) is the answer.

5. Which of the following statements about the electron is incorrect?
(i) It is a negatively charged particle.
(ii) The mass of an electron is equal to the mass of a neutron.
(iii) It is a basic constituent of all atoms.
(iv) It is a constituent of cathode rays.
Solution:
Option (ii) is the answer.

6. Which of the following properties of an atom could be explained correctly by Thomson Model of an atom?
(i) Overall neutrality of atom.
(ii) Spectra of a hydrogen atom.
(iii) Position of electrons, protons and neutrons in an atom.
(iv) Stability of atom.
Solution:
Option (i) is the answer.

7. Two atoms are said to be isobars if.
(i) they have the same atomic number but a different mass number.
(ii) they have the same number of electrons but a different number of neutrons.
(iii) they have the same number of neutrons but a different number of electrons.
(iv) the sum of the number of protons and neutrons is the same but the number of protons is different.
Solution:
Option (iv) is the answer.

8. The number of radial nodes for 3p orbital is _____.
(i) 3
(ii) 4
(iii) 2
(iv) 1
Solution:
Option (iv) is the answer.

9. Number of angular nodes for 4d orbital is _____.
(i) 4
(ii) 3
(iii) 2
(iv) 1
Solution:
Option (iii) is the answer.

10. Which of the following is responsible to rule out the existence of definite paths or trajectories of electrons?
(i) Pauli's exclusion principle.
(ii) Heisenberg's uncertainty principle.
(iii) Hund's rule of maximum multiplicity.
(iv) Aufbau principle.
Solution:
Option (ii) is the answer.

11. A total number of orbitals associated with the third shell will be _____.
(i) 2
(ii) 4
(iii) 9
(iv) 3
Solution:
Option (iii) is the answer.

12. Orbital angular momentum depends on _____.
(i) l
(ii) n and l
(iii) n and m
(iv) m and s
Solution:
Option (i) is the answer.

13. Chlorine exists in two isotopic forms, Cl-37 and Cl-35 but its atomic mass is 35.5. This indicates the ratio of Cl-37 and Cl-35 is approximately
(i) 1:2
(ii) 1:1
(iii) 1:3
(iv) 3:1
Solution:
Option (iii) is the answer.

14. The pair of ions having same electronic configuration is _____.
(i) Cr^{3+}, Fe^{3+}
(ii) Fe^{3+}, Mn^{2+}
(iii) Fe^{3+}, Co^{3+}

(iv) Sc^{3+}, Cr^{3+}
Solution:
Option (ii) is the answer.

15. For the electrons of an oxygen atom, which of the following statements is correct?
(i) Zeff for an electron in a 2s orbital is the same as Zeff for an electron in a 2p orbital.
(ii) An electron in the 2s orbital has the same energy as an electron in the 2p orbital.
(iii) Zeff for an electron in 1s orbital is the same as Zeff for an electron in a 2s orbital.
(iv) The two electrons present in the 2s orbital have spin quantum numbers ms but of opposite sign.
Solution:
Option (iv) is the answer.

16. If travelling at the same speeds, which of the following matter waves have the shortest wavelength?
(i) Electron
(ii) An alpha particle (He2+)
(iii) Neutron
(iv) Proton
Solution:
Option (ii) is the answer.

II. Multiple Choice Questions (Type-II)
In the following questions, two or more options may be correct.

17. Identify the pairs which are not of isotopes?
(i) $_6X^{12}$, $_6Y^{13}$
(ii) $_{17}X^{35}$, $_6Y^{37}$
(iii) $_6X^{14}$, $_7Y^{14}$
(iv) $_4X^8$, $_5Y^8$
Solution:
Option (iii) and (iv) are the answers.

