CHEMISTRY

BOOKS - MTG IIT JEE FOUNDATION

ATOMIC STRUCTURE

Illustrations

1. What is black body radiation ? How are frequency and wave number related to each other ?

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2. An electron has been excited from first to fourth energy state in an atom. What are the possible transitions when the electron come back to the ground state ?

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3. Why are Bohr orbits called stationary states ?

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4. Calculate the energy of photon of radiations whose frequency is $5 \times 10^{14} \ \mathrm{s}^{-1}$.

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5. what will be the wavelength of a ball of mass 0.1 kg moving with a velocity of $10ms^{-1}$?

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6. Calculate the mass of a photon with wavelength 3.6Å.

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7. What should be the uncertainty in position if uncertainty in momentum is $1 \times 10^{-2} g \ \ \mathrm{cm/s}$?

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8. An electron is in 4f orbital. What possible values for quantum numbers, n,l,m and s can it have ?

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9. Write down the quantum number for $3p_x$ and $4d_{xz}$.

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10. Describe the orbital having $n = 2, l = 1$ and $m = 0$.

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11. The number of radial nodes for 3p orbital is.....

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12. The maximum number of electrons theoritically possible for seventh principal shell is

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13. If $n = 2, l = 2, m = 0, s = -1/2$ are sets of quantum numbers, is the state possible or not ?

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14. How many electrons in an atom may have the following quantum numbers ?

$n = 3, m_s = -1/2$

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15. How many subshells are associated with $n = 4$?

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Solved Examples

1. How many electrons can be filled in all the orbitals with $n + l = 5$?

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2. An electron of hydrogen atom jumps from 5^{th} shell to 1^{st} shell. How many spectral lines are produced ?

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3. Calculate the frequency and energy of photon whose wavelength is 3000Å.

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4. What physical meaning is attributed meaning is attributed to the square of the absolute value of wave function $\left|\Psi^2\right|$?

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5. What is the lowest shell which has an f-subshell?

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6. Calculate the kinetic energy of the ejected electron when ultra-violet radiation of frequency $1.6 \times 10^{15} s^{-1}$ strikes the surface of potassium metal. Threshold frequency of potassium is $5 \times 10^{14} s^{-1} \left(h = 6.63 \times 10^{-34} Js\right)$.

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7. 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 prinicipal quantum number in multielectron atoms?

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8. Heisenberg uncertainty principle has no significance in our every day life. Explain.

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9. When would wavelength associated with an electron become equal to the wavelength associated with a proton ?

$\left(m_e = 9.1095 \times 10^{-28} g \text{ and } m_p = 1.6725 \times 10^{-24} g\right).$

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10. Calculate the wavelength, frequency, and wave number of a light wave whose period is $2.0 \times 10^{-10} s$.

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11. On the basis of Heisenbergs uncertainty principle show that the electron cannot exist within the nucleus.

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Exercise Multiple Choice Question

1. The existence of nucleus was discovered by

A. J.J. Thomson

B. Rutherford

C. Bohr

D. Pauli.

Answer: B

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2. Which of the following is not correct ?

A. $\lambda = v/c$

B. $E = mc^2$

C. $h = E/v$

D. $\lambda = h/p$

Answer: A

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3. Which of the following has the largest de Broglie wavelength (all have eual velocity)?

A. CO_2

B. Electron

C. NH_3

D. Proton

Answer: B

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4. The uncertainty principle was first stated by

A. Pauli

B. Heisenberg

C. Planck

D. de Broglie

Answer: B

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5. The unit of frequency is

A. hertz

B. cycle/sec

C. both (a) and (b)

D. none of these

Answer: C

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6. Bohr atomic model can explain

A. the spectrum of hydrogen atom only

B. the spectrum of an atom or ion containing one electron only

C. the epectrum of hydrogen molecule

D. the solar spectrum.

Answer: B

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7. The number of electrons which can be accommodated in an orbital is

A. one

B. two

C. three

D. four.

Answer: B

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8. Which electronic level would allow an atom to absorb a photon but not to emit a photon ?

