CHEMISTRY

PHYSICAL, INORGANIC, AND ORGANIC CHEMISTRY

NUCLEAR CHEMISTRY

Solved Example

1. Complete the following table:

Particle	Mass No.	Atomic No.	Protons	Neitrons	Electrons
Nitrogen atom	-	-	-	7	7
Calcium ion	-	20	-	20	-
Oxygen atom	16	8	-	-	-
Bromide ion	-	-	-	45	36

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2. Certain sum glasses having small of $AgCl$ incroporated the lenses, on expousure to light of appropriate wavelength turns to gray colour to reduce the glare following the reactions:

$$AgCl \xrightarrow{hv} Ag(\text{Gray}) + Cl$$

If the heat of reaction for the decomposition of $AgCl$ is $248kJmol^{-1}$, what maximum wavelength is needed to induce the desired process?

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3. The threshold frequency v_0 for a metal is $6 \times 10^{14}s^{-1}$. Calculate the kinetic energy of an electron emitted when radiation of frequency $v = 1.1 \times 10^{15}s^{-1}$ hits the metal.

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4. Find ratio of radius of 2^{nd} orbit of He^+ ion &3^{rd} orbit of Be^{+3} ion.

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5. what are the frequency and wavelength of a photon emitted during a transition from n = 5 state to the n =2 state in the hydrogen atom?

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6. A single electron system has ionization energy $1.118 \times 10^7 Jmol^{-1}$. Calculate the number of protons in the nucleus of the system .

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7. Calculate the wavelength of a photon emitted when an electron in H - atom maker a transition from $n = 2$ to $n = 1$

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8. Calculate wavelength for 2^{nd} line of Balmer series of He^+ ion

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9. If electron make transition from 7^{th} excited state to 2^{nd} state in H atom sample find the max. number of spectral lines observed.

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

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11. A golf ball has a mass of $40g$ and a speed of $45m/s$. If the speed can be measured within accuracy of 2%, calculate the uncertainty in the position.

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12. Write the electronic configuration and find the no. of unpaired electrons as well as total spin for the following atoms:

(i)_(6)C(ii)_(8)O(iii)_(15)P(iv) $\_\ (21)Sc$ (v) $\_\ (26)Fe$ (vi) $\_\ (10)Ne$

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13. Write the four quantum numbers for V and VI electrons of carbon atom.

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14. Calculate the total spin and magnitic moment for atoms having atomic numbers $7, 24, 34$ and 36.

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15. $.^{23}$ Na is the more stable isotope of Na. Find out the process by which $._{11}^{24}$ Na can undergo radioactive decay.

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16. The number of β - particle emitted during the change $._aX^c \rightarrow {}_dY^b$ is

A. $\dfrac{a-b}{4}$

B. $d+\left(\dfrac{a-b}{2}\right)+c$

C. $d+\left(\dfrac{c-b}{2}\right)-a$

D. $d+\left(\dfrac{a-b}{2}\right)-c$

Answer: C

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17. $._7N^{13}$ changes to $._6C^{13}$ by the emission of

A. _ $(8)^{13}O$ + _(-1)^(0)e`

B. _ $(6)^{13}C$ + _(+1)^(0)e`

C. _ $(6)^{13}C + K$ electron capture

D. _ $(5)^{9}Be$ + _(2)^(4)He`

Answer: B

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18. A radioactive element X has an atomic number of 100. It decays directly into an element Y which decays directly into an element Z. In both the processes either one α or one β - particle is emitted. Which of the following statement could be true?

A. Y has an atomic number of 102

B. Z has an atmic number of 101

C. Z has an atomic number of 97

D. Z has an atomic number of 99

Answer: D

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Miscellaneous Solved Problems Msps

1. The ratio of $(E_2 - E_1)$ to $(E_4 - E_3)$ for He^+ ion is approximately equal to (where E_n is the energy of nth orbit):

A. 10

B. 15

C. 17

D. 12

Answer: B

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2. If the binding energy of 2^{nd} excited state of a hydrogen like sample os $24eV$ approximately, then the ionisation energy of the sample is approximately

A. $54.4eV$

B. $24eV$

C. $122.4eV$

D. $216eV$

Answer: D

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3. The ionisation energy of H atom is $21.79 \times 10^{-19}J$. The the value of binding energy of second excited state of Li^{2+} ion

A. $3^2 \times 21.7 \times 10^{-19}J$

B. $21.79 \times 10^{-19}J$

C. $\frac{1}{3} \times 21.79 \times 10^{-19} J$

D. $\frac{1}{3^2} \times 21.79 \times 10^{-19} J$

Answer: B

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4. The wave number of the first line in the Balmer series of hydrogen is $15200 cm^{-1}$. What would be the wavenumber of the first line in the Lyman series of the Be^{3+} ion?

A. $2.4 \times 10^5 cm^{-1}$

B. $24.3 \times 10^5 cm^{-1}$

C. $6.08 \times 10^5 cm^{-1}$

D. $1.313 \times 10^6 cm^{-1}$

Answer: D

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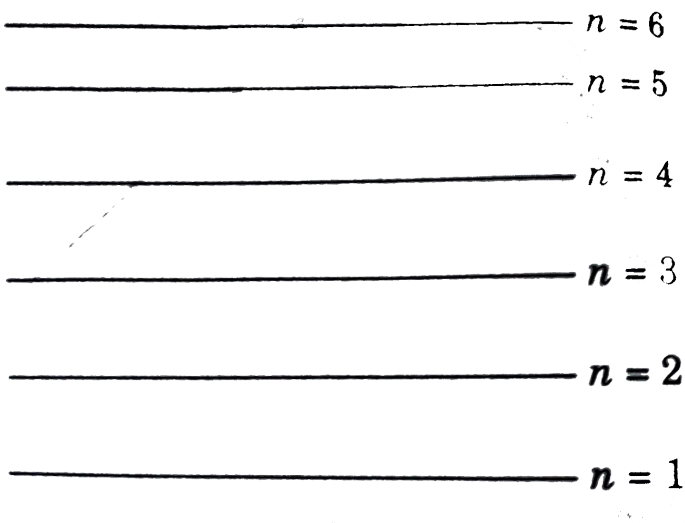
5. What would be the maximum number of emission lines for atomic hydrogen that you would expert to see with the naked eye if the only electronic energy involved are those as shown in figure ?



A. 4

B. 6

C. 5

D. 15

Answer: A

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6. The de Broglie wavelength of an electron moving in a circular orbit is λ .

The minimum radius of orbit is :

A. $\frac{\lambda}{\pi}$

B. $\frac{\lambda}{2\pi}$

C. $\frac{\lambda}{4\pi}$

D. $\frac{\lambda}{3\pi}$

Answer: B

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7. Uncertainty in position of a hypothetical subatomic particle is 1Å and uncertainty in velocity is $\frac{3.3}{4\pi} \times 10^{5}$ m/s then the mass of the particle is approximately (h = 6.6×10^{-34} Js) :

A. $2 \times 10^{-28} kg$

B. $2 \times 10^{-27} kg$

C. $2 \times 10^{-29} kg$

D. $4 \times 10^{-29} kg$

Answer: C

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8. Which of the following set of quantum numbers is not valid.

A. $n = 3, l = 2, m = 2, s = +\frac{1}{2}$

B. $n = 2, l = 0, m = 0, s = -\frac{1}{2}$

C. $n = 4, l = 2, m = -1, s = +\frac{1}{2}$

D. $n = 4, l = 3, m = 4, s = -\frac{1}{2}$

Answer: D

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9. What is the total spin value in case of $_(26)Fe^{3+}$ ion ?

A. $+1$or - 1

B. $+2$or - 2

C. $+2.5$or - 2.5

D. $+3$or - 3

Answer: C

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Board Level Exercise

1. Calculate the number of electrons, protons and neutrons in the following species:

(i)_(15)^(31)P (ii) $_(15)^{31}P^{3-}$

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2. The rest mass of the photon is

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3. What is the energy of the electron in He^{+} in ground state?

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4. Calculate the total number of electron is 1 mol of ammonia

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5. What is difference between a quantum and a photon?

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6. What is the symbol of the species with number of electrons equal to 36, protons eual to 35 and neutrons equal to 45 ?

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7. Give an isobar,isotone , and isotope of $._6C^{14}$

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8. The azimuthal quantum number l of an orbital is 3. What are the possible value of m?

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9. How many electrons in a fully filled f-subshell have $m = 0$?

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10. Why $3d$ sub-shell has higher energy than $4s$ sub-shell in a muti-electron atom?

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11. Arrange the following type of radiations in increasing order of frequency: (a) radiation from microwave oven (b) amber light from traffic signal (c). radiation from FM radio (d) cosmic rays from outer space and (e) X-rays

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12. Calcultte the enrgy required for the process ,

$He^{+}(g) \rightarrow He^{2+}(g) + e$

The ionization energy for the H-atom in the grounds state is $2.18 \times 10^{-18} \text{Jatom}^{-1}$.

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13. Calculate the wavelength a particle of mass $m = 6.6 \times 10^{-27} kg$ moving with kinetic energy $7.425 \times 10^{-13} J$ $h = 6.6 \times 10^{-34} kgm^2 s^{-1}$

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14. If an electron is , to be located within 10pm. what will be the uncertainty in its velocity ?

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15. How many sub-shell are there in N shell? How many orbitals are there in d sub-shell?

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16. Consider the following radioactive change $\_ (11)^{22} Na \rightarrow$ _(10)^(22)Ne`

What is the type of particle captured or emitted?

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17. How many orbitals are possible in

a. 4th energy level b. $5f$ sub-shell

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18. How many spherical nodal surface are there in

a. a $3s$ orbital

b. a $3p$ orbital

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19. What is the number of d electrons in Cr^{3+} ions?

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20. The mass of photon having wavelength $1nm$ is :

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21. How many quantum number are needed in designate an orbital ? Name them

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22. $._{92}^{235}U$ decays with emission of α and β- particles to form ultimately $._{82}^{207}Pb$. How many α and β-particles are emitted per atom of Pb produced?

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23. What is the shape $2s$ orbital .Give two point of difference between $1s$ and $2s$ orbital.

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24. Write electronic configuration of Fe^{2+} and Fe^{3+} ions. Which of these has more number of unpaired electrons? Atomic no. of Fe is 26.

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25. Derive the relationship between the wavelength of the de-Broglie wave and the kinetic energy of the particle.

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26. State and explain Heisenberg's uncertainty principle.

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27. Draw the shapes of various p and d orbitals.

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28. Write balanced nuclear equations for each of the following:

(a) α-emission from curium-242

β-emission from magnesium-28

(c) positron emission from xenon-118

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29. Among the following pairs of orbital which orbital will experience the larger effective nuclear charge?

a. $2s$ and $3s$, b. $4d$ and $4f$, c. $3d$ and $3p$

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30. State Hund's rule of maxium multiplicity. How is it used in electronic distribution in nitrogen atom $(Z = 7)$?

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31. Describe the experiment which led to the discovery of the proton.

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32. What are the shortcoming of Rutherford's model of atom?

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33. Nitrogen laser produces a radiation at a wavelength of $33.71nm$. If the number of photons emitted is 5.6×10^{24}. calculate the power of this laser.

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34. Define the followings:

(i) Nuclear fission (ii) Nuclear fusion (iii) Binding energy.

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35. What are the various postulates of Bohr's model of atom? How could Bohr's model explain the existance of so many lines in the specturm of hydrogen?

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36. Write down electronic configuration of Fe^{3+} ion and anwer the following:

(i) What is the number of electrons having $n + l = 3$ in it?

(ii) How many electrons in it have $n = 3$ and $m = 0$?

(iii) How many electrons in it have $l = 1$?

What is the number of electrons in M-shell?

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37. Assign groups to the elements A, B, C, D and E starting from element $X\left(\text{group}2^{nd}\right)$

$$X(IIA) \xrightarrow{-\alpha} A \xrightarrow{-\beta} B \xrightarrow{-\beta} C \xrightarrow{-\alpha} D$$

What is relation between A and D?

What is relation between A, B and C?

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38. Write down electronic configuration of chromium $(Z = 24)$ and indicate in it.

(i) numbers of sub-shells

(ii) number of orbitals

(iii) number of electrons in M-shell

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39. Prove that $E_n = -13.6 \times \frac{z^2}{n^2} eV/a \rightarrow m$ for n^{th} orbit in single electron species.

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Exercise 1

1. Why cathode ray tube experiment is not conducted at atmospheric pressure?

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2. Complete the following table:

Particale	Atomic No.	Mass No.	No. of electrons	No. of protons	N
Sodium atom	11	- - -	- - -	- - -	12
Aluminium ion	- - -	27	10	- - -	- -
Chloride ion	- - -	- - -	18	- - -	18
Phosphorus atom	- - -	31	- - -	15	- -
Coprous ion	- - -	- - -	28	- - -	35

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3. The approximate radius of a H-atom is 0.05 nm, and that of proton is 1.5×10^{-15} m. Assuming both hydrogen atom and the proton to be spherical, calculate fraction of the space in an atom of hydrogen that is occupied by the nucleus.

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4. (A) Find the radius of nucleus of an atom having atomic mass number equal to 125. $\left(\text{Take}R_0 = 1.3 \times 10^{-15} m\right)$ (B) Find the distance of closest approach when an α particle is projected towards the nucleus of silver atom having speed v. (mass of α particle $= m_{\alpha}$, atomic number pf $Ag = 47$)

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5. Calculate the energy of 100 photons if the wavelength of the light is $2000Å$.

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6. How many photons are emitted per second by a $5mW$ laser operating at $620nm$?

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7. The Vividh Bharati Station of All india Radio, Delhi broadcasts on a frequency of $1368kHz$ (kilo hertz). Calculate the wavelength and wave number of the electronetic radiation emitted by the transmitter.

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8. One quantum is absorbed per gaseous molecules of Br_2 for converting into Br atoms. If light absorbed has wavelength 5000Å, calculate energy required in kJ//mol.

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9. The eyes of certain member of the reptile family pass a single visual signal to the brain when the visual receptors are struck by photons of wavelength $850nm$. If a total energy of $3.15 \times 10^{14} J$ is required to trip the signal. What is the minimum number of photons that must strike the receptor?

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10. Two bulbs 'A' and 'B' emit red light and yellow light at 8000 "Å" and 4000 "Å" respectively. The number of photons emitted by both the bulbs per second is the same. If the red bulb is labelled as 100 watts, find the wattage of the yellow bulb.

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11. The threshold frequency for the ejection of electrons from potassium metal is $5.3 \times 10^{14} s^{-1}$. Will the photon of a radiation having energy $3.3 \times 10^{-19} J$ exhibit photoelectric effect? $\left(h = 6.626 \times 10^{-34} Js\right)$

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12. If a light with frequency $4 \times 10^{16} Hz$ emitted photoelectrons with double the maximum kinetic as are emitted by the light of frequency $2.5 \times 10^{16} Hz$ from the same metal surface, then what is the threshold frequency $\left(v_0\right)$ of the metal?

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13. If the work function (w) of an arbitrary metal is $3.1 eV$, find its threshold wavelength and the maximum kinetic energy of the electron emitted when radiation of $300 nm$ strike the metal surface. $(\text{Take} hc = 12400 eV Å)$

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14. Which state of the triply ionized Beryllium $\left(Be^{3+}\right)$ has the same orbit radius as that of the ground state of hydrogen atom?

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15. If the velocity of the electron in first in first of H atom is $2.18 \times 10^{6} m/s$, what is its value in third orbit?

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16. Consider Bohr's theory for hydrogen atom . The magnitude of orbit angular momentum orbit radius and velocity of the electron in nth energy state in a hydrogen atom are l , r and v respectively. Find out the value of 'x' if product of v, r and l (vrl) is directly proportional to n^{x}.

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17. Find the ratio of the time period of 2^{nd} Bohr orbit of He^{+} and 4^{th} Bohr orbit of Li^{2+}

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18. Consider three electron jumps described below for the hydrogen atom

X: n=3 to n=1

Y: n=4 to n=2

Z: n=5 to n=3

(a) The photon emitted in which transition X, Y or (Z) will have shortest wavelength ?

(b) For which transition will the electron experience the longest charge in orbit radius ?

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19. A hydrogen sample is prepared in a particular excited state. Photons of energy $2.55eV$ get absorbed into the sample to take some of the electrons to a further excited state B. Find orbit numbers of the states A

and B. Given the allowed energies of hydrogen atom:

$E_1 = -13.6eV, E_2 = -3.4eV, E_3 = -1.5eV, E_4 = -0.85eV. E_6 = -0.54eV$

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20. A single electron ion has nuclear chrage $+Ze$ where Z is atomic number and e is electronic charge. It requires $16.52eV$ to excite the electron from the second Bohr orbit to third Bohr orbit. Find

(a) The atomic number of element?

(b) The energy required for transition of electron from first to third orbit?

(c) Wavelength of photon required to remove electron from first Bohr orbit to infinity?

(d) The kinetic energy of electron on first Bohr orbit?

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21. The energy levels of hypothetical one electron atom are shown below.

$0eV$____________$n = \infty$

$-0.50eV$____________$n = 5$

$-1.45eV$ __________ $n = 4$

$-3.08eV$ __________ $n = 3$

$-5.3eV$ __________ $n = 2$

$-15.6eV$ __________ $n = 1$

(a) Find the ionisation potential of atom?