18. Out of the following pairs of electrons, identify the pairs of electrons present in degenerate orbitals :
(i) (a) n = 3, l = 2, ml = –2, ms= − 1/2
(b) n = 3, l = 2, ml = –1, ms= − 1/2
(ii) (a) n = 3, l = 1, ml = 1, ms = +1/2
(b) n = 3, l = 2, ml = 1, ms = +1/2
(iii) (a) n = 4, l = 1, ml = 1, ms = +1/2
(b) n = 3, l = 2, ml = 1, ms = +1/2
(iv) (a) n = 3, l = 2, ml = +2, ms = − 1/2

(b) n = 3, l = 2, ml = +2, ms = +1/2
Solution:
Option (i) and (iv) are the answers.

19. Which of the following sets of quantum numbers is correct?

	n	l	ml
(i)	1	1	+2
(ii)	2	1	+1
(iii)	3	2	–2
(iv)	3	4	–2

Solution:
Option (ii) and (iii) are the answers

20. In which of the following pairs, the ions are iso-electronic?
(i) Na^+, Mg^{2+}
(ii) Al^{3+}, O^-
(iii) Na^+, O^{2-}
(iv) N^{3-}, Cl^-
Solution;
Option (i) and (iii) are the answers.

21. Which of the following statements concerning the quantum numbers are correct?
(i) The angular quantum number determines the three-dimensional shape of the orbital.
(ii) The principal quantum number determines the orientation and energy of the orbital.
(iii) The magnetic quantum number determines the size of the orbital.
(iv) Spin quantum number of an electron determines the orientation of the spin of the electron relative to the chosen axis.
Solution:
Option (i) and (iv) are the answers.

III. Short Answer Type

22. Arrange s, p and d sub-shells of a shell in the increasing order of effective nuclear charge (Zeff) experienced by the electron present in them.
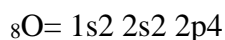**Solution:**
d<p<s
S orbitals shield the electrons from the nucleus more than p-orbitals which shield more in d.

23. Show the distribution of electrons in oxygen atom (atomic number 8) using orbital diagram.
Solution:

$_8O$= 1s2 2s2 2p4

24. Nickel atom can lose two electrons to form Ni2+ ion. The atomic number of nickel is 28. From which orbital will nickel lose two electrons.
Solution:
One Ni atom has 28 electrons and its electronic configuration is : [Ar] 4s2 3d8
It becomes Ni2+ by losing 2 electrons, hence configuration of Ni2+ is : [Ar] 4s0 3d8
So, nickel loses two electrons from the 4s orbital, not the 3d orbital as per the Aufbau principle

25. Which of the following orbitals are degenerate?
3dxy, 4dxy, 3dz2 , 3dyx, 4dyx, 4dzz
Solution:
The energy of orbitals depends on the principal quantum number or the main shell to a large extent. Hence, orbitals with an equal value of n will have the same levels of energy and will be called degenerate orbitals.
Degenerate orbitals are 3dxy, 3dz2, 3dyx because they have the same main shell n = 3.
And 4dxy, 4dyx, 4dzz because they have the same value of n=4.

26. Calculate the total number of angular nodes and radial nodes present in 3p orbital.
Solution:
Nodes are the region present among the orbitals where the probability density of finding electrons will be zero.
In case of np orbitals , radial nodes = n – l – 1 = 3 –1 - 1 = 1
Angular nodes = l = 1.

27. The arrangement of orbitals based on energy is based upon their (n+l) value. Lower the value of (n+l), lower is the energy. For orbitals having the same values of (n+l), the orbital with a lower value of n will have lower energy.

I. Based upon the above information, arrange the following orbitals in the increasing order of energy
(a) 1s, 2s, 3s, 2p
(b) 4s, 3s, 3p, 4d
(c) 5p, 4d, 5d, 4f, 6s
(d) 5f, 6d, 7s, 7p
II. Based upon the above information, solve the questions given below :
(a) Which of the following orbitals has the lowest energy?
4d, 4f, 5s, 5p
(b) Which of the following orbitals has the highest energy?