A. 3s

B. 2p

C. 1s

D. 3d

Answer: C

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9. The principal quantum number of an atom is related to the

A. size of shell

B. spin angular momentum

C. orbital angular momentum

D. orientation of orbital

Answer: A

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10. According to the uncertainty principle,

A. $E = mc^2$

B. $\Delta x \times \Delta p \approx h/4\pi$

C. $\lambda = h/p$

D. $\Delta x \times \Delta p \approx h/6\pi$

Answer: B

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11. When the azimuthal quantum number l = 1, the shape of the orbital will be

A. spherical

B. dumb-bell

C. double dumb - bell

D. circular

Answer: B

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12. The outermost electronic configuration of the most electronegative element is

A. ns^2np^2

B. ns^2np^4

C. ns^2np^5

D. ns^2np^6

Answer: C

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13. No two electrons in an atom of an element have

A. same proncipal quantum number

B. same azimuthal quantum number

C. same magnetic quantum number

D. identical set of all four quantum numbers.

Answer: D

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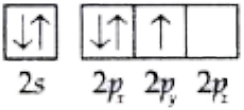
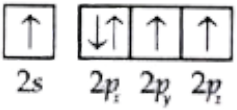
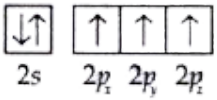
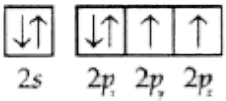
14. the orbital diagram in which aufbau principal is violated is :

A. 

B. 

C. 

D. 

Answer: B

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15. If uncertainty in possition of electron is zero, then the uncertainty in its momentum would be .....

A. 0

B. $h/2\pi$

C. $h/4\pi$

D. infinity.

Answer: D

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16. de-Broglie equation tells about

A. the relation between electron and nucleus

B. the relation between electron and proton

C. the relation between electron and neutron

D. electrons having duel nature of wave and particle.

Answer: D

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17. When an electron jumps from L to K shell -

A. energy is released

B. energy is absorbed

C. energy is sometimes released and sometimes absorbed

D. energy is neither absorbed nor released.

Answer: A

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18. Which of the following orbitals does not exist ?

A. 6s

B. 3p

C. 2d

D. 4f

Answer: C

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19. Which of the following is not possible ?

A. $n = 3, l = 2, m = 0$

B. $n = 1, l = 0, m = 0$

C. $n = 3, l = 3, m = 2$

D. $n = 4, l = 3, m = -3$

Answer: C

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20. For 4s-orbital, m has the value

A. 2

B. 4

C. -1

D. 0

Answer: D

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21. Presence of three unpaired electrons in phosphorus atom can be explained by

A. Pauli's rule

B. Uncertainty principle

C. Aufbau's rule

D. Hund' rule.

Answer: D

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22. The maximum number of electrons in a subshell is given by the expression

A. $4l - 2$

B. $4l + 2$

C. 2n

D. $2n^2$

Answer: D

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23. Which of the following relates to photon both as wave motion and as a stream of particles ?

A. Interference

B. Diffraction

C. $E = mc^2$

D. $E = hv$

Answer: D

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24. The number of nodes in 5d orbital is

A. 0

B. 1

C. 2

D. 3

Answer: C

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25. For which of the following species, Bohr theory is not applicable ?

A. Be^{3+}

B. Li^{2+}

C. He^{2+}

D. H

Answer: C

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26. If quantum number for last electron is $n = 3, l = 0, m = 0$, then atomic number is

A. 12,13

B. 13,14

C. 10,11

D. 11,12

Answer: D

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27. Which of the following transitions have minimum wavelength

A. $n_4 \rightarrow n_1$

B. $n_2 \rightarrow n_1$

C. $n_4 \rightarrow n_2$

D. $n_3 \rightarrow n_1$

Answer: A

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28. Planck's constant has the dimension (unit) of

A. work

B. energy

C. angular momentum

D. linear momentum.

Answer: C

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29. When the frequency of light incident an a metallic plate is doubled , the KE of the emitted photoelectrons will be :