(b) Find the short wavelength limit of the series terminating at $n = 2$?

(c) Find the wave no. of photon emitted for the transition made by the electron from third orbit to first orbit?

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22. The excitation energy of a hydrogen -like ion in its first excited state is $40.8eV$ Find the energy needed to remain the electron from the ion

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23. Calculate the two highest wavelength of the radiation emitted when hydrogen atoms make transition from higher state to $n = 2$

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24. What electron transition in the He^+ spectrum would have the same wavelength as the first Lyman transition of hydrogen.

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25. Calculate the frequency of light emitted in an electron transition from the sixth to the second orbit of a hydrogen atom. In what region of the specturm does this frequency occur?

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26. At what atomic number would a transition from $n = 2 \text{to} n = 1$ energy level result in emission of photon of $\lambda = 3 \times 10^{-8} m$?

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27. Calculate the energy emitted when electron of 1.0 gm atom of Hydrogen undergo transition giving the spectrtal lines of lowest energy is visible region of its atomic spectra. Given that, R_H=$1.1 \times 10^7 m^{-1}$, $c = 3 \times 10^8 m/\sec, h = 6.625 \times 10^{-34} J\sec.$

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28. In a container a mixture is prepared by mixing of three samples of hydrogen helium ion $\left(He^+\right)$ and lithium ion $\left(Li^{2+}\right)$. In sample , all the hydrogen atoms are in 1st excited state and all the He^+ ions are in third excited state and all the Li^{2+}) ions are in fifth excited state. Find the total number of spectral lines observed in the emission spectrum of such a sample when the electrons return back to the ground state.

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29. An electron in H-atom in its ground state absorbs 1.5 times as much energy as the minimum required for its escape (i. e., 13 . 6 eV) from the atom . Calculate the wavelength of emitted electron.

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30. Deduce the condition when the De-Broglie wavelength associated with an electron would be equal to that associated with a proton if a proton is 1836 times heavier than an electron.

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31. An electron, practically at rest, is initially accelerated through a potential difference of 100 volts. It then has a de Broglie wavelength $= \lambda_1 Å$. It then get retarded through 19 volts and then has a wavelength $\lambda_2 Å$. A further retardation through 32 volts changes the wavelength to $\lambda_3 Å$, What is $\dfrac{\lambda_3 - \lambda_2}{\lambda_1}$?

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32. If an electron having kinetic energy $2eV$ is accelerated through the potential difference of 2 volt. Then calculate the wavelength associated with the electron

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33. The uncertainty in position and velocity of the particle are 0.1 nm and $5.27 \times 10^{-24} ms^{-1}$ respectively then find the approximate integral mass of the particle (in g) . $\left(h = 6.625 \times 10^{-34} Js\right)$

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34. An electron moving near an atomic nucleus has a speed of $6 \times 10^6 \pm 1\,\%\, m/s$. What is the uncertainty in its position?

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35. An electrons in a hydrogen atom finds itself in the fourth energy level.

(i) Write down a list of the orbits that it might be in.

(ii) Can it be in all of these orbitals at once?

(iii) Can you tell which orbital it is in ?

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36. The wave function of $3s$ electron is given by

$$\Psi_{3s} = \frac{1}{81\sqrt{3}\prod}\left(\frac{1}{a_0}\right)^{3/2}\left[27 - 18\left(\frac{r}{a_0}\right) + 2\left(\frac{r}{a_0}\right)^2\right]e^{-r/3a_0}$$

It has a node at $r = r_0$, Find out the relation between r_0 and a_0

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37. How many unpaired electrons are there in Ni^{2+}?

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38. Write the electronic configuration of the element having atomic number 56

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39. Given below are sets of quantum numbers for given orbitals. Name these orbitals.

(a) $n = 3, l = 1$ (b) $n = 5, l = 2$ (c) $n = 4, l = 1$ (d) $n = 2, l = 0$ (e) $n = 4, l = 2$

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40. Point out the anugular momentum of an electron in,

(a) $4s$ orbital (b) $3p$ orbital (c) 4^{th} orbit)according to Bohr model)

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41. Which of the following sets of quantum numbers are impossible for electrons? Explain why in each case.

Set	n	l	m	s
(i)	1	0	1	$+\frac{1}{2}$
(ii)	3	0	0	$-\frac{1}{2}$
(iii)	1	2	2	$+\frac{1}{2}$
(iv)	4	3	-3	$+\frac{1}{2}$
(v)	5	2	1	$-\frac{1}{2}$
(vi)	3	2	1	0

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42. Find the total spin and spin magnetic moment of following ion.

(i) Fe^{+3} (ii) Cu^{+}

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43. Calculate the loss in mass during the change:

$._3Li^7 + ._1He^1 \rightarrow 2._2He^4 + 17.25MeV$

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44. When $\wedge(24)Mg$ is bombared with neutron then a proton is ejected. Complete the equation and report the new element formed.

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45. Write equations for the following transformation:

(a) $._7^{17}N(n, p)$ (b) $._{19}^{39}K(n, \alpha)$

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46. Explain with reason the nature of emitted particle by:

A. $._7^{14}N(n, p)$

B. $._{18}^{35}Ar$

C. $._{32}^{80}Ge$

D. $._{20}^{40}Ca$

Answer: (a) $._{20}^{38}Ca$: It has n/p=18/20=0.9, Which lies below the belt of stability and thus positron emitter

$$._{20}^{38}Ca \rightarrow ._{19}^{38}K + _{+1}^{0}e$$

(b) $._{18}^{35}Ar$: It has $\frac{n}{p} = \frac{17}{18} = 0.994$, which lies below the belt of stability and thus, positron emitter

$$._{18}^{35}Ar \rightarrow ._{17}^{35}Cl + ._{+1}^{0}e$$

If $n/p < 1$ and nuclear charge is high the nuclide may show K-electron capture.

(c) $._{32}^{80}Ge$: It has $\frac{n}{p} = \frac{48}{32} = 1.5$, which lies above the belt of stability and thus β-emitter

$$._{32}^{80}Ge \rightarrow ._{33}^{80}As + _{-1}^{0}e$$

(d) $._{20}^{40}Ca$: It has both magic number $p = 20, m = 20$ and thus, stable.

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47. For the given series reaction in n^{th} step, find out the number of protons & energy.

_ (92).$^{238}U \rightarrow Ba + Kr + 3_0n^1 + \text{Energy}(E)$

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Part Ii

1. The element having no neutron in the nucleus of its atom is-

(a). hydrogen

(b). nitrogen

(c). helium

(d). boron

A. Hydrogen

B. Nitrogen

C. Helium

D. Boron

Answer: A

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2. The mass of cathode ray particle is:

A. Same for different gases

B. Different for different gases

C. Minimum for H_2 gas

D. Different for same gases

Answer: A

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3. The ration of the e/m (specific charge) values of an electron and an α - particle is

A. $2:1$

B. $1:1$

C. $1:2$

D. None of these

Answer: D

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4. Rutherford's α particle scattering experiment eventually led to the conclusion that

A. mass and energy are related

B. electrons occupy space around the nucleus

C. neutrons are buried deep in the nucleus

D. the point of impact with matter can be precisely determined

Answer: B

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5. The value of Planck's constant is $6.63 \times 10^{-34} Js$. The velocity of light is $3 \times 10^{8} m/\sec$. Which value is closest to the wavelength of a quantum of light with frequency of $8 \times 10^{15} \sec^{-1}$?

A. $5 \times 10^{-18} m$

B. $4 \times 10^{-8} m$

C. $3 \times 10^{7} m$

D. $2 \times 10^{-25} m$

Answer: B

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6. The MRI (magnetic resonance imaging) body scanners used in hospitals operate with $400 MHz$ radio frequency. The wavelength corresponding to this radio frequency is.

A. $0.75 m$

B. $0.75cm$

C. $1.5m$

D. $2cm$

Answer: A

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7. Electromagnetic radiation of wavelength 242 nm is just sufficient to ionise the sodium atom . Calculate the ionisation energy of sodium in kJ mol^{-1}.

A. 494.65

B. 400

C. 247

D. 600

Answer: A

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8. A bulb of 40 W is producing a light of wavelength 620 nm with 80% of efficiency , then the number of photons emitted by the bulb in 20 seconds are :

$(1eV = 1.6 \times 10^{-19}J, hc = 12400eV)$

A. 2×10^{18}

B. 10^{18}

C. 10^{21}

D. 2×10^{21}

Answer: D

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9. Light of wavelength λ falls on metal having work functions hc/λ_0 . Photoelectric effect will take place only if :

A. $\lambda \geq \lambda_0$

B. $\lambda \geq 2\lambda_0$

C. $\lambda \leq \lambda_0$

D. $\lambda \leq \lambda_0/2$

Answer: C

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10. A phot of energy $h\upsilon$ is absorbed by a free electron of a metal having work function $\phi < h\upsilon$

A. The electron is sure to come out

B. The electron is sure to come out with a kinetic energy $(hv - w)$

C. Either the electron does not come out or it comes with a kinetic energy $(hv - w)$

D. It may come out with a kinetic energy less than $(hv - w)$

Answer: D

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11. Correct order of radius of the first orbit of $H, He^{+}, Li^{2+}, Be^{3+}$ is :

A. $H > He^{+} > Li^{2+} > Be^{3+}$

B. $Be^{3+} > Li^{2+} > He^{+} > H$

C. $He^{+} > Be^{3+} > Li^{2+} > H$

D. $He^{+} > H > Li^{2+} > Be^{3+}$

Answer: A

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12. What is likely to be orbit number for a circular orbit of diameter $20nm$ of the hydrogen atom:

A. 10

B. 14

C. 12

D. 16

Answer: B

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13. Which is the correct relationship?

(a). E_1 of $H = 1/2E_2$ of $He^+ = 1/3E_3$of $Li^{2+} = 1/4E_4$of Be^{3+}

(b). $E_1(H) = E_2(He^+) = E_3(Li^{2+}) = E_4(Be^{3+})$

(c). $E_1(H) = 2E_2(He^+) = 3E_3(Li^{2+}) = 4E_4(Be^{3+})$

(d). No relation

A. $E_1 \text{of} H = 1/2E_2 \text{of} He^+ = 1/3E_3 \text{of} Li^{2+} 1/4E_4 \text{of} Be^{3+}$

B. $E_1(H) = E_2(He^+) = E_3(Li^{2+}) = E_4(Be^{3+})$

C. $E_1(H) = 2E_2(He^+) = 3E_3(Li^{2+}) = 4E_4(Be^{3+})$

D. No relation

Answer: B

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14. If the value of $E = -78.4 \text{kcal//mol}$, the order of the orbit in hydrogen atom is-

A. 4

B. 3

C. 2

D. 1

Answer: C

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15. If velocity of an electron in I orbit of H atom is V, what will be the velocity of electron in 3^{rd} orbit of Li^{2+}

A. V

B. $V/3$

C. $3V$

D. $9V$

Answer: A

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16. In a certain electronic transition in the hydrogen atoms from an initial state (1) to a final state (2), the difference in the orbit radius $\left(\left(r_1 - r_2\right)\right.$ is 24 times the first Bohr radius. Identify the transition-

A. $5 \rightarrow 1$

B. $25 \rightarrow 1$

C. $8 \rightarrow 3$

D. $6 \rightarrow 5$

Answer: A

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17. S_1 : Bohr model is applicable for Be^{2+} ion .

S_2 : Total energy coming out of any light source is integral multiple of energy of one photon.

S_3 : Number of waves present in unit length if wave number .

S_4 : e/m ratio in cathode ray experiment is independent of the nature of the gas .

Select the correct set of True-False for above statement.

A. $FFTT$

B. $TTFF$

C. $FTTT$

D. $TFFF$

Answer: C

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18. S_1 : Potential energy of the two opposite charge system increase with the decrease in distance .

S_2 : When an electron makes transition from higher orbit to lower orbit it's kinetic energy increases.

S_3 : When an electron make transition from lower energy to higher energy state its potential energy increases.

S_4 : 11 eV photon can free an electron from 1 st excited state of He^+ ion .

Select the correct set of true-false for above statements.

A. $TTTT$

B. $FTTF$

C. $TFFT$

D. $FFFF$

Answer: B

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19. The energy of a hydrogen atom in its ground state is $-13.6eV$. The energy of the level corresponding to the quantum number n=5 is

A. $-0.54eV$

B. $-5.40eV$

C. $-0.85eV$

D. $-2.72eV$

Answer: A

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20. The wavelength of a spectral life for an electronic transition inversely proportional to:

A. number of electrons undergoing transition

B. the nuclear charge of the atom

C. the velocty of an electron undergoing transition

D. the difference in the energy involved in the transition

Answer: D

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21. In a sample of H - atom electrons make transition from 5^{th} excited state to ground state, producing all possible types of photons, then number of lines in infrared region are

A. 4

B. 5

C. 6

D. 3

Answer: C

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22. Total no of lines in Lyman series of H spectrum will be-

(where n=no. of orbits)

A. n

B. $n - 1$

C. $n - 2$

D. $n(n + 1)$

Answer: B

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23. Number of visible lines when an electron returns from 5th orbit to ground state in H spectrum :

A. 5

B. 4

C. 3

D. 10

Answer: C

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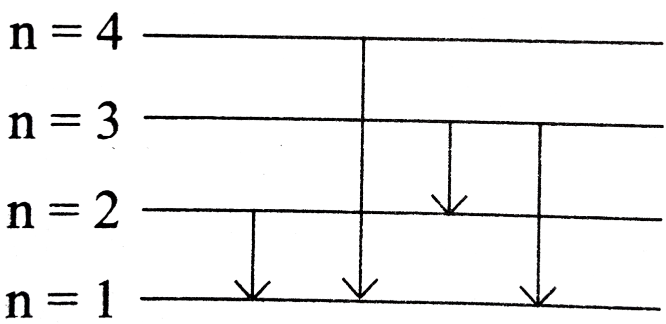
24. Suppose that a hypothetical atom gives a red, green, blue and violet line spectrum. Which jump according to figure would give off the red spectral line.



A. $3 \rightarrow 1$

B. $2 \rightarrow 1$

C. $4 \rightarrow 1$

D. $3 \rightarrow 2$

Answer: D

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25. The difference between the wave number of 1st line of Balmer series and last line of Paschen series for Li^{2+} ion is :

A. $\frac{R}{36}$

B. $\frac{5R}{36}$

C. $4R$

D. $\frac{R}{4}$

Answer: D

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26. The approximate wavelength associated with a gold-ball weighting 200 g and moving at a speed of 5m/h is of the order of :

A. $10^{-1}m$

B. $10^{-20}m$

C. $10^{-30}m$

D. $10^{-40}m$

Answer: C

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27. What possible can be the ratio of the de-Broglie wavelength for two electrons each having zero initial energy and accelerated through 50 volts and 200 volts ?

A. $3:10$

B. $10:3$

C. $1:2$

D. $2:1$

Answer: D

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28. In H-atom if $r1$ is the radius fo first Bohr orbit de-Broglie wavelength of an elecrton in 3^{rd} orbit is :

A. $3\pi x$

B. $6\pi x$

C. $\frac{9x}{2}$

D. $\frac{x}{2}$

Answer: B

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29. An α - particle is accelerated through a potential difference of V volts from rest. The de-Broglie's wavelengths associated with it is.

A. $\sqrt{\frac{150}{V}}$ Å

B. $\frac{0.286}{\sqrt{V}}$ Å

C. $\frac{0.101}{\sqrt{V}}$ Å

D. $\frac{0.983}{\sqrt{V}}$ Å

Answer: C

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30. de Broglie wavelength of electron in second orbit of Li^{2+} ion will be equal to de Broglie's wavelength of electron in :

A. $n = 3$ of H-atom

B. $n = 4$ of C^{5+} ion

C. $n = 6$ of Be^{3+} ion

D. $n = 3$ of He^{+} ion

Answer: B

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31. The wavelength of a charged particle .... the square root of the potential difference through which it is accelerated .

A. is inversely proportional to

B. is directly proportional to

C. is independent of

D. is unrelated with

Answer: A

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32. The uncertainty in the momentum of an electron is $1.0 \times 10^{-5} kgms^{-1}$.

The uncertainty in its position will be : (h = 6.626×10^{-34} Js)

A. $1.05 \times 10^{-28} m$

B. $1.05 \times 10^{-26} m$

C. $5.27 \times 10^{-30} m$

D. $5.25 \times 10^{-28} m$

Answer: C

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Exercise 2

1. Which is not true with respect to the cathode rays ?

A. A steam of electrons

B. Charged particles

C. Move with same speed as that of light

D. Can be deflected electric field

Answer: C

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2. Which of the following does not characteristic X -rays ?

A. The radiation can ionise the gas

B. it causes fluresce effect on ZnS

C. `Deflected by electric and magnetic fields

D. Have wavelength shorter than ultraviolet rays

Answer: C

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3. The mass to charge ratio (m/e) for a cation os $1.5 \times 10^{-8}\ kg/C$. What is the mass of this cation?

A. $2.4 \times 10^{-19}g$

B. $2.4 \times 10^{-27}g$

C. $2.4 \times 10^{-24}g$

D. none of these

Answer: C

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4. From the α-particle scattering experiment, Rutherford conculded that

A. α-particles can come within a distance of the order of $10^{-14}m$ of the nucleus

B. the radius of the nuclear is less than $10^{-14}m$

C. Scattering follows Coulomb's law

D. All of these

Answer: D

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5. An oil drop has $6.39 \times 10^{-19} C$ charge .How many electrons does this oil drop has ?