5p, 5d, 5f, 6s, 6p
Solution:
(i) (a) the increasing order of energy of the given orbital is : 1s >2s >2p> 3s
(b) the increasing order of energy of the given orbital is : 3s<3p<4s<4d
(c) the increasing order of energy of the given orbital is : 4d<5p<6s<4f<5d
(d)the increasing order of energy of the given orbital is: 7s<5f<6d<7p
(ii) (a) among the orbitals, 5s has the lowest energy.
the (n+l) value for 5s is the lowest = 5 + 0 = 5. Other orbitals have (n+l)value more than 5 –
5p= 5 + 1 = 6 , 4f = 4 + 3 = 7 , 4d = 4 + 2 = 6.
(b) among the orbitals , 5f has the highest energy because the (n +l) value - 5 + 3 = 8 is highest.
5d = 5 + 2 = 7 , 5p = 5 + 1= 6 , 6s =6 + 0 = 6 , 6p =6 + 1 = 7.

28. Which of the following will not show deflection from the path on passing through an electric field?
Proton, cathode rays, electron, neutron
Solution:
Neutron will not show deflection from the path on passing through an electric field.
This is due to the neutral nature of the neutron particles. Therefore, it has no charge and does not get affected by any electric field.
Among other 3 particles proton (positive), electron (negative), cathode rays (the beam of electrons, negatively charged) all have charges in them so they will get deflected easily by an electric field.

29. An atom having atomic mass number 13 has 7 neutrons. What is the atomic number of the atom?
Solution:
The mass number of an atom = number of protons + number of neutrons
Therefore atomic number (number of protons) = mass number – no. Of neutrons.
The atomic number of atom: 13 – 7 = 6.

30. Wavelengths of different radiations are given below :
λ(A) = 300 nm
λ(B) = 300 μm
λ(c) = 3 nm
λ (D) 30 A°
Arrange these radiations in the increasing order of their energies.
Solution:
According to Planck's quantum theory, energy is related to the frequency of radiation by :
E = h × Frequency
So, E is proportional to 1/ λ
Hence, the relation b/w energy and wavelength are inversely proportional, therefore lesser the wavelength higher will be the energy of the radiation.
For the given wavelengths
λ(A) = 300 nm = 300 x 10-9 m = 3 x 10 -7 m
λ(B) = 300 μm = 3 00 x 10-6 = 3 x 10-4
λ(c) = 3 nm = 3 x 10 – 9
λ (D) 30 A° = 3 X 10 - 9

the increasing order of the given wavelengths : λ(c) = λ (D) <λ(A)< λ(B)
hence the increasing order of energy will be the opposite: λ(B)< λ(A:<λ(c) = λ (D)

31. The electronic configuration of the valence shell of Cu is 3d10 4s1 and not 3d94s2. How is this configuration explained?
Solution:
Configuration with filled and half-filled orbitals has extra stability. In 3d104s1, d orbitals are filled and s orbitals are half-filled.

32. The Balmer series in the hydrogen spectrum corresponds to the transition from n1 = 2 to n2 = 3,4,.......... This series lies in the visible region. Calculate the wavenumber of the line associated with the transition in Balmer series when the electron moves to n = 4 orbit. (RH= 109677 cm-1)
Solution:
 According to Bohr's model for the hydrogen atom

ν = RH(1/n12-1/ n22)cm-1

here, n1 = 2 and n2 = 4 and H = Rydberg's constant = 109677

Hence, wave number -v= 109677 (¼-1/16)
                                     = 20564.44cm-1

33. According to de Broglie, the matter should exhibit dual behaviour, that is both particle and wave-like properties. However, a cricket ball of mass 100 g does not move like a wave when it is thrown by a bowler at a speed of 100 km/h. Calculate the wavelength of the ball and explain why it does not show wave nature.
Solution:
m= 100g or 0.1kg
v= 100km/h =100*1000/60*60 = 1000/36m/s
λ =h/mv = 2.387*10-34m

34. What is the experimental evidence in support of the idea that electronic energies in an atom are quantized?
Solution:
The bright-line spectrum shows that the energy levels in an atom are quantized. These lines are obtained as a result of electronic transitions between the energy .and if the electronic energy levels were continuous and not quantized or discrete; the atomic spectra would have shown a continuous absorption(from lower to higher energy level transition) or emission (from higher to lower energy level transition.