A. doubled

B. halved

C. more than double

D. increases but less than double.

Answer: C

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30. The wavelength (in nanometer) associated with a proton moving at 1.0×10^3 m/s is

A. 0.032 nm

B. 0.40 nm

C. 2.5 nm

D. 14.0 nm

Answer: B

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31. A 0.66 kg ball is moving with a speed of 100 m/s. The associated wavelength will be $\left(h = 6.6 \times 10^{-34}\ \text{J s}\right)$

A. 6.6×10^{-32} m

B. 6.6×10^{-34} m

C. 1.0×10^{-35} m

D. 1.0×10^{-32} m

Answer: C

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32. The line spectrum of He^{+} ion will resemble that of :

A. H atom

B. Li^{+} ion

C. He atom

D. Be^{2+} ion

Answer: A

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33. When the electron of a hydrogen atom jumps from the n=4 to the n=1 state , the number of all pos - sible spectral lines emitted is :-

A. 15

B. 9

C. 6

D. 3

Answer: C

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34. In photoelectric effect, the kinetic energy of photoelectrons increases linearly with the

A. wavelength of incident light

B. frequency of incident light

C. velocity of incident light

D. atomic mass of element.

Answer: B

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35. An electron will have highest energy in the set

A. 3,2,1,1/2

B. 4,2,-1,1/2

C. 4,1,0,-1/2

D. 5,0,0,1/2

Answer: B

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36. Which is not the name of scientist

A. Pauli

B. Aufbau

C. Hund

D. Planck

Answer: B

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37. Which of the following set of quantum numbers is not consistent with the theory ?

A. $n = 2, l = 1, m = 0, s = +1/2$

B. $n = 4, l - 3, m = 2, s = -1/2$

C. $n = 3, l = 2, m = 3, s = -1/2$

D. $n = 4, l = 3, m = 3, s = +1/2$

Answer: C

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38. Simultaneous determination of exact position and momentum of an electron is.

A. possible

B. not possible

C. sometimes possible and sometimes impossible

D. none of these

Answer: B

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39. Energy of electron in the H-atom is determined by

A. only n

B. both n and l

C. n, l and m

D. all the four quantum numbers.

Answer: A

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40. A subshell with $l = 2$ is called

A. s

B. p

C. d

D. f

Answer: C

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41. Shape of an orbital is given by

A. spin quantum number

B. magnetic quantum number

C. azimuthal quantum number

D. principal quantum number.

Answer: C

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42. The electronic configuration of an atom/ion can be defined by the following

A. Aufbau principle

B. Pauli's exclusion principle

C. Hund's rule of maximum multiplicity

D. All of the above

Answer: D

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43. The energy is lowest for the orbital

A. 3d

B. 4p

C. 4s

D. 4f

Answer: C

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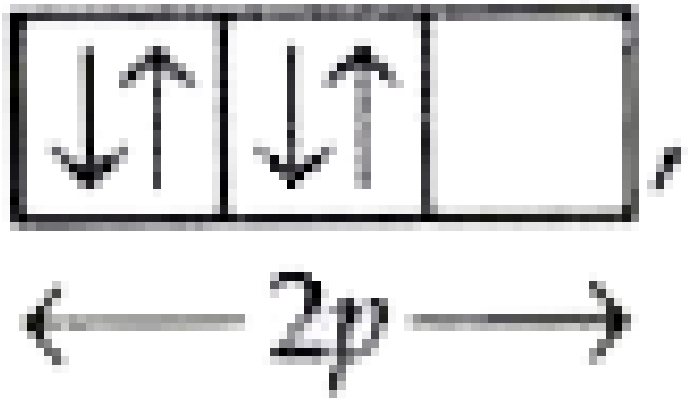
44. If the electronic structure of oxygen atom is written as



it would violate

A. Hund's rule

B. Pauli's principle

C. both Hund's and Pauli's principle

D. none of the above

Answer: A

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45. Photo electric effect can be explained only by assuming that light