A. 2

B. 4

C. 6

D. 8

Answer: B

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6. Which of the following statement is true in the context of photoelectic effect?

A. The kinetic energy of ejected electron is independent of the intensity of a radiation.

B. The number of photoelectrons ejected depends upon the intensity of the incident radiation.

C. The kinetic energy of the emitted electrons depends on the frequency of the incident radiation

D. All of these

Answer: D

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7. The ratio of slopes of K_{max} vs. V and V_0 vs. v curves in the photoelectric effect gives (v= freqency. K_{max}= maximum kinetic energy, V_0=stopping potential) :

A. charge of electron

B. Planck's constant

C. work function

D. the ratio of Planck's constant of electronic charge

Answer: A

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8. A light source of wavelength λ illuminates a metal and ejects photo-electrons with $(K.E.)_{\max} = 1.eV$ Another light source of wavelength $\frac{\lambda}{3}$, ejects photo-electrons from same metal with $(K.E.)_{\max} = 4eV$ Find the value of work function?

A. $1eV$

B. $2eV$

C. $0.5eV$

D. none of these

Answer: C

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9. In Bohr's model of the hydrogen atom the ratio between the period of revolution of an electron in the orbit of $n = 1$ to the period of the revolution of the electron in the orbit $n = 2$ is :-

(a). $1:2$

(b). $2:1$

(c). $1:4$

(d). $1:8$

A. $1:2$

B. $2:1$

C. $1:4$

D. $1:8$

Answer: D

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10. In two individual hydrogen atoms electrons move around the nucleus in circular orbits of radii R and 4R. The ratio of the time taken by them to complete one revolution is:

A. $1:4$

B. $4:1$

C. $1:8$

D. $8:1$

Answer: C

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11. The angular momentum of electron in a given orbit is J . Its kinetic energy will be :

A. $\frac{1}{2}\frac{J^2}{mr^2}$

B. $\frac{Jv}{r}$

C. $\frac{J^2}{2m}$

D. $\frac{J^2}{2\pi}$

Answer: A

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12. The potential energy of the electron present in the ground state of Li^{2+} ion is represented by :

A. $\frac{3e^2}{8\pi \in_0 r}$

B. - $\frac{3e^2}{8\pi \in_0 r}$

C. $\frac{3e^2}{4\pi \in_0 r}$

D. - $\frac{3e^2}{4\pi \in_0 r}$

Answer: A

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13. Which transition in Li^{2+} would have the same wavelength as the $2 \rightarrow 4$ transition in He^+ ion ?

A. $4 \rightarrow 2$

B. $2 \rightarrow 4$

C. $3 \rightarrow 6$

D. $6 \rightarrow 2$

Answer: C

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14. Let v_1 be the frequency of series limit of Lyman series, v_2 the frequency of the first line of Lyman series and v_3 the frequency of series limit of Balmer series. Then which of the following is correct ?

A. $\upsilon_1 - \upsilon_2 = \upsilon_3$

B. $\upsilon_2 - \upsilon_1 = \upsilon_3$

C. $\upsilon_3 = 1/2\left(\upsilon_1 - \upsilon_3\right)$

D. $\upsilon_1 + \upsilon_2 = \upsilon_3$

Answer: A

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15. Number of visible lines when an electron returns from 5th orbit to ground state in H spectrum :

A. 5

B. 4

C. 3

D. 10

Answer: C

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16. If the shortest wave length of Lyman series of H atom is x, then the wave length of the first line of Balmer series of H atom will be-

A. $9x/5$

B. $36x/5$

C. $5x/9$

D. $5x/36$

Answer: B

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17. In a sample of H-atoms , electrons de-excite from a level 'n' to 1 . The total number of lines belonging to Balmer series are two . If the electrons are ionised from level 'n' by photons of energy 13 eV . Then the kinetic energy of the ejected photoelectrons will be :

A. $12.15eV$

B. $11.49eV$

C. $12.46eV$

D. $12.63eV$

Answer: A

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18. A particle X moving with a certain velocity has a debroglie wave length of $1A^{\circ}$. If particle Y has a mass of 25% that of X and velocity 75% that of X, debroglies wave length of Y will be :-

(a). $3A^{\circ}$

(b). $5.33A^{\circ}$

(c). $6.88A^{\circ}$

(d). $48A^{\circ}$

A. 3Å

B. 5.33Å

C. 6.88Å

D. 48Å

Answer: B

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19. which of the given statement(s) is /are false ?

(P) orbital angular momentum of the azimuthal quantum number as lowest for any principle quantum number is $\frac{h}{\pi}$,

(Q) if n=3 ,l=0 ,m=0 for the last valence shell electron ,them the possible atomic number may be 12 or 13 .

(R) total spin of electrons for the atom _ (25) Mn is $\pm \frac{7}{2}$.

(S) spin magnetic moment of inert gas is zero .

A. I, II and III

B. II and III only

C. I and IV only

D. none of these

Answer: A

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20. The value of the spin only magnetic moment of a particular ion is 2.83 Bohr magneton. The ion is

A. Fe^{2+}

B. Ni^{2+}

C. Mn^{2+}

D. Co^{3+}

Answer: B

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21. What are the values of the orbital angular momentum of an electron in the orbitals $1s, 3s, 3d$ and $2p$:-

(a). $0, 0\sqrt{6h}, \sqrt{2h}$

(b). $1, 1\sqrt{4h}, \sqrt{2h}$

(c). $0, 1\sqrt{6h}, \sqrt{3h}$

(d). $0, 0\sqrt{20h}, \sqrt{6}$

A. `0, 0, sqrt(6)

B.

C.

D.

Answer: A

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22. After np orbitals are filled, the next orbital filled will be :-

(a). $(n+1)s$

(b). $(n+2)p$

(c). $(n+1)d$

(d). $(n+2)s$

A. $(n+1)s$

B. $(n+2)p$

C. $(n+1)d$

D. $(n+2)s$

Answer: A

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23. If n and l are respectively the principal and azimuthal quantum numbers , then the expression for calculating the total number of electrons in any energy level is :

A. $\sum_{l=1}^{l=n} 2(2l+1)$

B. $\sum_{l=1}^{l=n-1} 2(2l+1)$

C. $\sum_{l=0}^{l=n+1} 2(2l+1)$

D. $\sum_{l=0}^{l=n-1} 2(2l+1)$

Answer: D

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24. The quantum number $+1/2$ and $-1/2$ for the electron spin represent

A. Rotation of the electron in clockwise and anticlockwise direction respectively.

B. Rotation of the electron in anticlockwise and clockwise direction respectively.

C. Magnetic moment of the electron pointing up down respectively

D. Two quantum mechanical spin states ehich have no classical analogue.

Answer: D

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25. Calculate the number of α- and β-particles emitted when $._{92}U^{238}$ into radioactive $._{82}Pb^{206}$.

A. $8\alpha, 6\beta$

B. $6\alpha, 6\beta$

C. $6\alpha, 8\beta$

D. $4\alpha, 4\beta$

Answer: A

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Exercise 20

1. The ratio of the de Broglie wavelength of a proton and alpha particles will be $1:2$ if their

A. velocity are in the ratio $1:8$

B. velocity are in the ratio $8:1$

C. kinetic energy are in the ratio $1:64$

D. kinetic energy are in the ratio $1:256$

Answer: B

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Exercise 21

1. If wavelength is equal to the distance travelled by the electron in one second , then :

A. $\lambda = \frac{h}{p}$

B. $\lambda = \frac{h}{m}$

C. $\lambda = \sqrt{\frac{h}{p}}$

D. $\lambda = \sqrt{\frac{h}{m}}$

Answer: D

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Exercise 22

1. An electron is continuonsly accelerated in vacume tube by appliying potential difference if its de Brogle wavelength is decresed by 1% the change in the kinetic energy of the electron is nearly

A. Decreased by 1%

B. Increased by 2%

C. Increased by 1%

D. Decreased by 2%

Answer: B

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Exercise 23

1. An electron in a hydrogen like atom makes transition from a state in which itd de Broglie wavelength is λ_1 to a state where its de Broglie wavelength is λ_2 then wavelength of photon (λ) generated will be :

A. $\lambda = \lambda_1 - \lambda_2$

B. $\lambda = \frac{4mc}{h}\left\{\frac{\lambda_1^2\lambda_2^2}{\lambda_1^2 - \lambda_2^2}\right\}$

C. $\lambda = \sqrt{\frac{\lambda_1^2\lambda_2^2}{\lambda_1^2 - \lambda_2^2}}$

D. $\lambda = \frac{2mc}{h}\left\{\frac{\lambda_1^2\lambda_2^2}{\lambda_1^2 - \lambda_2^2}\right\}$

Answer: D

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Exercise 24

1. Consider an electron in the n^{th} orbit of a hydrogen atom in the Bohr model . The circumference of the orbit can be expressed in terms of the de Broglie wavelength λ of the electron as :

A. $(0.529)n\lambda$

B. $\sqrt{n}\lambda$

C. $(13.6)\lambda$

D. $n\lambda$

Answer: D

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Exercise 25

1. Which orbitals is non-directional ?

A. s

B. p

C. d

D. All

Answer: A

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Exercise 26

1. In case of $D_{x^2-y^2}$ orbital :

A. Probability of finding the electron along x-axis zero

B. Probability of finding the electron along y-axis zero

C. Probability of finding the electron is maximum along x and y-axis

D. Probability of finding the electron is zero in $x - y$ plane

Answer: C

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Exercise 27

1. The radial probability is the probability of finding electron in a small spherical shell around the nucless at a particular distance ® Hence radial probility is

A. $4\pi r^2 dr\psi^2$

B. $\frac{4}{3}\pi r^2 dr\psi^2$

C. $2\pi r^2 dr\psi^2$

D. $4\pi r dr\psi$

Answer: A

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Exercise 28

1. In an atomic orbital , the sign of inhes indicates the

A. sign of the probability distribution

B. sign of charge

C. sign of the wave function

D. presence or absence of electron

Answer: C

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Exercise 29

1. Correct set of four quantum numbers for the valence (outermost) electron of rubidium $(Z = 37)$ is

A. $n = 5, l = 0, m = 0, s = +1/2$

B. $n = 5, l = 1, m = 0, s = +1/2$

C. $n = 5, l = 1, m = 1, s = +1/2$

D. $n = 6, l = 0, m = 0, s = +1/2$

Answer: A

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Part Ii Single And Double Value Integer Type

1. The ratio of specific charge (e/m) of a proton and that of an α-particle is:

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2. How many of the following statement are true about the cathode rays?

(i) Path of travelling is straight from the cathode with a very high velocity as it produces shadow of an object placed in its path

(ii) Rays consist of material particle.

(iii) They deflect towards negative end of the electrode.

(iv) They produce yellow glow when the glass will beyond anode.

(v) Cathode rays penetrate through thin sheets of aluminium and metals.

(vi) They affect the photographic plates

(vii) The ratio of charge (e) to mass (m) i.e. charge//mass is same for all cathode rays irrespective of the gas used in the tube.

$e/m = 1.76 \times 10^{11} Ckg^{-1}$

(viii) Cathode rays are visible at low voltage.

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3. When a certain metal was irradiated with light frequency $1.6 \times 10^{16} Hz$, the photo electrons emitted had twice the kinetic energy as did photoelectrons emitted with frequency $1 \times 10^{16} Hz$ when the same metal was irradiated with light then threshold frequency $x \times 10^{15} Hz$. Find "x".

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4. Compare the energies of two radiation one with a wavelength of $300 nm$ and other with $600 nm$.

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5. The latent heat of fusion of ice is $330J/g$. Calculate the number of photons of radiation of frequency $5 \times 10^{13}s^{-1}$ to cause the melting of 1 mole of ice. Take $h = 6.6 \times 10^{-34}J.S.$ Express your answer as $X \times 10^{22}$, what is the value of 'X'

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6. The work function for a metal is $40eV$. To emit photo electrons of zero velocity from the surface of the metal the wavelength of incident light should be xnm.

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7. A single electron system has ionization energy $20902.2kJ/mo \leq$. Find the number of protons in the nucleus of the system.

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8. Electrons in a sample of H-atoms make transition from state n=x to some lower excited state. The emission spectrum from the sample is found to contain only the line belonging to a particular series. If one of the photons has an energy of 0.6375 eV . Find the value of x.

$$\left[\text{Take}0.6375eV = \frac{3}{4} \times 0.85eV\right]$$

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9. If first ionisation potential of a hypothetical atom is $16V$, then the first excitation potential will be :

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10. Electrons in the H-atoms jumps from some higher level to 3rd energy level . If six spectral lines are possible for the transition find the initial position of electron.

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11. An element undergoes a reaction as shown $sx + 2e^{-} \rightarrow x^{-2}$

Energy released $= 30.87$ ev/atom. If the energy released is used to dissociated $4g$ to H_2 molecules equally into H^+ and H^+ is excited state of H atoms where the electron travels in orbit whose circumference equal to four times its de -roglie's wavelength. Determine the minimum number of moles of x that would be required.

Given IE of $H = 13.6$ ev/atom, bond energy of $H_2 = 4.526$v/molecule

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12. Photons of equal energy were incident on two different gas samples. One sample containing H-atoms in the ground state and the other sample containing H-atoms in some excited state with a principle quantum number 'n'. The photonic beams totally ionise the H-atoms. If the difference in the kinetic energy of the ejected electrons in the two different cases is $12.75eV$. Then find the principal quantum number 'n' of the excited state.

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13. There are two samples of H and He^+ atom. Both are in some excited state. In hydrogen atom, total number of lines observed in Balmer series is 4 in He^+ atom total number of lines observed in Paschen series is 1. Electron in hydrogen sample make transitions to lower states from its excited state, then the photon corresponding to the line of maximum energy line Balmer series of H sample is used to further excite the already excited He^+ sample. The maximum excitation level of He^+ sample will be :

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14. Photon having energy equivalent to the binding energy of $4th$ state of He^+ atom is used to eject an electron from the metal surface of work function $1.4eV$. If electrons are further accelerated through the potential difference of $4V$ then the minimum value of De-brogile wavelength associated with the electron is:

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15. In a sample of H-atoms in ground state electrons make transition from ground state to a particular excited state where path length is 5 times de Broglie wavelength , electrons make back transition to the ground state producing all possible photons. If photon having 2nd highest energy of this sample can be used to excite the electron in a particular excited state of Li^{2+} ion then find the final excited state of Li^{2+} ion .

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16. An electron in Li^{2+} ion makes a transition from higher state n_2 to lower state $n_1 = 6$. The emitted photons is used to ionize an electron in H-atom from 2nd excited state. The electron on leaving the H-atom has a de Broglie wavelength λ - 12.016Å.Find the value of n_2.

Note : Use $(12.016)^2 = \frac{150 \times 144}{13.6 \times 11}, \lambda_{\text{Å}} = \sqrt{\frac{150}{KE_{eV}}}$

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17. The radial distribution curve of $2s$ sub-level consists of x nodes. Value of x is :

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18. If each orbital can hold a maximum of 3 electrons, the number of elements in $4th$ periodic table (long form) is.

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19. How many of these orbitals have maximum orbital angular distribution is maximum at an angle of 45° to the axial direction.

$d_{xy}, d_{x^2-y^2} d_{yz}, d_{xz}, d_{z^2}, P_x P_y P_z, s$

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20. Total number of electrons having $n + l = 3$ in $Cr(24)$ atom in its ground state is.

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21. An ion $\left(Mn^{a+}\right)$ has the magnetic moment equal to 4.9 B.M` What is the value of (a) :

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22. In all, how many nodal planes are there in the atomic orbitals for the principal quantum number $n = 3$?

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23. The number of neutrons accompanyng the formation of $\_(54)^{139}Xe$ and $\_(38)^{139}Xe$ from the absorption of a slow neutron by $\_(92)^{235}U$ followed by nuclear fision is:

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24. $._{90}Th^{234}$ disintegrates to give $._{82}Pb^{206}Pb$ as the final product. How many alpha and beta particles are emitted during this process ?

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Part Iii

1. Which is true about an electron-

(a). rest mass of electron is $9.1 \times 10^{-28}g$

(b). mass of electron increases with the increase in velocity

(c). molar mass of electron is $5.48 \times 10^{-4}g/\text{mole}$

(d). e/m of electron is $1.7 \times 10^{8}\text{coulomb}/g$

A. Rest mass of electron is $9.1 \times 10^{-28}g$

B. Mass of electron increases with the increase in velocity

C. Molar mass of electron is $5.48 \times 10^{-4}g/mo \leq$

D. e/m of electron is $1.7 \times 10^{8}co\underline{o}mb/g$

Answer: A, B, C, D

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2. Isotone of $\_(32)^{76}Ge$ is//are:

A. $\_(32)^{77}Ge$

B. $\_(33)^{77}As$

C. $\_(34)^{77}Se$

D. $\_(34)^{78}Se$

Answer: B, D

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3. Which of the following is iso-electronic with neon-

A. O^{2-}

B. F^{-}

C. Mg

D. Na

Answer: A, B, C, D

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4. Many elements have non-integral atomic masses because

A. they have isotopes

B. their isotopes have non-intergral masses

C. the constituents, neutrons, protons and electrons combine to give fractional masses

D. none of these

Answer: A

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5. When alpha particle are sent through a thin metal foil ,most of them go straight through the foil because

A. alpha particles are much heavier than electrons

B. alpha particles are positively charged

C. most part of the atom is empty space

D. alpha particles move with high speed

Answer: A, C

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6. Which of the following statement (s) are wrong?