35. Out of electron and proton which one will have, a higher velocity to produce matter waves of the same wavelength? Explain it.
Solution:

Out of electron and proton, being the lighter particle electron will have a higher velocity and will also produce matter waves of the same wavelength.

36. A hypothetical electromagnetic wave is shown in Fig. 2.2. Find out the wavelength of the radiation.
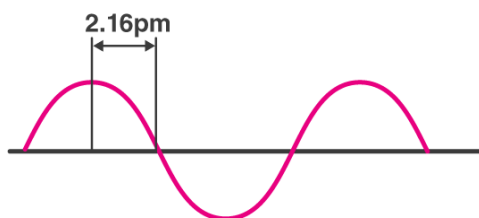
Solution:
The wavelength can be defined as the distance between two alike successive points in a wave (usually b/w two maxima s i.e. peaks or two minima s i.e. troughs are shown in the fig.)
So, for the given hypothetical wave, wavelength λ = 4 * 2.16 pm
= 8.64 pm.

37. Chlorophyll present in green leaves of plants absorbs light at 4.620×10^{14} Hz. Calculate the wavelength of radiation in nanometer. Which part of the electromagnetic spectrum does it belong to?
Solution:
Relation b/w wavelength and frequency can be expressed as :
$\lambda = c/\nu$, where c be the velocity of light and ν is the frequency of the radiation.
For the given problem $\lambda = 3 \times 10^8$ ms-1 / 4.620×10^{14} Hz
= 0.6494 times10^{-6}m-1

38. What is the difference between the terms orbit and orbital?
Solution:
The orbit stands for a definite circular path for the electrons to revolve around the nucleus. It represents the two-dimensional motion of the electrons around the nucleus, the orbital is not that well-defined path because it's a region around the nucleus where the probability of finding an electron is maximum.

39. Table-tennis ball has a mass 10 g and a speed of 90 m/s. If speed can be measured within an accuracy of 4% what will be the uncertainty in speed and position?
Solution:
According to Heisenberg's uncertainty principle :
"It is fundamentally impossible to determine accurately both the velocity and the position of a particle at the same time.
$\Delta x . \Delta p \geq h/4\pi$

From the given problem,

mass of the ball = 4 g and speed is = 90 m /s

hence,the uncertainity of speed is $\Delta v = 4/100 \times 90 = 3.6$ m/s
Δx is given by $\Delta x = h/4\pi m\Delta v$

Hence , the uncertainity of postion is $\Delta x = 6.26 \times 10^{-34} / 4 \times 3.14 \times 4 \times 3.6$

$$= 1.46 \times 10^{-33} \text{ m}$$

40. The effect of the uncertainty principle is significant only for the motion of microscopic particles and is negligible for the macroscopic particles. Justify the statement with the help of a suitable example.
Solution:
The uncertainty principle is only significantly applicable for microscopic particles and not macroscopic particles this can be concluded from the measurement of uncertainty:
For example, if we take a particle or an object of mass 1 milligram i.e. 10^{-6} kg)

We calculate the,
$\Delta x. \Delta v = 60626*10^{-34}/ 4*3.14*10^{-6}$

$= 10^{-28}$ m^{-2} s $^{-1}$
The value we got is negligible and very insignificant for the uncertainty principle to apply to the particle.

41. The hydrogen atom has only one electron, so mutual repulsion between electrons is absent. However, in multielectron atoms mutual repulsion between the electrons is significant. How does this affect the energy of an electron in the orbitals of the same principal quantum number in multielectron atoms?
Solution:
The hydrogen atom has only one electron, so mutual repulsion between electrons is absent. However, in multielectron atoms mutual repulsion between the electrons is significant. How does this affect the energy of an electron in the orbitals of the same principal quantum number in multielectron atoms?

IV. Matching Type
In some of the following questions, one option of the left column maybe Correlated to more than one option in the right column.