A. is a form of transverse wave

B. is a form of longitudinal waves

C. can be polarised

D. consists of quanta.

Answer: D

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46. Momentum is

A. directly proportional to wavelength

B. inversely proportional to wavelength

C. equal to $\lambda / 2\pi$

D. not related to wavelength.

Answer: B

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47. Ψ represents

A. length of wave

B. wave number of wave

C. amplitude of wave

D. frequency of wave.

Answer: C

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48. The uncertainty involved in the measurement of velocity of electron with a distance of 0.1Å is

A. $5.79 \times 10^8 \ \text{m/s}$

B. $5.79 \times 10^5 \ \text{m/s}$

C. $5.79 \times 10^6 \ \text{m/s}$

D. $5.79 \times 10^7 \ \text{m/s}$

Answer: C

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49. The de Broglie wavelength associated with a ball of mass $1kg$ having kinetic enegry $0.5J$ is

A. 6.626×10^{-34} m

B. 13.20×10^{-34} m

C. 10.38×10^{-21} m

D. 6.626×10^{-34} Å

Answer: A

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50. The probability of finding an electron residing in a p_x orbital is zero

A. in the yz plane

B. in the xy plane

C. in the y-direction

D. in the z-direction.

Answer: D

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Exercise Match The Following

	List-I	List-II
	(P) Aufbau principle	(1) $\Delta x \times \Delta p \approx h/4\pi$
1.	(Q) de-Broglie	(2) Orientation of electron in an orbital
	(R) Hund'srule	(3) Electronic configuration
	(S) Heisenberg principle	(4) $\lambda = h/mv$

A. P $\rightarrow$ 3, Q $\rightarrow$ 4, R $\rightarrow$ 2, S $\rightarrow$ 1

B. P $\rightarrow$ 2, Q $\rightarrow$ 1, R $\rightarrow$ 3, S $\rightarrow$ 4

C. P $\rightarrow$ 1, Q $\rightarrow$ 2, R $\rightarrow$ 4, S $\rightarrow$ 3

D. P $\rightarrow$ 4, Q $\rightarrow$ 3, R $\rightarrow$ 2, S $\rightarrow$ 1

Answer: A

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List-I	List-II
(P) Photon	(1) Value is 4 for N shell
(Q) Electron	(2) Probability density
$(R)\Psi^2$	(3) always exhibits positive value
$(S)n$	(4) momentum and wavelength both

2.

A. P $\rightarrow$ 1,Q $\rightarrow$ 3,R $\rightarrow$ 4,S $\rightarrow$ 2

B. P $\rightarrow$ 4,Q $\rightarrow$ 2,R $\rightarrow$ 3,S $\rightarrow$ 1

C. P $\rightarrow$ 4,Q $\rightarrow$ 4,R $\rightarrow$ 2,3,S $\rightarrow$ 1,3

D. P $\rightarrow$ 4,Q $\rightarrow$ 2,R $\rightarrow$ 1,S $\rightarrow$ 2

Answer: C

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List-I	List-II
(P) Light has dual character	(1) de-Broglie's theory
(Q) Electrons have dual character	(2) Einstein theory principle
(R) N has electronic configuration $1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$ not $1s^2 2s^2 2p_x^2 2p_y^1$	(3) Aufbau
(S) 4s orbital is filled before 3d	(4) Hund's rule

3.

A. P $\rightarrow$ 1,Q $\rightarrow$ 2,R $\rightarrow$ 4,S $\rightarrow$ 3

B. P $\rightarrow$ 2,Q $\rightarrow$ 1,R $\rightarrow$ 4,S $\rightarrow$ 3

C. P $\rightarrow$ 2,Q $\rightarrow$ 4,R $\rightarrow$ 3,S $\rightarrow$ 1

D. P $\rightarrow$ 3,Q $\rightarrow$ 4,R $\rightarrow$ 2,S $\rightarrow$ 1

Answer: B

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4.