A. Photons having energy $400kJ$ will break 4 mole bonds of a moiecule A_2 where A - A bond dissociation energy is $100kJ/mol$.

B. Two bulbs are emitting light having wavelenght 2000Å & 3000Å respectively. If the bulbs A & B are 40 watt and 30 watt respectively then the ratio of no. of photons emitted by A & B per day is $1:2$

C. When an electron make transition from lower to higher orbit, photon is emitted.

D. None of these

Answer: A, B, C

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7. The spectrum of He^{+} is expected to be similar to that of

A. Li^{2+}

B. He

C. H

D. Na

Answer: A, C

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8. Chose the currect on the basis of Bohr's theory

A. Velocity of electron $\propto \frac{1}{n}$

B. Frequency of revolution $\propto \frac{1}{n^3}$

C. Radius of orbit $\propto n^2 Z$

D. Electrostatic force on electron $\propto \frac{1}{n^4}$

Answer: A, B, D

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Part Iv Comprehension

1. In the photoelectric effect the eletrons are emiited intantaneously from a given matal plate when it is irradiated with radiation of frequency equal to or greater then some minimum ferquency, is called the threshold frequency.According to Planck's idea, light may be considered to be made up discrete particles called photons.Each photon carries energy equal ti hv.When this photon cllides with the electron of the metal, the electron acquires energy of the emitted electron is given by :

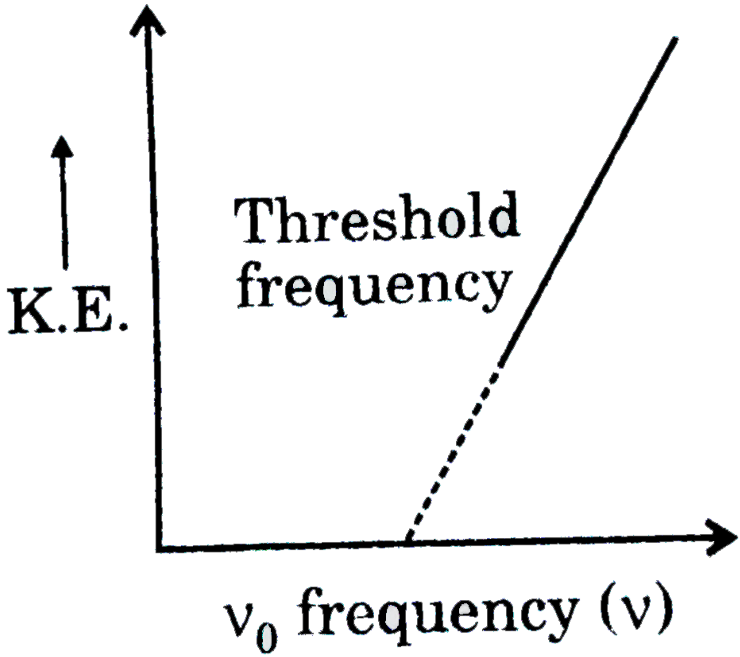
$$hv = K.E_{\text{maximum}} + PE = \frac{1}{2}mu^2 + PE$$

If the incident rediation is of threshold frequency the electron will be emitted without any kinetic energy

i.e hv_0

$$\therefore \frac{1}{2}mu^2 = hv - hv_0$$

A plot of kinetic energy of the emitted electron versus frequency of the incident radiation yields a straight line given as :



A beam of white light is dispersed into its wavelenght components of potassium metal. What of the electron emitted by the different light component ?

A. blue gt green gt orange gt yellow

B. violet gt blue gt orange gt red

C. yellow gt green gt blue gt violet

D. orange gt yellow gt blue gt violet

Answer: B

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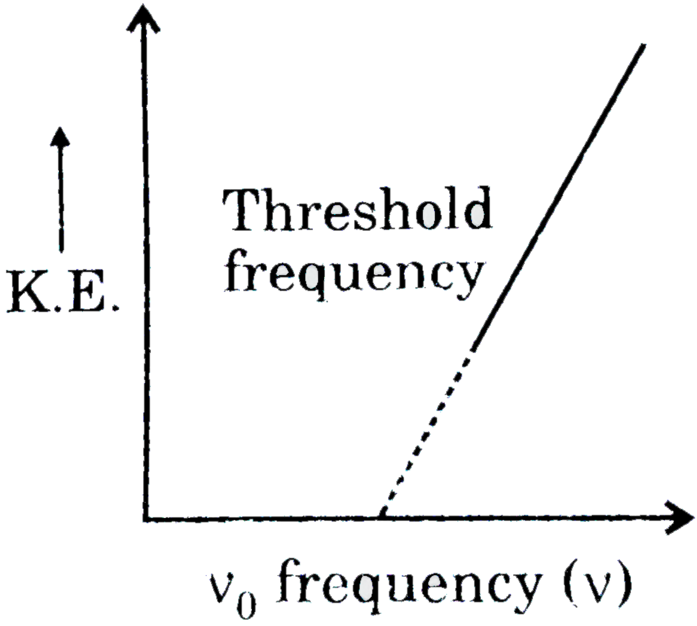

A laser producting monochromatic lights of different wavelenght is uesd to eject electrons from the sheet of glod having threshold frequency $6.15 \times 10^{14} s^{-1}$ Which of the following incident rediation will be suitable for the ejecting of electrons ?

A. 1.5 moles of photons having frequency $3.05 \times 10^{14} s^{-1}$

B. 0.5 moles of photon of frequency $12.3 \times 10^{12} s^{-1}$

C. One photon with frequency $5.16 \times 10^{15} s^{-1}$

D. All of the above

Answer: C

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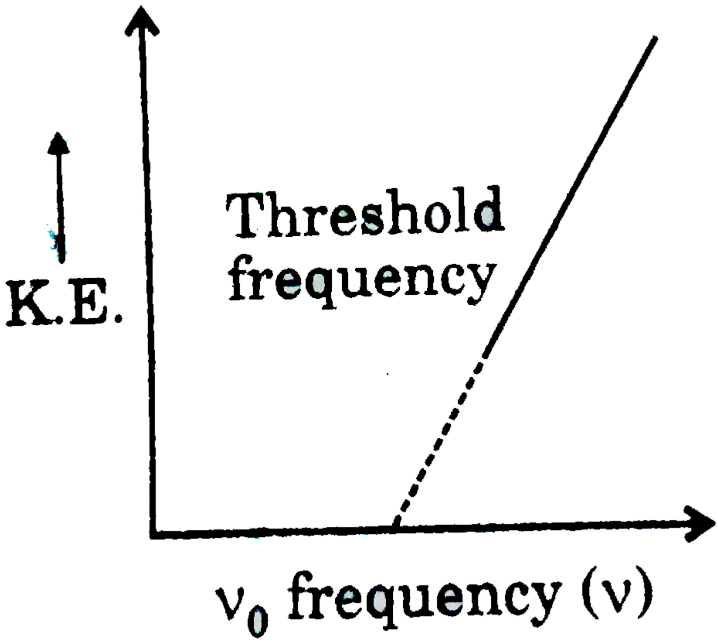

The number of photoelectrons emitted depends upon :

A. The intensity of the incident radiation

B. The frequency of the incident radiation

C. The product of intensity and frequency of incident radiation

D. None of these

Answer: A

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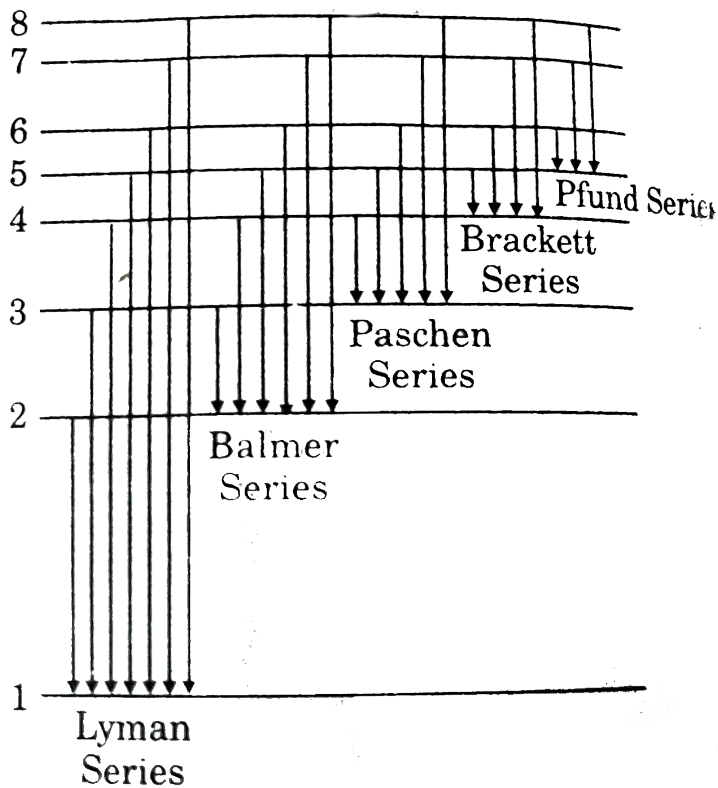
4. the only electron in the hydrogen atom resides under ordinary conditions in the first orbit. When energy is supplied the electron moves to higher energy orbit depending on the amount of energy absorbed. It emits energy. Lyman series is formed when the electron returns to the lowest orbit while Balmer series is formed when the electron returns to second. Similarly, Paschen, Breakett and Pfund series are formed when electron returns to the third, fourth and fifth orbits from higher energy orbits respectively (as shown in figure).



Maximum number of different lines produced when electron jump from nth level to ground level is equal to

$\frac{n(n-1)}{2}$.

For example in the case of $n = 4$, number of lines produced is 6. $(4 \rightarrow 3, 4 \rightarrow 2, 4 \rightarrow 1, 3 \rightarrow 2, 3 \rightarrow 1, 2 \rightarrow 1)$. When an electron returns from $n_2 \text{to} n_1$ state, the number of different lines in the spectrum will be equal to $\frac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$

If the electron comes back from energy level having energy E_2 to energy level having energy E_1, then the difference may be expressed in terms of energy of photon as:

$$E_2 - E_1 = \Delta E, \lambda = \frac{hc}{\Delta E}, \Delta E = hv(v \text{ - frequency})$$

Since h and c are constants ΔE corresponds to definite energy: thus each transition from one energy level to another will produce a light of definite wavelength. This is actually observed as a line in the spectrum of hydrogen atom.

Wave number of line is given by the formula:

$$\bar{v} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

where R is a Rydberg constant $\left(R = 1.1 \times 10^7 m^{-1}\right)$.

(i) First line of a series : It is called line of longest wavelength of line of smallest energy'.

(ii) Series limit or last line of a series : It is the line of shortest wavelength or line of highest energy.

Last line of breakett series for H-atom has wavelength λ_1Å and 2nd line of Lyman series has wavelength λ_2Åthen:

A. $\frac{128}{\lambda_1} = \frac{9}{\lambda_2}$

B. $\frac{16}{\lambda_1} = \frac{9}{\lambda_2}$

C. $\frac{4}{\lambda_1} = \frac{1}{\lambda_2}$

D. $\frac{128}{\lambda_1} = \frac{8}{\lambda_2}$

Answer: A

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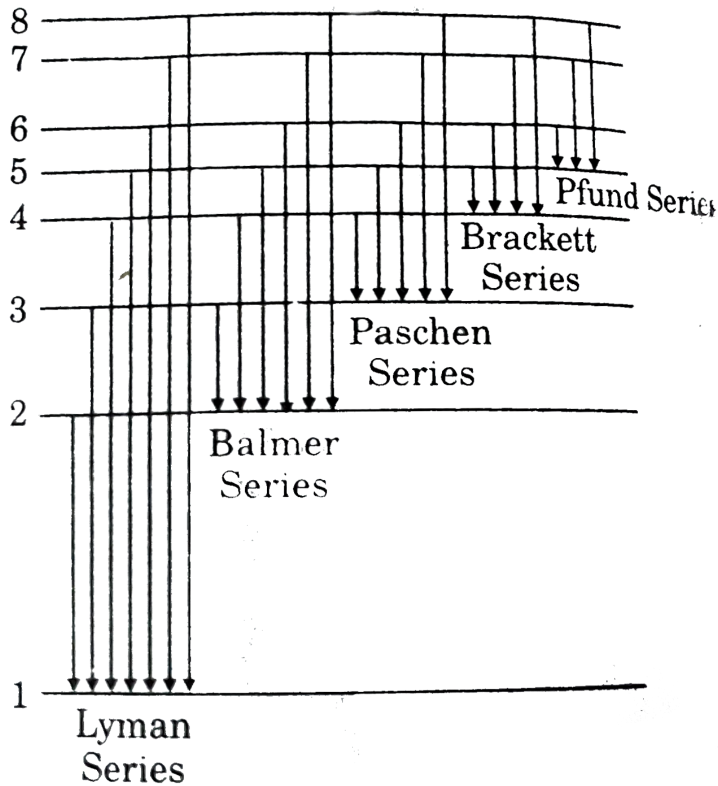

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(ii) Series limit or last line of a series : It is the line of shortest wavelength or line of highest energy.

Last line of breakett series for H-atom has wavelength $\lambda_1 \mathring{A}$ and 2nd line of Lyman series has wavelength $\lambda_2 \mathring{A}$then:

A. T F F

B. F T T

C. T F T

D. T T T

Answer: D

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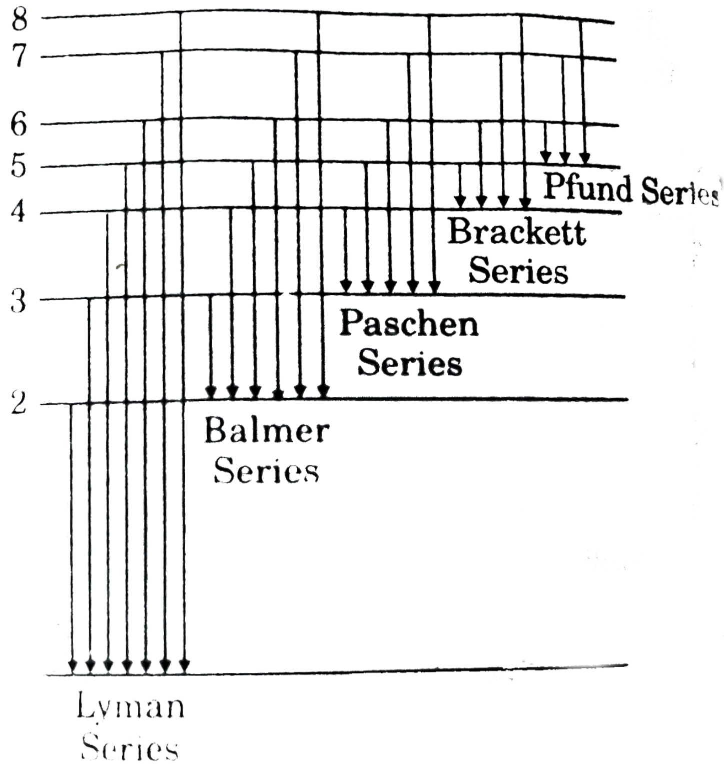

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wave number of the first line of Paschen series in Be^{3+} ion is :

A. $\frac{7R}{16}$

B. $\frac{7R}{144}$

C. $\frac{7R}{9}$

D. $\frac{R}{144}$

Answer: C

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7. de Broglie proposed dual nature for electron by putting his famous equation $\lambda = \frac{h}{mv}$. Later on, Heisenberg proposed uncertainty principle as $\delta p \Delta x \geq \frac{h}{4\pi}$. On the contrary,

Particle nature of electron was established on the basis of photoelectric effect. When a photon strikes the metal surface it gives up its energy to the electron. Part of this energy (say W) is used by the electrons to escape from the metal and the remaining energy imparts kinetic energy

$\left(1/2mv^2\right)$ to the ejected photoelectron. The potential applied on the surface to reduce the velocity of photoelectron to zero is known as stopping potential .

The circumference of third orbit of a single electron species is 3 nm. What may be the approximate wavelength of the photon required to just ionize electron from this orbit?

A. $19.2 \times 10^{-2} m$

B. $5.76 \times 10^{-2} m$

C. $3.84 \times 10^{-2} m$

D. $1.92 \times 10^{-2} m$

Answer: D

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When a beam of photons of a particular energy was incident on a surface of a particular pure metal having work function =(40 eV), some emitted photoelectrons had stopping potential equal to 22 V. some had 12V and rest had lower values. Calculate the wavelength of incident photons assuming that at least one photoelectron is ejected with maximum possible kinetic energy :

A. 310Å

B. 298Å

C. 238Å

D. 200Å

Answer: D

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The circumference of third orbit of a single electron species is 3 nm. What may be the approximate wavelength of the photon required to just ionize electron from this orbit?