42. Match the following species with their corresponding ground state electronic configuration.

Atom / Ion	Electronic configuration
(i) Cu	(a) 1s2 2s2 2p6 3s2 3p6 3d10
(ii) Cu2+	(b) 1s2 2s2 2p6 3s2 3p6
(iii) Zn2+	(c) 1s2 2s2 2p6 3s2 3p6 3d10 4s1

| (iv) Cr3+ | (d) 1s2 2s2 2p6 3s2 3p63d9 |
| | (e) 1s2 2s2 2p6 3s2 3p6 3d3 |

Solution:

(i) → c

(ii) →d

(iii) →a

(iv) →e

43. Match the quantum numbers with the information provided by these.

Quantum number Information provided

(i) Principal quantum number	(a) orientation of the orbital
(ii) Azimuthal quantum number	(b) energy and size of orbital
(iii) Magnetic quantum number	(c)spin of an electron
(iv) Spin quantum number	(d) shape of the orbital

Solution:

(i) → b

(ii) → d

(iii) → a

(iv) → c

44. Match the following

Rules **Statements**

(i) Hund's Rule	(a) No two electrons in an atom can have the same set of four quantum numbers.
(ii) Aufbau Principle	(b) Half-filled and filled orbitals have extra stability. (c) The pairing of electrons in the orbitals belonging to the same subshell does not take place until each orbital is singly occupied.
(iii) Pauli Exclusion Principle	
(iv) Heisenberg's Uncertainty Principle	(d) It is impossible to determine the exact position and exact the momentum of a subatomic particle simultaneously. (e) In the ground state of atoms, orbitals are filled in the order of their increasing energies.

Solution;

(i) → c

(ii) → e

(iii) → a

(iv) → d

45. Match the following

(i) X-rays	(a) ν = 100-0 104 Hz
(ii) UV	(b) ν = 1010Hz
(iii) Long radio waves	(c) ν = 1016 Hz
(iv) Microwave	(d) ν = 1018Hz

Solution:
(i)→ d
(ii)→ c
(iii) →a
(iv) →b

46. Match the following

(i) Photon	(a)Value is 4 for N shell
(ii) Electron	(b)Probability density
(iii) ψ2	(c)Always positive value
(iv) The principal quantum number n	(d)Exhibits both momentum and wavelength

Solution:
(i)→ d
(ii)→ a
(iii) →b
(iv)→ c

47. Match species are given in Column I with the electronic configuration given in Column II.

Column I	
(i) Cr	(a) [Ar]3d84s0
(ii) Fe2+	(b) [Ar]3d104s1
(iii) Ni2+	(c) [Ar]3d64s0
(iv) Cu	(d) [Ar] 3d54s1
	(e) [Ar]3d64s2

Solution:
(i) →c
(ii) →b
(iii) →a
(iv) →d

V. Assertion and Reason Type
In the following questions, a statement of Assertion (A) followed by a statement
of Reason (R) is given. Choose the correct option out of the choices given

below each question.

48. . Assertion (A): All isotopes of a given element show the same type of chemical behaviour.
Reason (R): The chemical properties of an atom are controlled by the
number of electrons in the atom.
(i) Both A and R are true and R is the correct explanation of A.
(ii) Both A and R are true but R is not the correct explanation of A.
(iii) A is true but R is false.
(iv) Both A and R are false.
Solution:
Option (i) is correct

49. Assertion (A): The black body is an ideal body that emits and absorbs radiations
of all frequencies.
Reason (R): The frequency of radiation emitted by a body goes from a lower
frequency to higher frequency with an increase in
temperature.
(i) Both A and R are true and R is the correct explanation of A.
(ii) Both A and R are true but R is not the explanation of A.
(iii) A is true and R is false.
(iv) Both A and R are false.
Solution:
Option (ii) is the answer.

50. Assertion (A): It is impossible to determine the exact position and exact
the momentum of an electron simultaneously.
Reason (R): The path of an electron in an atom is clearly defined.
(i) Both A and R are true and R is the correct explanation of A.
(ii) Both A and R are true and R is not the correct explanation of A.
(iii) A is true and R is false.
(iv) Both A and R are false.
Solution:
Option (iii) is correct