List-I (Orbital)	List-II (Radial nodes)
$(P) 3p$	(1) 0
$(Q) 5d$	(2) 1
$(R) 4f$	(3) 2
$(S) 4s$	(4) 3

A. P $\rightarrow$ 2,Q $\rightarrow$ 3,R $\rightarrow$ 1,S $\rightarrow$ 4

B. P $\rightarrow$ 4,Q $\rightarrow$ 2,R $\rightarrow$ 3,S $\rightarrow$ 1

C. P $\rightarrow$ 1,Q $\rightarrow$ 2,R $\rightarrow$ 4,S $\rightarrow$ 3

D. P $\rightarrow$ 3,Q $\rightarrow$ 2,R $\rightarrow$ 4,S $\rightarrow$ 1

Answer: A

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5.

List-I	List-II
((P) Radius of n^{th} orbit	(1) inversely proportional to Z
(Q) Energy of n^{th} orbit	(2) integral multiple of $h/2\pi$
(R) Angular momentum of electron	(3) inversely proportional to n^2
(S) Velocity of electron in n^{th} orbit	(4) inversely proportional to $'n'$

A. P $\rightarrow$ 2,Q $\rightarrow$ 4,R $\rightarrow$ 2,S $\rightarrow$ 1

B. P $\rightarrow$ 4,Q $\rightarrow$ 2,R $\rightarrow$ 3,S $\rightarrow$ 1

C. P $\rightarrow$ 1,Q $\rightarrow$ 2,R $\rightarrow$ 2,S $\rightarrow$ 4

D. P $\rightarrow$ 3,Q $\rightarrow$ 4,R $\rightarrow$ 2,S $\rightarrow$ 1

Answer: C

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Exercise Assertion Reason Type

1. Assertion : An orbital cannot have more than two electrons.

Reason : The two electrons in an orbital have opposite spin.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: B

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2. Assertion (A) : p orbital is dumb- bell shaped

Reason (R) :Electron presents in p orbital can have any one of three value of magnetic quantum number i.e. $0, \ +1, \ \text{or} \ \ -1$

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: B

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3. Assertion : Angular momentum of 1s, 2s, 3s, etc., is same.

Reason : 1s, 2s, 3s etc. , all have spherical shape.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: B

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4. Assertion : Hydrogen has one electron in its orbit but it produces several spectral lines.

Reason : There are many excited energy levels available.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: A

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5. Assertion : The 19^{th} electron in potassium atom enters into 4s orbital and not the 3d - orbital.

Reason : (n+1) rule followed for determining the orbital of the lowest energy state.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: A

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6. Assertion : 2s orbita has one node.

Reason : Number of nodes in 2s orbital is same as in 2p orbital.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: C

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7. Assertion : All microscopic bodies in motion have wave character.

Reason : Microscopic bodies have very large mass.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: C

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8. Assertion : Black body is an ideal body that emits and absorbs radiations of all frequencies.

Reason : The frequency of radiation emitted by a body goes from a lower frequency to higher frequency with an increase in temperature.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: B

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9. Assertion : It is impossible to determine the exact position and exact momentum of an electron simultaneously.

Reason : The path of an electron in an atom is clearly defined.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: C

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10. Assertion : The energy of an electron is largely determined by its principal quantum number.

Reason : The principal quantum numbe (n) is a measure of the most probable distance of finding the electron around the nucleus.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason are false.

Answer: A

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Exercise Comprehension Type

1. PASSAGE - I : The electron with the highest energy in an atom has the quantum numbers $n = 4, l = 1, m = 0, s = 1/2$

The element could be

A. copper

B. silver

C. gallium

D. indium

Answer: C

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2. PASSAGE - I : The electron with the highest energy in an atom has the quantum numbers $n = 4, l = 1, m = 0, s = 1/2$

The orbital angular momentum of the electron is

A. zero

B. $1.4\hbar$

C. $4.5\hbar$

D. $0.87\hbar$

Answer: B

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3. PASSAGE - I : The electron with the highest energy in an atom has the quantum numbers $n = 4, l = 1, m = 0, s = 1/2$

The orbital occupied by the electron by convention, is

A. $4p_x$

B. $4p_y$

C. $4p_z$

D. any one of these.

Answer: C

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4. PASSAGE -II : The uncertainty in the position of a flying dust particle mass 0.1 mg is found to be 10^{-4}m. The uncertainly in the position of

another flying dust particle of mass 0.5 mg is also found to be same .