A. $91.1nm$

B. $364.7nm$

C. $821nm$

D. $205nm$

Answer: C

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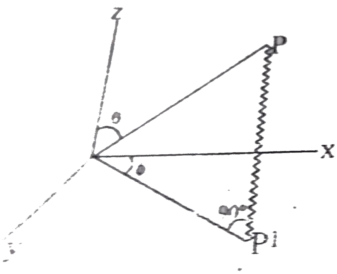
10. After the faliure of Bohr atomic theory but its ability to explain to the atomic spectral a need was felt for the new model that could incorporate, the concept of stationary orbit, de Broglie concept, Heisenberg uncertainity principle. The concept that in corporate above facts is called quantum mechanics of the atomic model wave mchanical model. it includes set of quantum number and $|\psi^2|$ a mathematical expression of the probability of finding an electron at all points in space. This probability function is the best indication available of how the electon behaves, for as a consequence of the Uncertainity Principle, the amount we can know about the electron is limited. While quantum mechanics can tell us the exact probability of finding an electron at any two particular points, it does not tell us how the electron moves from one of these points to the other. Thus the idea of an electron orbit is lost, it is replaced with a description of where the electron is most likely to be found. This total picture of the probability of finding an electron at various points in space is called an orbital.



show variation in axis

There are various types of orbitals possible, each corresponding to one of the possible combinations of quantum numbers. These orbitals are classified according to the value of n and l associated with them. In order to avoid confusion over the use of two numbers, the numerical velues of l are replaced by letters, electrons in orbitals with $l = 0$ are called s-electrons those occupying orbitals for which $l = 1$ are p-electrons and those for which $l = 2$ are called d-electrons. The numerical and alphabetical correspondences are summarized in table. Using the alphabetical notation for l, we would say that in the ground state of hydrogen atom ($n = 1, l = 0$) we have a $1s$-electron, or that the electron moves in a $1s$-orbital. The relation of the spherical polar co-ordinates r, θ and ϕ to Cartesian coordinates x, y and z. To make the concept of an orbital more meaningful, it is helpful to examine the actual solution of the wave function for the one-electron atom. Because of the spherical sysmmetry of the atom, the wave functions are most simply expressed in terms of a spherical polar-coordinate system, shown in fig., which has its orbit at the nucleus. It is found that the wave function can be expressed as the product of two functions, one of which (the "angular part" X) depends only the angle θ and ϕ the other of which (the "radial part" R) depends only on the distance from the nucleus. Thus we have

$$\phi(r, \theta, \phi) = R(r)X(\theta, \phi)$$

Angular and radial parts of hydrogen atom wave function

$$\left(\text{Angular part}X(\theta, \phi), , \text{Radial part}R_{n,l}(r)\right), \left(X(s) = \left(\frac{1}{4\pi}\right)^{1/2}, , R(1s) = 2\left(\frac{z}{a_0}\right)^{3/}\right.$$

This factrorization helps us to visualize the wave function, since it allows us to consider the angular and radial dependences separately. It contains the expression for the angular and radial parts of the one electron atom wave function. Note that the angular part of the wave function for an s-orbital it alwats the same, $(1/4\pi)^{1/2}$ regardless of principal quantum number. It is also true that the angular dependence of the p-orbitals and of the d-orbitals is independent of principle quantum number. Thus all orbitals of given types (s, p, or d) have the same angular behavour The table shows, however, that the radial part of the wave function depends both on the principal quantum n and on the angular momentum quantum number l.

To find the wave function for a particular state, we simply multiply the appropriate angular and radial parts togather called normalized wave function.

The probability of finding an electron at a point within an atom is proportional to the square of orbital wave function, i.e., ψ^2 at that point. Thus, ψ^2 is known as probability density and always a positive quantity.

$\psi^2 dV\left(\text{or}\psi^2.\,4\pi r^2 dr\right)$. represents the probability for finding electron in a small volume dV surrounding the nucleus.

The electron probility density for $1s$-orbital best represented by the relation.

A. $\frac{1}{2\sqrt{\pi}}\left(\frac{Z}{a_0}\right)^{3/2} \times e^{\frac{r}{a_0}}$

B. $\frac{1}{\pi}\left(\frac{Z}{a_0}\right)^3 \times e^{-\frac{2zr}{a_0}}$

C. $\frac{1}{\pi}\left(\frac{Z}{a_0}\right)^{3/2} \times e^{\frac{r}{a_0}}$

D. $\frac{2}{\pi}\left(\frac{Z}{a_0}\right)^3 \times e^{-\frac{2zr}{a_0}}$

Answer: B

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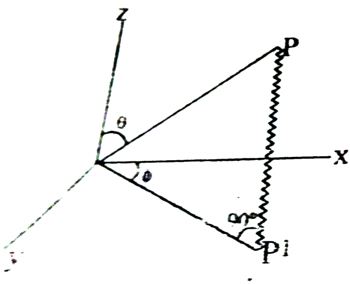

show variation in axis

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$\psi^2 dV\left(\text{or}\psi^2.\,4\pi r^2 dr\right)$. represents the probability for finding electron in a small volume dV surrounding the nucleus.

The angular wave function of which orbital with not disturb by the variation with azimuthal angle only

A. $1s$ and $2s$

B. $2p_z$ and $2d_z^2$

C. $2p_x$ and $3d_z^2$

D. $2p_x$ and $2s$

Answer: A

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12. Quantum number area assigned to get complete information of electrons regarding their energy angular momentum ,spectral lines etc. Four quantum number are known i.e principal quantum numbers which tell the distinct shell and its angular momentum .Azimuthal tell about subshell and Magnetic quantum number deals with different orbitals in subshell. spin quantum number defines the spin of electrons designated as $+\frac{1}{2}$ or $-\frac{1}{2}$

Electrons are filled in orbitals according to Hund's rule of maximum multiplicity .

Two unpaired electrons present in carbon atom are different with respect to their :

A. Principle quantum number

B. Azimuthul quantum number

C. Magnetic quantum number

D. Spin quantum number

Answer: C

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123 respectively .

Electrons are filled in oritals and Hun's rule of maximum multicity .

Number of electrons having the quantum numbers n=4, l=0, $s = -\frac{1}{2} \in Zn^{+2}$ ion is /are :

A. 1

B. 0

C. 2

D. 5

Answer: B

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14. Quantum number area assigned to get complete inforamtion of electrons regarding their energy engular momentum ,spectral lines etc. Four quantum number are known i.e pricipal quantum numbers which tell the diatence shell and its angular momentum .Azimuthal and of courase shape of orbital , Magnetic qunatum number deals with syudy of orientations or deganeracy of a subshell . spin quantum number defines te spin of electrons designaated as $+\frac{1}{2}$ or $-\frac{1}{2}$ respresented by 123 and 123 respectively .

Electrons are filled in oritals and Hun's rule of maximum multicity .

spin angular momentum for unpaires electron in sodium (Atomic No =11) is :

A. $\frac{\sqrt{3}}{2}$

B. $0.866h/2\pi$

C. $-\frac{\sqrt{3}}{2}\frac{h}{2\pi}$

D. None of these

Answer: B

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Exercise 3

1. Calculated the energy required to excite one litre of hydrogen gas at $1atm$ and $298K$ to the first excited state of atomic hydorgen. The enegry for the dissociation of $H - H$ bond is $436kJmol^{-1}$.

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2. The orbit having Bohr radius equal to 1st Bohr orbit of H-atom is :

A. $n = 2$ of He^{+}

B. $n = 2$ of B^{+4}

C. $n = 3$ of Li^{2+}

D. $n = 2$ of Be^{+3}

Answer: D

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3. (a) The wave function of an electron in $2s$ orbital in hydrogen atom is given below:

$$\psi_{2s} = \frac{1}{4(2\pi)^{1/2}}\left(\frac{z}{a_0}\right)^{3/2}\left(2 - \frac{r}{a_0}\right)\exp\left(-r/2a_0\right)$$

where a_0 is the radius. This wave function has a radial node at $r = r_0$. Express r_0 in terms of a_0.

(b) Calculate the wavelength of a ball of mass $100g$ moving with a velocity of $100ms^{-1}$.

(c) $\_(92)X.^{238} \xrightarrow{-8\alpha} -6\beta Y$. Find out atomic number, mass number of Y and identify it.

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4. a.Calculate the velocity of an electron in the first Bohr's orbit of hydrogen atom (given $r = a_0$).

b. Find de Broglie's wavelength of the electron in the first Bohr's orbit.

c. Find the orbital angular momentum of $2p$ orbital in terms of $h/2\pi$ units.

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5. The hydrogen -like species Li^{2+} is in a spherically symmetric state S_1 with one node. Upon absorbing light , the ion undergoes transition to a state S_2. The state S_2 has one radial node and its energy is equal is to the ground state energy of the hydrogen atom.

The orbital angular momentum quantum number of the state S_2 is

A. $1s$

B. $2s$

C. $2p$

D. $3s$

Answer: B

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6. The hydrogen -like species Li^{2+} is in a spherically symmetric state S_1 with one node. Upon absorbing light , the ion undergoes transition to a state S_2. The state S_2 has one radial node and its energy is equal is to the ground state energy of the hydrogen atom.

Energy of the state S_1 in units of the hydrogen atom ground state energy is

A. 0.75

B. 1.50

C. 2.25

D. 4.50

Answer: C

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7. The hydrogen -like species Li^{2+} is in a spherically symmetric state S_1 with one node. Upon absorbing light , the ion undergoes transition to a state S_2. The state S_2 has one radial node and its energy is equal is to the ground state energy of the hydrogen atom.

The orbital angular momentum quantum number of the state S_2 is

A. 0

B. 1

C. 2

D. 3

Answer: B

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8. The work function (ϕ) of some metals is listed below. The number of metals which will show photoelectric effect when light of 300 nm wavelength falls on the metal is

$$\begin{pmatrix} Metal & Li & Na & K & Mg & Cu & Ag & Fe & Pt & W \\ \phi(eV) & 2.4 & 2.3 & 2.2 & 3.7 & 4.8 & 4.3 & 4.7 & 6.3 & 4.75 \end{pmatrix}$$

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9. The maximum number of electrons that can have principal quantum number, n = 3, and spin quantum number m_s = - 1 /2, is

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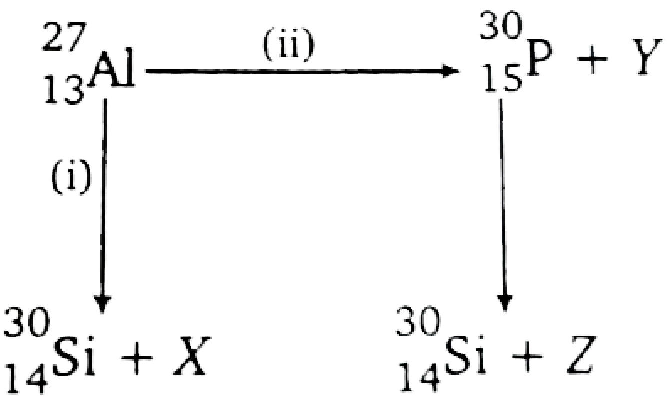
10. Bombardment of aluminium by α - particle leads to its artificial disintegration in two ways, (i) and (ii) as shown.

Products X, Y and Z respectively, are



A. proton, neutron, positron

B. neutron, position, proton

C. proton, positron, neutron

D. position, proton, neutron

Answer: A

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11. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is [a_0 is Bohr radius] :

A. $\frac{h^2}{4\pi^2 m a_0^2}$

B. $\frac{h^2}{16\pi^2 m a_0^2}$

C. $\frac{h^2}{32\pi^2 m a_0^2}$

D. $\frac{h^2}{64\pi^2 m a_0^2}$

Answer: C

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12. The periodic table consists of 18 groups. An isotope of copper, on bombardment with protons, undergoes a nuclear reaction yielding element X as shown below. To which group, element X belongs in the periodic table ?

$._{29}Cu^{63} + ._{1}H^{1} \rightarrow 6._{0}n^{1} + ._{2}He^{4}(\alpha) + 2._{1}H^{1} + ._{Z}X^{A}$

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13. In the nuclear transmutation :

$._{4}^{9}Be + X \rightarrow {}_{4}^{8}Be + Y$

(X,Y) is (are)

A. (γ, n)

B. (p, D)

C. (n, D)

D. (γ, p)

Answer: A, B

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14. In an atom, the total number of electrons having quantum numbers

$n = 4, |m_l| = 1$ and $m_s = -\frac{1}{2}$ is

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15. Not considering the electronic spin, the degeneracy of the second excited state $(n = 3)$ of H-atom is 9, while the degeneracy of the second excited state of H^- is

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Part Ii

1. which of the following ions has the maximum magnetic moment ?

A. Mn^{+2}

B. Fe^{+2}

C. Ti^{+2}

D. Cr^{+2}

Answer: 1

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2. Energy of H-atom in the ground state is $-13.6eV$. Hence energy in the second excited state is

A. $-6.8eV$

B. $-3.4eV$

C. $-1.51eV$

D. $-4.53eV$

Answer: 3

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3. Uncertainty in position of a particle of $25g$ in space is $10^{-8}m$ Hence uncertainty in velocity $\left(ms^{-1}\right)$ is (Planck's constant $h = 6.6 \times 10^{-34}Js$)

A. 2.1×10^{-18}

B. 2.1×10^{-34}

C. 0.5×10^{-34}

D. 5.0×10^{-24}

Answer: 1

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4. The de-Broglie wavelength of the tennis ball of mass 60g moving with a velocity of $10m/s$ is approx.: (Plank's constant $h = 6.63 \times 10^{-34}Js$)

A. $10^{-33}m$

B. $10^{-31}m$

C. $10^{-16}m$

D. $10^{-25}m$

Answer: 1

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5. In Bohr series of lines of hydrogen spectrum, third line from the red end corresponds to which one of the following inner orbit jumps of electron for Bohr orbit in atom in hydrogen :

A. $3 \rightarrow 2$

B. $5 \rightarrow 2$

C. $4 \rightarrow 1$

D. $2 \rightarrow 5$

Answer: 2

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6. The number of d-electron retained in Fe^{2}(At no. of$Fe = 26$) ion is.

A. 3

B. 4

C. 5

D. 6

Answer: 4

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7. The orbital angular momentum for an electron revolving in an orbit is given by $\sqrt{l(l+1)}\frac{h}{2\pi}$. What is the momentum of an s-electron?

A. $+\frac{1}{2}.\frac{h}{2\pi}$

B. Zero

C. $\frac{h}{2\pi}$

D. $\sqrt{2}.\frac{h}{2\pi}$

Answer: 2

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8. The wavelength of the radiation emitted , when in a hydrogen atom electron falls from infinity to stationary state 1 , would be :

(Rydberg constant = $1.097 \times 10^7 m^{-1}$)

A. $91nm$

B. $192nm$

C. 406

D. $9.1 \times 10^{-6}nm$

Answer: 1

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9. Which of the following sets of quantum numbers is correct for an electron in 4f-orbtial ?

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

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

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

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

Answer: 3

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10. Consider the ground state Cr atom $(Z = 24)$. The number of electron with the azimuthal number $l = 1$ and 2 ,respectively are

A. 12 and 4

B. 12 and 5

C. 16 and 4

D. 16 and 5

Answer: 2

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11. Which of the following statement is correct in relation to the hydrogen atom :

A. $3s$, $3p$ and $3d$ orbitals all have the same energy

B. $3s$ and $3p$ orbitals are of lower energy than $3d$ orbital

C. $3p$ orbital is lower in energy than $3d$ orbital

D. $3s$ orbital is lower in energy than $3p$ orbital

Answer: 1

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12. In a multi-electron atom, which of the following orbitals described by the three quantum numbers will have the same energy in the absence of magnetic and electric field?

1) $n = 1, l = 0, m = 0$

2) $n = 2, l = 0, m = 0$

3) $n = 3, l = 1, m = 1$

4) $n = 3, l = 2, m = 1$

5) $n = 3, l = 2, m = 0$

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13. Uncertainty in the position of an electron mass $\left(9.1 \times 10^{31} kg\right)$ moving with a velocity $300 ms^{-1}$ accurate uptp 0.001% will be :

A. $19.2 \times 10^{-2} m$

B. $5.76 \times 10^{-2} m$

C. $1.92 \times 10^{-2} m$

D. $3.84 \times 10^{-2} m$

Answer: 3

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14. According to Bohr's theory, the angular momentum of electron in the fifth Bohr orbit is:

A. $25\frac{h}{\pi}$

B. $1.0\frac{h}{\pi}$

C. $10\frac{h}{\pi}$

D. $2.5\frac{h}{\pi}$

Answer: 4

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15. The spin-only magnetic moment [in units of Bohr magneton, $\left(\mu_B\right.$ of $\left.Ni^{2+}\right)$ in aqueous solution would be (atomic number of $Ni = 28$)

A. 2.84

B. 4.90

C. 0

D. 1.73

Answer: 1

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16. Which of the following nuclear reactions will generate an isotope ?

A. Neutron particle emission

B. Positron emission

C. α-particle emission

D. β-particle emission

Answer: 1

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17. The ionization enthalpy of hydrogen atom is $1.312 \times 10^6 Jmol^{-1}$. The energy required to excite the electron in the atom from $n = 1$ to $n = 2$ is :

A. $8.51 \times 10^5 Jmol^{-1}$

B. $6.56 \times 10^5 Jmol^{-1}$

C. $7.56 \times 10^5 Jmol^{-1}$

D. $9.84 \times 10^5 Jmol^{-1}$

Answer: 4

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18. Which of the following set of quantum numbers represents the highest energy of an atom ?

A. $n = 3, l = 0, m = 0, s = +\frac{1}{2}$

B. $n = 3, l = 1, m = 1, s = +\frac{1}{2}$

C. $n = 3, l = 2, m = 1, s = +\frac{1}{2}$

D. $n = 4, l = 0, m = 0, s = +\frac{1}{2}$

Answer: 3

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19. The energy required to break one mole of $Cl - Cl$ bonds in Cl_2 is $242 kJmol^{-1}$. The longest wavelength of light capable of breaking a since $Cl - Cl$ bond is

A. $594 nm$

B. $640 nm$

C. $700 nm$

D. $494 nm$

Answer: 4

Watch Video Solution

20. Ionisation energy of He^{+} is 19.6×10^{-18}Jatom^{-1}. The energy of the first stationary state $(n = 1)$ of Li^{2+} is.

A. $4.41 \times 10^{-16} Ja \rightarrow m^{-1}$

B. $-4.41 \times 10^{-17} Ja \rightarrow m^{-1}$

C. $-2.2 \times 10^{-15} Ja \rightarrow m^{-1}$

D. $8.82 \times 10^{-17} Ja \rightarrow m^{-1}$

Answer: 2

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21. A gas absorbs a photon of $355nm$ and emits at two wavelengths . If one of the emission is at 680 nm , the other is at :

A. $1035nm$

B. $325nm$

C. $743nm$

D. $518nm$

Answer: 3

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22. The frequency of light emitted for the transition $n = 4$ to $n = 2$ of He^+ is equal to the transition in H atom corresponding to which of the following ?

A. $n = 2$ to $n = 1$

B. $n = 3$ to $n = 2$

C. $n = 4$ to $n = 3$

D. $n = 3$ to $n = 1$

Answer: 1

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23. The electrons identified by quantum numbers n and l :-

(a) n=4, l=1 (b) n=4, l=0 (c) n=3, l=2 (d) n=3, l=1

Can be placed in order of increasing energy as

A. $n = 4, l = 1$

B. $n = 4, l = 0$

C. $n = 3, l = 2$

D. $n = 3, l = 1$

Answer: 2

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24. Energy of an electron is givem by $E = -2.178 \times 10^{-18} J\left(\frac{Z^2}{n^2}\right)$.

Wavelength of light required to excited an electron in an hydrogen atom from level $n = 1$ to $n = 2$ will be

$\left(h = 6.62 \times 10^{-34} Js\right.$ and $c = 3.0 \times 10^{8} ms^{-1}$).

A. $1.214 \times 10^{-7} m$

B. $2.816 \times 10^{-7} m$

C. $6.500 \times 10^{-7} m$

D. $8.500 \times 10^{-7} m$

Answer: 1

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25. The correct set of four quantum numbers for valence electrons of rubidium atom (Z=37) is

A. $5, 0, 0, +\frac{1}{2}$

B. $5, 1, 0, +\frac{1}{2}$

C. $5, 1, 1, +\frac{1}{2}$

D. $5, 0, 1, +\frac{1}{2}$

Answer: 1

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26. Which of the following is the energy of a possible excited state of hydrogen?

A. $+13.6eV$

B. $-6.8eV$

C. $-3.4eV$

D. $+6.8eV$

Answer: 3

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Advanced Level Problems

1. A $5g$ orbital has

A. Zero angular node and zero radial node

B. Zero radial node and two angular nodes

C. 4 radial nodes and 4 angular nodes

D. Zero radial node and 4 angular nodes

Answer: 4

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2. The threshold wavelength (λ_0) of sodium metal is 6500Å. If UV light of wavelength 360Å is used, what will be kinetic energy of the photoelectron in erge?

A. 55.175×10^{-12}

B. 3.056×10^{-12}

C. 52.119×10^{-12}

D. 48.66×10^{-10}

Answer: 3

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3. An electron beam can undergo defraction by crystals .Through what potential should a beam of electrons be accelerated so that its wavelength becomes equal to $1.54Å$

A. $54.3vo <$

B. $63.3vo <$

C. $66.2vo <$

D. None of these

Answer: 2

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4. Radiation corresponding to the transition n=4 to n=2 in hydrogen atoms falls on a certain metal (work function=2.5 eV). The maximum kinetic energy of the photo-electrons will be:

A. $0.55eV$

B. $2.55eV$

C. $4.45eV$

D. None of these

Answer: 4

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5. Calculate the number of photons emitted by a $100W$ yellow lamp in $1.0s$. Take the wavelength of yellow light as $560nm$ and assume 100 percent efficiency.

A. 6.8×10^{20}

B. 4×10^{12}

C. 4×10^{20}

D. 2.8×10^{20}

Answer: 4

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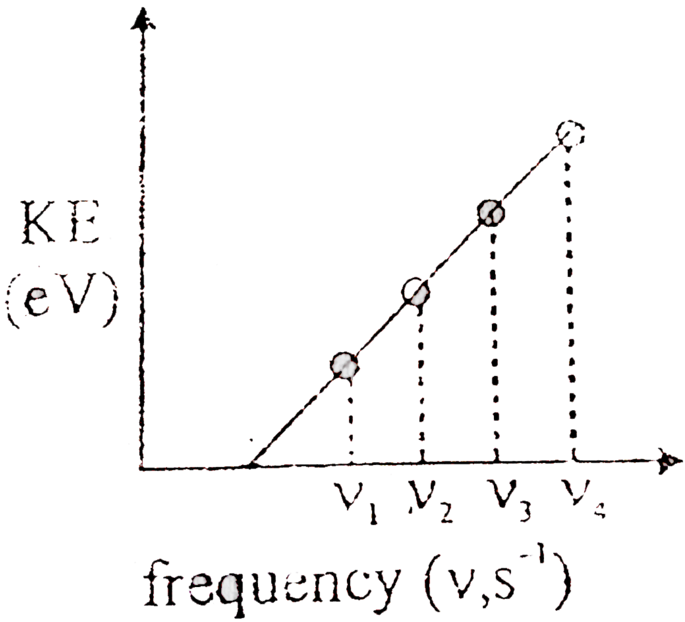
6. In a photoelectric experiment, kinetic energy of photoelectrons was plotted against the frequency of incident radition (v), as show in figure. Which of the following statements is correct ?



A. The threshold frequency is v_1

B. The slope of this line is equal to Plank's constant

C. As the frequency of incident wavelength increases beyond threshold frequency, kinetic energy of photoelectrons decreases.

D. It is impossible to obtain such a graph

Answer: 2

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7. Which of the following process not lead to formation of isobars?

A. 1α particle and 2β particles are emitted

B. Positron emission

C. β particle (_(-1)e^(0)) emission

D. K-electron capture

Answer: 1

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8. A sample of hydrogen (in the form of atoms), is made to absorb white light. 52% of the hydrogen atoms got ionised. In order to calculate the ionisation energy of hydrogen from its absorption spectrum (assuming the electrons that got ejected have $KE = 0$), it is possible by measuring the frequency of the:

A. line of shortest wavelength

B. line of longest wavelength

C. line of greatest intensity

D. line of smallest intensity

Answer: 1

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9. In what region of the electromagnetic spectrum would you look the spectral line resulting from the electronic transition from the tenth to the fifth electronic level in the hydrogen atoms ? $\left(R_H = 1.10 \times 10^5 cm^{-1}\right)$

A. Microwave

B. Infrared

C. Visible

D. Ultraviolet

Answer: 2

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10. Consider Xenon $(Z = 54)$. The maximum number of electrons in this atom that have the values for their quantum numbers as $n = 4, l = 3$ and $s = \frac{1}{2}$ in its ground state is:

A. Zero

B. 7

C. 9

D. 14

Answer: 1

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11. The increasing order (lowest first) for the values of e/m (charge//mass) for electron (e), proton (p), neutron (n), and alpha particle (α) is

A. e, p, n, α

B. n, p, e, α

C. e, α, e

D. n, α, p, e

Answer: 4

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12. An electron in an atom jumps in such a way that its kinetic energy changes from x to $\frac{x}{4}$. The change in potential energy will be:

A. $+\frac{3}{2}x$

B. $-\frac{3}{8}x$

C. $+\frac{3}{4}x$

D. $-\frac{3}{4}x$

Answer: 1

Watch Video Solution

13. What atomic number of an element "X" would have to become so that the 4th orbit around X would fit inside the I Bohr orbit of H atom ?

A. 3

B. 4

C. 16

D. 25

Answer: 3

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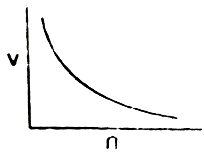
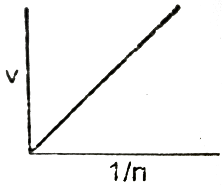
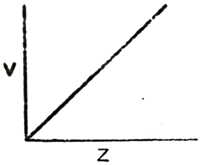
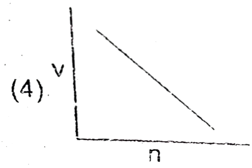
14. Select the incorrect graph for velocity of e^- in an orbit vs. Z, $\frac{1}{n}$ and n :

A. (1) 

B. (2) 

C. (3) 

D. 

Answer: 4

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15. Which of the following is discreted in Bohr's theory?

A. Potantial energy

B. Kinetic energy

C. Velocity

D. Angular momentum

Answer: 4

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16. The mass of a proton is 1836 times more than the mass of an electron. It a sub-atomic of mass $(m)207$ times the mass of electron is captured by the nucleus, then the first ionization potential of H:

A. decreases

B. increases

C. remains same

D. may be decreases ot increase

Answer: 2

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17. In any subshell, the maimum number of electrons having same value of spin quantum number is :

A. $\sqrt{l(l+1)}$

B. $l+2$

C. $2l + 1$

D. $4l + 2$

Answer: 3

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18. Which quantum number defines the orientation of orbital in the space around the nucleus?

A. Principal quantum number (n)

B. Angular momentum quantum number(l)

C. Magnetic quantum number (m_l)

D. Spin quantum number (m_s)

Answer: 3

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19. For similar orbitals having different values of n:

A. the most probable distance increases with increases in n

B. the most probable distance decreases with increases in n

C. the most probable distance remains constant with increases in n

D. None

Answer: A

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20. Maximum number of nodes are present in :

A. $5s$

B. $5p$

C. $5d$

D. All have same number of nodes

Answer: 4

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21. The correct set of quantum numbers for the unpaired electron of chlorine atom is

A. $n = 2, l = 1, m = 0$

B. $n = 2, l = 1, m = 1$

C. $n = 3, l = 1, m = 1$

D. $n = 3, l = 0, m = 0$

Answer: 3

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22. Which of the following has the maximum number of unpaired electrons?

A. Mn

B. Ti

C. V

D. Al

Answer: 1

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23. The angular velocity of an electron occupying the second Bohr orbit of He^+ ion is $\left(\text{insec}^-\right)$:

A. 2.067×10^{16}

B. 3.067×10^{16}

C. 1.067×10^{18}

D. 2.067×10^{17}

Answer: 1

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24. An excited state of H atom emits a photon of wavelength λ and returns in the ground state. The principal quantum number of excited state is given by:

A. $\sqrt{\lambda R(\lambda R - 1)}$

B. $\sqrt{\frac{\lambda R}{(\lambda R - 1)}}$

C. $\sqrt{\lambda R(\lambda R - 1)}$

D. $\sqrt{\frac{(\lambda R - 1)}{\lambda R}}$

Answer: 2

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25. Light of wavelength λ strikes a metal surface with intensity X and the metal emits Y electrons per second of average energy Z. What will

happen to Y and Z if X is havled?

A. T will be halved

B. Y will double

C. Y will be remain same

D. Z will be halved

Answer: 1

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26. Neutron scattering experiments have shown that the radius of the nucleus of an atom is directly proporitonal to the cube root of the number of nucleons in the nucleus. From $\_(3)^7Li$ to $\_(76)^{189}Os$ the radius is:

A. Halved

B. the same

C. Doubled

D. Tripled

Answer: 4

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27. The nucleus of an atom is located at $x = yx = z = 0$. If the probability of finding an electron in $d_{x^2 - y^2}$ orbital in a tiny volume around $x = a, y = 0, z = 0$ is 1×10^{-5}, what is the probability of finding the electron in the same size volume around $x = 0, y = a, z = 0$?

A. 1×10^{-5}

B. $1 \times 10^{-5} \times a$

C. $-1 \times 10^{-5} \times a$

D. zero

Answer: 1

View Text Solution

28. The energy of a I,II and III energy levels of a certain atom are E, $\frac{4E}{3}$ and 2E respectively. A photon of wavelength λ is emitted during a transition from III to I. what will be the wavelength of emission for II to I?

A. $\lambda/2$

B. λ

C. 2λ

D. 3λ

Answer: 4

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29. A compound of vanadium has a magnetic moment of $1.73BM$. What will be the electronic configurations:

A. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1$

B. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$

C. $1s^22s^22p^63s^23p^63d^3$

D. $1s^22s^22p^63s^23p^63d^4$

Answer: 1

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30. Calculate the minimum and maximum number of electrons which may have magnetic quantum number $m = +1$ and spin quantum number $s = -\frac{1}{2}$ in chromium (Cr)

A. 0, 1

B. 1, 2

C. 4, 6

D. 2, 3

Answer: 4

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Part Ii Section 1

1. Find the quantum of the excited state of electrons in He^{+} ion which on transition to first excited state emit photons of wavelengths $108.5nm$. $\left(R_{H} = 1.09678 \times 10^{7} m^{-1}\right)$

A. 6

B. 5

C. 4

D. 2

Answer: B

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2. For a 3s-orbital

$$\Phi(3s) = \frac{1}{a\sqrt{3}}\left(\frac{1}{a_0}\right)^{3/2}\left(6 - 6\sigma + \sigma^2\right) \in^{-\sigma/2}$$

where $\sigma = \dfrac{2rZ}{3a_\sigma}$

What is the maximum radial distance of node from nucleus?

A. $\dfrac{2}{3}\dfrac{\left(3 + 3\sqrt{3}\right)a_0}{Z}$

B. $\dfrac{3}{2}\dfrac{\left(3 + 3\sqrt{3}\right)a_0}{Z}$

C. $\dfrac{3}{2}\dfrac{\left(3 - 3\sqrt{3}\right)a_0}{Z}$

D. $\dfrac{3}{2}\dfrac{\left(3 - \sqrt{3}\right)a_0}{Z}$

Answer: B

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3. A glow-worm of mass $5.0g$ emits red light $(650nm)$ with a power of $0.10w$. Entirely in the backward direction. To what speed will it have accelerated sfter $10y$ if released into free space and assumed to live?

A. $21ms^{-1}$

B. $29ms^{-1}$

C. $31.8ms^{-1}$

D. $0.08ms^{-1}$

Answer: A

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4. Calculate the energy required to excited one litre of hydrogen gas at 1 atm and $298K$ to the excited state of atomic hydrogen. The energy for the disociation of H-H bond is $436kJmol^{-1}$. Also calculate the minimum frequency of photon to break this bond.

A. $98.19 Hz$

B. $10.93 \times 10^{14} Hz$

C. $10^{15} Hz$

D. $6.22 \times 10^{14} Hz$

Answer: B

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5. O_2 undergoes photochemical dissociation into one normal oxygen atom and one excited oxygen atom. Excited oxygen atom is $1.967 eV$ more energetic than normal . The dissociation of O_2 into two normal atoms of oxygen required $498 kJ mol^{-1}$, what is the maximum wavelength effective for photochemical dissociation of O_2?

A. $1.01 nm$

B. $1.64 nm$

C. $1.74 nm$

D. $2.74nm$

Answer: C

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6. If the subsidiary quantum number of a subenergy level is 4, the maximum and minimum values of the spin multiplicities are:

A. 9, 1

B. 10, 1

C. 10, 2

D. 4, - 4

Answer: C

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7. 1 mol of He^{+} ion is excited. Spectral analysis showed existence of 50% ions in $3rd$ level, 25% in $2nd$ level and remaining 25% in ground state. Ionization energy of He^{+} is $54.4eV$, calculate total energy evolved when all the ions retirn ground state.

A. $331.13 \times 10^{4} J$

B. $400.14 \times 10^{4} J$

C. $10^{4} J$

D. $6.66 \times 10^{4} J$

Answer: A

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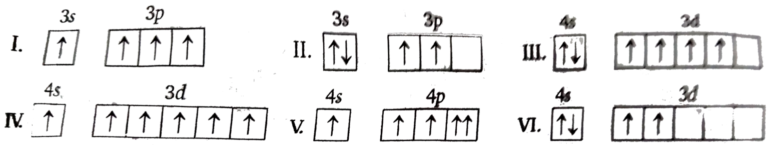
8. Consider the following six electronic configurations (remaining inner orbitals are completely filled) and mark the incorrect option.