The uncertainly in the velocity of the lighter dust particle is nearly

A. $5 \times 10^{-24}\ \mathrm{m\,s^{-1}}$

B. $2.5 \times 10^{-24}\ \mathrm{m\,s^{-1}}$

C. $1.25 \times 10^{-24}\ \mathrm{m\,s^{-1}}$

D. $5 \times 10^{-25}\ \mathrm{m\,s^{-1}}$

Answer: A

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5. PASSAGE -II : The uncertainty in the position of a flying dust particle mass 0.1 mg is found to be 10^{-4}m. The uncertainly in the position of another flying dust particle of mass 0.5 mg is also found to be same .

The uncertainty in the velocity of the heavier dust particle as compared to the lighter dust particle is

A. 5 times

B. 1/5 times

C. same

D. 50 times.

Answer: B

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6. PASSAGE -II : The uncertainty in the position of a flying dust particle mass 0.1 mg is found to be 10^{-4}m. The uncertainly in the position of another flying dust particle of mass 0.5 mg is also found to be same . If the third flying dust particle of mass 1 mg had the same uncertainty in position as in its velocity, the uncertainty in its momentum would be

A. $5. \times 10^{-28}$ $\mathrm{kg\,ms^{-1}}$

B. 5.2×10^{-34} $\mathrm{kg\,ms^{-1}}$

C. 7.2×10^{-15} $\mathrm{kg\,ms^{-1}}$

D. 7.2×10^{-21} $\mathrm{kg\,ms^{-1}}$

Answer: D

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7. PASSAGE-III : Dual nature of matter was proposed by de Broglie in 1923, it was experimentally verified by Davission and Germer by diffraction experiment.

Wave character of matter has significance only for microscopic particles. De Broglie wavelength or wavelength of matter wave can be calculated using the following relation

$$\lambda = \frac{h}{mv}$$

where, 'm' and 'v' are the mass and velocity of the particle.

De Broglie hypothesis suggested that electron waves were being diffracted by the target, much as X-rays are diffracted by planes of atoms in the crystals.

The wavelength associated with a golf ball weight 200 g and moving with speed of 5 m/hr is

A. $3.72 \times 10^{-10} m$

B. $8.56 \times 10^{-20} m$

C. $2.96 \times 10^{-25} m$

D. $2.38 \times 10^{-30} m$

Answer: D

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Wave nature of electrons is shown by

A. photoelectric effect

B. compton effect

C. diffraction experiment

D. Stark effect.

Answer: C

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9. PASSAGE-III : Dual nature of matter was proposed by de Broglie in 1923, it was experimentally verified by Davission and Germer by

diffraction experiment.

Wave character of matter has significance only for microscopic particles. De Broglie wavelength or wavelength of matter wave can be calculated using the following relation

$$\lambda = \frac{h}{mv}$$

where, 'm' and 'v' are the mass and velocity of the particle.

De Broglie hypothesis suggested that electron waves were being diffracted by the target, much as X-rays are diffracted by planes of atoms in the crystals.

De - Broglie equation is obtained by combination of which of the following theories ?

A. Planck's quantum theory and theory of diffraction

B. Einstein's theory of mass - energy equivalence and theory of diffraction

C. Planck's quantu theory and Einstein's theory of mass-enery equilibrium

D. None of these.

Answer: C

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Exercise Integer Numerical Value Type

1. Total number of orbitals present in M shell is

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2. Number of nodes present in 5f-orbital is

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3. The maximum value of x in $2s^2p^x$ is

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4. If an electron is present in the third orbit of hydrogen atom, maximum number of emission spectral lines will be

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5. The energy (in kJ) of one mole of photons of radiatio whose frequency is 5×10^{14} Hz is $\left(h = 6.62 \times 10^{-34} \text{ J s}\right)$

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