A. Stability order : $II > I > IV > III$

B. Order of spin multiplicity: $IV > III = I > II$

C. V does not violate all the three rules of electronic configuration

D. If VI represents A and A^+ when kept near a magnet, acts as diamagnetic substance

Answer: A, B, C

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9. Choose the correct statement (s) :

A. The shape of an atomic orbital depends upon azimuthal quantum number

B. The orientation of an atomic orbital depends upon the magnetic quantum number

C. The energy of an electron in an atomic orbital of multi-electron depends upon principal quantum number only

D. The number of degenerate atomic orbitals of one type depends upon the value of azimuthal quantum number

Answer: A, B, D

View Text Solution

10. The radial distribution functions $[P(r)]$ is used to determine the most probable radius, which is used to find the electron in a given orbital $\frac{dP(r)}{dr}$ for $1s$-orbital of hydrogen like atom having atomic number Z, is $\frac{dP}{dr} = \frac{4Z^3}{a_0^3}\left(2r - \frac{2Zr^2}{a_0}\right)e^{-2Zr/a_0}$:

A. At the point maximum value of radial distribution function $\frac{dP(r)}{dr} = 0$, one antinode is present

B. Most probable radius of Li^{2+} is $\frac{a_0}{3}$ pm

C. Most probable radius of He^+ is $\frac{a_0}{2}$ pm

D. Most probable radius of hydrogen atom is a_0 pm

Answer: A, B, C, D

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11. For radial probability curves. Which of the following is/are correct ?

A. The number of maxima in $2s$ orbital are two

B. The number of spherical or radial nodes is equal to $n - l - 1$

C. The number of angular modes are 'l'

D. $3d_z^2$ has 3 angular nodes

Answer: A, B, C

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12. d_{xy} orbital has lobes between x- and y- axes. The wave function of two lobes are positive and those of other two are negative. The positive wave function signifies that :

A. both x and y are positive

B. both x and y are negative

C. either x ir y us negative

D. None of these

Answer: A, B

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13. The dissociation energy of H_2 is $430.53 kJmol^{-1}$, If H_2 is of dissociated by illumination with radiation of wavelength $253.7nm$, the fraction of the radiant energy which will be converted into ikinetic energy is given by

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14. The IE_1 of H is $13.6eV$. It is exposed to electromagnetic waves of $1028Å$ and gives out induced radiation. Find out orbit of these induced radiation.

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15. A hydrogen like atom (atomic number z) is in a higher excited state of quantum number n. This excited atom can make a transition to the first excited state by successively emitting two photons of energies $10.2eV$ and $17.0eV$ respectively. Alternatively the atom from the same excited state can make a transition to the second excited state by successively emitting 2 photons of energy $4.25eV$ and$5.95eV$ respectively. Determine the value of $(n + z)$

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16. A moving particle is associated with wavelength $5 \times 10^{-8}m$. If its momentum is reduced to half of its value compute the new wavelength. If answer is 10^{-x} then find 'x'.

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17. According to Bohr's theory, the electronic energy of an electron in the n^{th} orbit is given by $E_n = \left(-2.17 \times 10^{-18}\right) \times \frac{z^2}{n^2} J$

Calculate the longest wavelength of light that will be needed in remove an electron from the third Bohr orbit of $He^{\oplus}$

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18. $._4Be^7$ captures a K electron into its nucleus .What is the mass number and atomic number of the nuclide formed ?

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19. Werner Heisenberg considered the limits of how precisely we can measure the properties of an electron or other microscopic particle. He determined that there is a fundamental limit to how closely we can measure both position and momentum. The more accurately we measure the momentum of a particle, the less accurately we can determine its position. The converse also true. This is summed up in what we now call the Heisenberg uncertainty principle.

The equation si $\delta x.\ \delta(mv) \geq \frac{h}{4\pi}$

The uncertainty in the position or in the momentum of a marcroscopic object like a baseball is too small to observe. However, the mass of microscopic object such as an electon is small enough for the uncertainty to be relatively large and significant.

If the uncertainties in position and momentum are equal, the uncertainty in the velocity is :

A. $\sqrt{\frac{h}{\pi}}$

B. $\sqrt{\frac{h}{2\pi}}$

C. $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$

D. none of these

Answer: C

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20. Werner Heisenberg considered the limits of how precisely we can measure the properties of an electron or other microscopic particle. He determined that there is a fundamental limit to how closely we can measure both position and momentum. The more accurately we measure the momentum of a particle, the less accurately we can determine its position. The converse also true. This is summed up in what we now call the Heisenberg uncertainty principle.

The equation si $\delta x. \delta(mv) \geq \frac{h}{4\pi}$

The uncertainty in the position or in the momentum of a marcroscopic object like a baseball is too small to observe. However, the mass of microscopic object such as an electon is small enough for the uncertainty to be relatively large and significant.

If the uncertainty in velocity and position is same, then the uncertainty in momentum will be :

A. $\sqrt{\frac{hm}{4\pi}}$

B. $m\sqrt{\frac{h}{4\pi}}$

C. $\sqrt{\frac{h}{4\pi m}}$

D. $\frac{1}{m}\sqrt{\frac{h}{4\pi}}$

Answer: A

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21. Werner Heisenberg considered the limits of how precisely we can measure the properties of an electron or other microscopic particle. He determined that there is a fundamental limit to how closely we can measure both position and momentum. The more accurately we measure the momentum of a particle, the less accurately we can determine its position. The converse also true. This is summed up in what we now call the Heisenberg uncertainty principle.

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The uncertainty in the position or in the momentum of a marcroscopic object like a baseball is too small to observe. However, the mass of microscopic object such as an electon is small enough for the uncertainty to be relatively large and significant.

What would be the minimum uncetaintty in de-Broglie wavelength of a moving electron accelerated by potential difference of 6 volt and whose uncetainty in position is $\frac{7}{22}$ nm?

A. 6.25Å

B. 6Å

C. 0.625Å

D. 0.1325Å

Answer: C

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Part Iii

1. The set of quantum numbers, n = 2, l = 2, m_l = 0 :

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2. The three quantum numbers n, l, m corresponding to the valence electron in rubidium $(Z = 37)$ are

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3. The radiation having the highest amount of energy has

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4. Mass of a typical star is $1.0 \times 10^{30} kg$. Assume that a star is typically $3/4$ hydrogen and $1/4$ helium by mass. The estimated number of protons (which are present in H as well as He) in a typical star is approximately

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5. Element having $(4, 0, 0 + 1/2)$ as a set of four quantum numbers for its valence electron is-

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Stage Ii

1. Hydrogen atom:

The electronic ground state of hydrogen atom contains one electron in the first orbit. If sufficient energy is provided, this electron can be promoted to higher energy levels. The electronic energy of a hydrogen-like species (any atom//ions with nuclear charge Z and one electron) can be given as

$E_n = -\frac{R_H Z^2}{n^2}$ where R_H = Rydberg constant, n = principal quantum number

The energy in Joule of an electron in the second orbit of H- atom is:

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Others

1. The speed of a certain proton is $0.45Mms^{-1}$. If the uncertainty in its momentum is to b reduced to 0.0100 percent, what incertainty in its location must be tolerated?

A. $0.60nm$

B. $0.72nm$

C. $0.80nm$

D. $0.70nm$

Answer: D

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2. A photon of frequency v causes photo electric emission from a surface with threshold frequency v_0. The de-Broglies wavelength (λ) of the photo electron emitted is given by:

A. $\Delta n = \frac{h}{2m\lambda}$

B. $\Delta n = \frac{h}{\lambda}$

C. $\left[\frac{1}{v_0} - \frac{1}{v}\right] = \frac{mc^2}{h}$

D. $\lambda = \sqrt{\frac{h}{2m\Delta V}}$

Answer: D

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3. The correct Schrodingers's wave equation for an electron with e as tatal energy and V as potential energy is :

A. $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi^2}{mh^2}(E - V)\psi = 0$

B. $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi m}{h^2}(E - V)\psi = 0$

C. $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$

D. $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi m^2}{h}(E - V)\psi = 0$

Answer: C

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4. The maximum radial probability in $1s$-orbital occures at a distance when : $\left[r_0 = \text{Bohr radius}\right]$

A. $r = r_0$

B. $r = 2r_0$

C. $r = \frac{r_0}{2}$

D. $2r = \frac{r_0}{2}$

Answer: A

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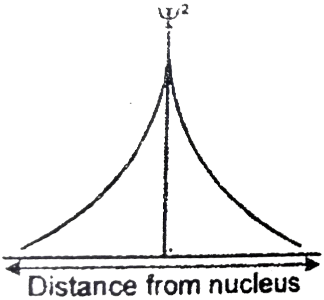
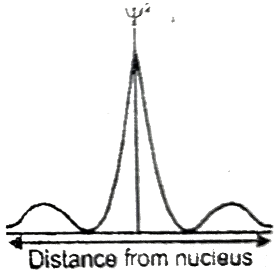
5. Consider following figure A and B indicating distribution of charge density $\left(\text{electron probability} \Psi^2\right)$ with distance r.



(A)



(B)

Select the correct statement:

A. A and B both for $1s$

B. A and B both are for $2s$

C. A is for $2s$, B is for $1s$

D. A is for $1s$, B is for $2s$

Answer: D

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6. The maximum probability of finding electron in the d_{xy} orbital is -

A. Along the x-axis

B. Along the y-axis

C. At an angle of 45° from the x and y axis

D. At an angle of 90° from the x and y axis.

Answer: C

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7. $3p_y$ orbital has .... nodal plane:

A. XY

B. YZ

C. ZX

D. All of these

Answer: C

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8. A 3p-orbital has :

A. Two non-spherical nodes

B. Two spheric nodes

C. One spherical and non spherical nodes

D. One spherical and two non spherical nodes

Answer: C

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9. According to Schrodinger model nature of electron in an atom is as :-

A. Particle only

B. Wave only

C. Particle and wave nature simultaneous

D. Sometimes waves and sometimes particle

Answer: C

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10. Choose the incorect statement from among the following:

A. A node is a point in space where the wave function (ψ) has zero amplitude.

B. The number of peaks in radial distribution is $n - l$

C. Radial probability density $\pi_{n, l(r)} = 4\pi r^2 R^2_{n, l}(r)$

D. ψ^2 represent the atomic orbital

Answer: D

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11. Which of the d orbitals not lies in the xy-plane.

A. $d_{x^2-y^2}$

B. d_{xy}

C. d_{xz}

D. d_{xy} and $d_{x^2-y^2}$

Answer: C

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12. Consider the following statements:

(a) Electron density in the XY plane in $3d_{x^2-y^2}$ orbital is zero

(b) Electron density in the XY plane in $3d_{z^2}$ orbital is zero.

(c) $2s$ orbital has one nodel surface

(d) for $2p_z$ orbital, XY is the nodal plane.

Which of these are incorrect statements :

A. a & c

B. b & c

C. Only b

D. a, b

Answer: D

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13. Which of the following d-orbitals has dough-out shape ?

A. d_{xy}

B. d_{yz}

C. $d_{x^2-y^2}$

D. d_{z^2}

Answer: D

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14. The permissible solution to the schrodinger wave equation gave an ideal of .... Quantum number

A. 4

B. 3

C. 2

D. 1

Answer: B

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15. The orbital with zero orbital angular momentum is.

A. s

B. p

C. d

D. f

Answer: A

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16. Which of the following is electronic configuration of $Cu^{2+}(Z = 29)$?

A. $[Ar]4s^1 3d^8$

B. $[Ar]4s^2 3d^{10} 4p^1$

C. $[Ar]4s^1 3d^{10}$

D. $[Ar]3d^9$

Answer: D

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17. Spin magnetic moment of $X^{n+}(Z = 26)$ is $\sqrt{24}B.M.$ Hence number of unpaired electrons and value of n respectively are:

A. 4, 2

B. 2, 4

C. 3, 1

D. 0, 2

Answer: A

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18. Which of the following ions has the maximum number of unpaired d-electrons ?

A. Zn^{2+}

B. Fe^{2+}

C. Ni^{3-}

D. Cu^{+}

Answer: B

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19. The total spin resulting from a d^7 configuration is :

A. 1

B. 2

C. $5/2$

D. $3/2$

Answer: D

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20. Given is the electronic configuration of element X

$$\begin{matrix} K & L & M & N \\ 2 & 8 & 11 & 2 \end{matrix}$$

The number of electrons present with $l = 2$ in an atom of element X is.

A. 3

B. 6

C. 5

D. 4

Answer: A

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21. The orbital angular momentum of an electron in $2s$-orbital is

A. $+\frac{1}{2}\frac{h}{2\pi}$

B. zero

C. $\frac{h}{2\pi}$

D. $\sqrt{2}\frac{h}{2\pi}$

Answer: B

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22. The possible value of l and m for the last electron in the Cl^{-} ion are :

A. 1 and 2

B. 2 and $+1$

C. 3 and -1

D. 1 and -1

Answer: D

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23. For an electron, with n=3 has only one radial node.

The orbital angular momentum of the electron will be :

A. 0

B. $\sqrt{6}\frac{h}{2\pi}$

C. $\sqrt{2}\frac{h}{2\pi}$

D. $3\left(\frac{h}{2\pi}\right)$

Answer: C

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24. $._{6}^{11}C$ on decay produces:

A. Positron

B. β-particle

C. α-particle

D. none of these

Answer: A

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25. $_{27}Co^{60}$ is radioactive because

A. its atomic number is high

B. it has high p/n ratio

C. it has high n/p ratio

D. none of these

Answer: C

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26. Consider α - , β- particles and γ - rays, each having an energy fo $0.5 Mev$ in increasing order f penertation power, the radiations are:

A. $\alpha < \beta < \gamma$

B. $\alpha < \gamma < \beta$

C. $\beta < \gamma < \alpha$

D. $\gamma < \beta < \alpha$

Answer: A

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27. $._{13}Al^{27}$ is a stable isotope. $._{13}Al^{29}$ is expected to disintegrate by

A. α-emission

B. β-emission

C. positron emission

D. proton emission

Answer: B

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28. Which of the following nuclear reactions will generate an isotope ?

A. β-emission

B. neutron emission

C. α-emission

D. positron emission

Answer: B

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29. The total number of α- and β-particles given out during nuclear given nuclear transformation is:

A. 2

B. 4

C. 6

D. 8

Answer: D

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30. 1st excitation potential for the H-like (hypothetical) sample is 24 V. Then:

A. Ionisation energy of the sample is $36eV$

B. Ionosation energy of the sample is $32eV$

C. Binding energy of 3^{rd} excited state is $2eV$

D. 2^{nd} excitation potential of the sample is $\frac{32 \times 8}{9}V$

Answer: B, C, D

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31. In which transition, one quantum of energy is emitted -

(a). $n = 4 \rightarrow n = 2$

(b). $n = 3 \rightarrow n = 1$

(c). $n = 4 \rightarrow n = 1$

(d). $n = 2 \rightarrow n = 1$

A. $n = 4 \rightarrow n = 2$

B. $n = 3 \rightarrow n = 1$

C. $n = 4 \rightarrow n = 1$

D. $n = 2 \rightarrow n = 1$

Answer: A, B, C, D

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32. In a H-like sample, electrons make transition from 4^{th} excited state upto 2^{nd} state. Then ,

A. 10 different spectral lines are observed

B. 6 different spectral lines are observed

C. number of lines belonging to the balmer series is 3

D. Number of lines belonging to paschen series is 2

Answer: B, C, D

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33. The change in orbital angular momentum corresponding to an electron transition inside a hydrogen atom can be-

(a). $\frac{h}{4\pi}$

(b). $\frac{h}{\pi}$

(c). $\frac{h}{2\pi}$

(d). $\frac{h}{8\pi}$

A. $\frac{h}{4\pi}$

B. $\frac{h}{\pi}$

C. $\frac{h}{2\pi}$

D. $\frac{h}{8\pi}$

Answer: B, C

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34. In a hydrogen like sample two different types of photons A and B are produced by electronic transition. Photon B has its wavelength in infrared region. If photon A has more energy than B, then the photon may belong to the region:

A. ultraviolet

B. visible

C. infrared

D. None

Answer: A, B, C

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35. The qualitative order of Debrogile wavelegnth for electron, proton and α particle is $\lambda_e > \lambda_P > \lambda_\alpha$ if

A. If kinetic energy is same for all particles

B. If the acelerating potential difference 'V' is same for all the particle (from rest)

C. If velocities are same for all particles

D. None of above

Answer: A, B, C

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36. Identify the correct statement (s)

A. Wavelength associated with a $1kg$ ball moving with the velocity $100m/s$ can't be calculated.

B. Wave nature of the running train is difficult to observe because wavelength is extermely small.

C. Wavelength associated with the electron can be calculated using the formulae $E = \frac{hc}{\lambda}$

D. If an electron is accelerated through $20V$ potential difference if it has already $5eV$ kinetic energy then wavelgnth of the electron is approximately $\sqrt{6}$Å.

Answer: B, D

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37. d_{z^2}-orbital has:

A. Two lobes along z-axis

B. Ring along yz-plane

C. Ring along xy-plane

D. Ring along x axis

Answer: A

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38. Which of the following statement is//are correct for an electron of quantum numbers $n = 4$ and $m = 2$?

A. The value of l may be 2

B. The value of l may be 3

C. The value of s may be $+1/2$

D. The value of l may be $0, 1, 2, 3.$

Answer: A, B, C

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39. if element $,_{25}X + y$ has spain magnetic moment 1.732 B.M then:

A. number of unpaired electron $= 1$

B. number of unparired electron $= 2$

C. $Y = 4$

D. $Y = 6$

Answer: A, D

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40. Which of the following statement (s) is (are) correct?

A. The electronic configuration of Cr is $[Ar](3d)^5(4s)^1$. (Atomic number of $Cr = 24$)

B. The magnetic quantum number may have negative values.

C. In silver atom, 23 electrons have a spin of one type and 24 of the opposite type. (Atomic number of $Ag = 47$)

D. None of these

Answer: A, B, C

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41. the configuration $[Ar]3d^{10}4s^2 4p^4$ is similar to that of :

A. boron

B. oxygen

C. sulphur

D. aluminium

Answer: B, C

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42. Which consists of charged particles of matter?

A. α-particle

B. β-particle

C. γ-tays

D. Anode rays

Answer: A, B, D

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43. Which of the following does not occur?

A. $\_(20)^{40}Ca + {}_0^1n \rightarrow {}_{19}^{40}K + {}_1^1H$

B. $\_(12)^{24}Mg + {}_2^4He \rightarrow {}_{14}^{27}Si + {}_0^1n$

C. $\_(48)^{113}Cd + {}_0^1n \rightarrow {}_{48}^{112}Cd + {}_{-1}^{0}e$

D. $\_(20)^{43}Ca + {}_2^4He \rightarrow {}_{21}^{46}Sc + {}_1^1H$

Answer: C

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44. If m_p is the mass of proton. m_n that of a neutron, M_1 that of $\_(10)Ne^{20}$ nucleus and M_2 that of $\_(20)Ca^{40}$ nucleus, then which of the following relations is//are not true?

A. $M_2 > 2M_1$

B. $M_2 < 20\left(m_p + m_n\right)$

C. $M_2 = 2M_1$

D. $M_2 < 2M_1$

Answer: A, C

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45. Pickout the correct statements:

A. Negative β-decay decreases the proportion of neutrons and increases the proportion of proton

B. Positive β-decay increases the proportion of neutrons and decreases the proportion of proton

C. K-electron capture increases the proportion of neutrons and increases the proportion of proton.

D. Positrons and electrons quickly unite to produce photons.

Answer: A, B, D

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46. Which of the following pair of electrons is excluded from an atom ?

A. $n=2, l=0, m=0, s=+\left(.^{1}/_{2}\right)$ and $n=2, l=0, m=0, s=+\left(.^{1}/_{2}\right)$

B. $n=2, l=1, m=+1, s=+\left(.^{1}/_{2}\right)$ and

$n=2, l=1, m=-1, s=+\left(.^{1}/_{2}\right)$`

C. $n=1, l=0, m=0, s=+\left(.^{1}/_{2}\right)$ and $n=1, l=0, m=0, s=-\left(.^{1}/._{2}\right)$

D. $n=3, l=2, m=-2, s=+$ (^(1)//_(2)) and

$n=3, l=0, m=0, s=+$ (^(1)//_(2))

Answer: A

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47. The de Broglie wavelength associated with particle is

A. inversely proportional to its momentum

B. inversely proportional to its energy

C. directly proportional to its velocity

D. directly proportional to its momentum

Answer: A

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48. The equation $E = hv$ indicates that

A. photons have both particle and wave nature

B. photons are waves

C. photons are stream of particles

D. no such inference can be drawn from the given equation

Answer: A

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49. Consider a $20W$ light source that emits monochromatic light of wavelength $600nm$. The number of photons ejected per second in terms of Avogadro's constant $\left(N_A\right)$ is approximately

A. N_A

B. $10^{-2}N_A$

C. $10^{-4}N_A$

D. $10^{-5}N_A$

Answer: C

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50. The species which has its fifth ionization potential equal to 340 V is :

A. B^{+}

B. C^{+}

C. B

D. C

Answer: C

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51. Isosters are compounds having similar geometry and isoelectronic species are species having the same number of electrons. The pair of species CO_2 and NO_2 is

A. isosteric and isoelectronic

B. isosteric, but not isoelectronic

C. isoelectronic, but not isosteric

D. neither isosteric nor isoelectronic

Answer: A

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52. The ratio of the energy of a photon of 2000Å wavelength radiation to that of 4000Å radiation is

A. $1/4$

B. 4

C. $1/2$

D. 2

Answer: D

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53. The phenomenon which suggested that light emitted in packets (quanta) is

A. electron diffraction

B. photoelectric effect

C. diffraction of light

D. black body radiation.

Answer: B

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54. Wave length associated with electron motion

A. increases with increase in the speed of electron

B. remains same irrespective of the speed of electron

C. decreases with increase of the speed of electron

D. changes with the atomic number of the atom to which it belond

Answer: C

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55. The metal that shows photoelectric emission at lowest frequency radiation is

A. beryllium

B. lithium

C. sodium

D. magnesium

Answer: C

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56. The number of unpaired electrons in the scandium atom is

A. 1

B. 2

C. 0

D. 3

Answer: A

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57. The fundamental particle which are responsible for keeping nucleons together is

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58. The maximum number of electrons in $3d_{z^2}$ orbital is-

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59. An ion has 18 electrons in the outermost shell it is

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60. The velocity of an electron in the second Bohr orbit of an element is $1.1 \times 10^6 s^{-1}$ Its velocity in the third orbit is

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61. The sum of all the quantum number of hydrogen atomm is

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62. The number of valence electrons in an atom with the configuration $1s^2 2s^2 2p^6 3s^2 3p^2$ is

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63. The wavelength of a moving body of mass $0.1mg$ is $3.31 \times 10^{-29} m$. The kinetic energy of the body in J would be :

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64. The weight range over which electronic excitations in organic compounds occur, is

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65. If the radius of the first Bohr orbit is r, then the deBroglie wavelength in the third bohr orbit is

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66. The quantum numbers for the 19^{th} electron of $Cr(Z = 24)$ are :

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67. Hydrogen atom:

The electronic ground state of hydrogen atom contains one electron in the first orbit. If sufficient energy is provided, this electron can be promoted to higher energy levels. The electronic energy of a hydrogen-like species (any atom//ions with nuclear charge Z and one electron) can be given as

$E_n = -\frac{R_H Z^2}{n^2}$ where R_H = Rydberg constant, n = principal quantum number

The energy required to promote the ground state electron of H-atom to the first excited state is:

When an electron returns from a higher energy level to a lower energy level, energy is given out in the form of UV//Visible radiation.

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68. Hydrogen atom:

The electronic ground state of hydrogen atom contains one electron in the first orbit. If sufficient energy is provided, this electron can be promoted to higher energy levels. The electronic energy of a hydrogen-like species (any atom//ions with nuclear charge Z and one electron) can be given as

$E_n = -\frac{R_H Z^2}{n^2}$ where R_H = Rydberg constant, n = principal quantum number

Calculate the wavelength of light (nm) for the electronic transition of H-atom from the first excited state to ground state.

In the model of hydrogen like atom put forward by Niels Bohr (1913) the electron orbits around the central nucleus. the bohr radius of n^{th} orbit of a hydrogen-like species is given by

$r = k\frac{n^2}{Z}$ " " where, k is constant

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69. Hydrogen atom:

The electronic ground state of hydrogen atom contains one electron in the first orbit. If sufficient energy is provided, this electron can be promoted to higher energy levels. The electronic energy of a hydrogen-like species (any atom//ions with nuclear charge Z and one electron) can be given as

$E_n = -\frac{R_H Z^2}{n^2}$ where R_H = Rydberg constant, n = principal quantum number

What is the principal quantum number, n' of the orbit of Be^3 that has the same Bohr radius as that of ground state hydrogen atom ?

n' =

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70. Hydrogen atom:

The electronic ground state of hydrogen atom contains one electron in the first orbit. If sufficient energy is provided, this electron can be promoted to higher energy levels. The electronic energy of a hydrogen-like species (any atom//ions with nuclear charge Z and one electron) can be given as

$E_n = -\frac{R_H Z^2}{n^2}$ where R_H = Rydberg constant, n = principal quantum number

The ratio of energy of an electron in the ground state Be^{3-} ion to that of ground state H atom is:

The kinetic and potential energies of an electron in the H atoms are given as

$$K.E. = \frac{e^2}{4\pi\varepsilon_0 2r} \text{ and } P.E. = -\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$$

A. 16

B. 4

C. 1

D. 8

Answer: **16**

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71. Hydrogen atom:

The electronic ground state of hydrogen atom contains one electron in the first orbit. If sufficient energy is provided, this electron can be promoted to higher energy levels. The electronic energy of a hydrogen-like species (any atom//ions with nuclear charge Z and one electron) can be given as

$E_n = -\dfrac{R_H Z^2}{n^2}$ where R_H = Rydberg constant, n = principal quantum number

Calculate the following :

(a) the kinetic energy (in eV) of an electron in the ground state of hydrogen atom.

(b) the potential energy (in eV) of an electron in the ground state of hydrogen atom.

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72. Hydrogen atom:

The electronic ground state of hydrogen atom contains one electron in the first orbit. If sufficient energy is provided, this electron can be promoted to higher energy levels. The electronic energy of a hydrogen-like species (any atom//ions with nuclear charge Z and one electron) can be given as

$E_n = -\dfrac{R_H Z^2}{n^2}$ where R_H = Rydberg constant, n = principal quantum number

A gaseous excited hydrogen-like species with nuclear charge Z can emit radiations of six different photon energies.

(a) The principal quantum number of the excited state is :

(b) It was observed that when this excited species emits photons of energy $= 2.64 eV$ when it comes to next lower energy state. Calculate the nuclear charge of the species.

The least energy required to remove an electron from a species is know as the ionization energy (I.E.) of the species. The experimental I.E. of He atom is $24.58 eV$.

A. 6

B. 5

C. 4

D. 3

Answer: (a) 4 **(b)** 2

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73. Hydrogen atom:

The electronic ground state of hydrogen atom contains one electron in the first orbit. If sufficient energy is provided, this electron can be promoted to higher energy levels. The electronic energy of a hydrogen-like species (any atom//ions with nuclear charge Z and one electron) can be given as

$E_n = -\frac{R_H Z^2}{n^2}$ where R_H = Rydberg constant, n = principal quantum number

Total energy required to remove two electrons from He is :

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74. The energy of stable states of the hydrogen atom is given by $E_n = -2.18 \times 10^{-8}/n^2[J]$ where n denotes the principal quantum number. Calculate the energy differences between $n = 2$ (first excited state) and $n = 1$ (ground state) and between $n = 7$ and $n = 1$.

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75. The energy of stable states of the hydrogen atom is given by $E_n = -2.18 \times 10^{-8}/n^2[J]$ where n denotes the principal quantum number.

In what spectral range is the Lyman series lying?

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76. The energy of stable states of the hydrogen atom is given by $E_n = -2.18 \times 10^{-8}/n^2[J]$ where n denotes the principal quantum number. Can a single photon, emitted in the first and//or sixth line of the Lyman series, ionize:

{:a) another hydrogen atom in its ground state?

{:b) a copper atom in the Cu crystal?

The electron work function of Cu is $\phi_{Cu} = 7.44 \times 10^{-19}J$.

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77. The energy of stable states of the hydrogen atom is given by $E_n = -2.18 \times 10^{-8}/n^2[J]$ where n denotes the principal quantum number. Calculate the de Broglie wavelength of the electrons emitted from a copper crystal when irradiated by photons from the first line and the sixth line of the Lyman series.

$h = 6.6256 \times 10^{-34} Js, \quad m_e = 9.1091 \times 10^{31} kg, \quad c = 2.99792 \times 10^8 ms^{-1}$

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78. Avogadro's Number: 6.022×10^{23}

An atom of $..^{238}U$ disontegates by a series of α-decays and β-decays until it becomes $.^{206}Pb$, which is stable.

(i) How many α-decays and many β-decays does an atom starting as $..^{238}U$ undergo before it becomes stable?

(ii) One of the following ten nuclides is formed from a series of disintegrations starting at $..^{238}U$. Which one?

$.^{235}U, .^{234}U, .^{228}Ac, .^{224}Ra, .^{224}Rn, .^{220}Rn, .^{215}Po, .^{212}Po, .^{212}Pb, .^{211}Pb.$

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79. Avogadro's Number: 6.022×10^{23}

In a thermal neutron-inducted fission process, $.^{235}U$ reacts with a neturon and breaks up into energetic fragmants and (normally) $2-3$ new neutrons.

We consider one single fission event: $235U + n \rightarrow .^{137}Te + X + 2n$

Identify the fragment X.

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80. In 1908 Rutherford together with H- Geiger measured the rate of emission of α particles (x) by radius (in the nature this element is represented by a single nuclide $._{88}^{226}Ra$) and found that $1.00g$ of radius emits $x = 3.42 \times 10^{10}\alpha$- particle per second.

In 1911 Ritherford and American physical chemist B. Boltwood measured the rate of formation of helium from radius. This experiment permits to obtain the most accurate value of Avogadro's number avaliable at the time, given that the value of molar volume of ideal gas was well established. To achieve this goal a sample of radium salt purified from decays products and contaning $m = 192$ mg of Re was put into a device an the volume of the evolved helium was measured. After 83 days $(t = 83.0\text{days})$ of the experiment $6.58mm^3$ of He was collected $\left(V_{He} = 6.58mm^3\text{corrected to}0\,^\circ\text{Cand}1atm\right)$.

To inderstand the results of this experiment we shall need the kinetic scheme of redioactive decay of Re which is given below (half-lives are the arrows, the type of decay is below the arrows).

$$Ra \xrightarrow{>1500\text{years}} \alpha Rn \xrightarrow{3.83\text{days}} \alpha RaA \xrightarrow{3.05\text{min}} \alpha RaB \xrightarrow{26.8} \beta RaC \xrightarrow{17.7\text{min}} \beta$$

$$\rightarrow RaC' \xrightarrow{1.63 \times 10^{-4} S} \alpha RaD \xrightarrow{27.1\text{years}} \beta RaE \xrightarrow{5\text{days}} \beta Po \xrightarrow{138\text{days}} \alpha Pb \text{ (stable)}$$

(RaA-RaE are intermediate products of radon decay).

Write the first six radioactive dacays using a modern natation showing atomic and mass numbers of all nuclei involved.

As a rough first approximation half-lives of all radius decay products, except those of RaD and Po, may be assumed to be negligible compared to the time of measurement t. Using this approximation perform the following calculations.

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81. In 1908 Rutherford together with H- Geiger measured the rate of emission of α particles (x) by radius (in the nature this element is represented by a single nuclide $\_(88)^{226}Ra$) and found that $1.00g$ of radius emits $x = 3.42 \times 10^{10}\alpha$- particle per second.

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(RaA-RaE are intermediate products of radon decay).

{:a) How many helium atoms were formed each decayed radius atom after 83 days?

{:b) How many helium atom were formed in total during the experiment?

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82. The dissociation of (molecular) chlorine is an endothermic process, $\Delta H = 243.6 kJmol^{-1}$. The disoociation can also attained by the effect of light.

At what wavelength can the dissociating effect of light be expected?

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83. The dissociation of (molecular) chlorine is an endothermic process, $\Delta H = 243.6 kJmol^{-1}$. The disoociation can also attained by the effect of light.

Can this effect also be obtained with light whose wavelength is smailer or larger than the calculayed critical wavelength?

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84. The dissociation of (molecular) chlorine is an endothermic process, $\Delta H = 243.6 kJ mol^{-1}$. The disoociation can also attained by the effect of light.

What is the energy of the photon with the critical wavelength?

When light that can effect the chlorine dissociation is incident on a mixture of gaseous chlorine and hydrogen, hydrogen chloride is formed. The mixture is irradiated with a mercury UV-lamp ($\ddot{e} = 253.6 nm$). The lamp has a power input of $10W$. An amount of 2% of the energy supplied is absorbed by the gas mixture (in a 10 litre vessel). Withn 2.5 seconds of irradiation 65 millomoles of HCl are formed.

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85. The dissociation of (molecular) chlorine is an endothermic process, $\Delta H = 243.6 kJ mol^{-1}$. The disoociation can also attained by the effect of light.

How large is the quantum yield (=the number of product molecules per absorbed photons)?

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86. The dissociation of (molecular) chlorine is an endothermic process, $\Delta H = 243.6 kJmol^{-1}$. The disoociation can also attained by the effect of light.

How can the value obtained be (qualitatovely) explained? Describe the reaction mechanism.

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87. One of naturally occurring radioactive decay series begins with $\_(90)^{232}Th$ and ends with a stable $\_(82)^{208}Pb$.

How many beta (β) decays are there in this series? Show by calculate.

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88. One of naturally occurring radioactive decay series begins with $\_(90)^{232}Th$ and ends with a stable $\_(82)^{208}Pb$.

How much energy in MeV is released in the complete chain?

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89. Hydrogen Atom and Hydrogen Molecule

The observed wavelengths in the line spectrum of hydrogen atom were first expressed in terms of a series by johann Jakob Balmer, a Swiss teacher. Balmer's empirical empirical formula is

$$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{n^2}\right), \quad N = 3, 4, 5$$

$$R_H = \frac{Mee^4}{8\varepsilon_0^2 h^3 c} = 109.678 cm^{-1}$$

Here,

R_H is the Rydberg Constant, m_e is the mass of electron. Niels Bohr derived this expression theoretically in 1913. The formula is easily generalized to any one electron atom//ion.

Calculate the iongest wavelength in $A\left(1Å = 10^{-10}m\right)$ in the 'Balmer series of singly ionized helium $\left(He^+\right)$ Ignore nuclear motion in your calculation.

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90. Hydrogen Atom and Hydrogen Molecule

The observed wavelengths in the line spectrum of hydrogen atom were first expressed in terms of a series by johann Jakob Balmer, a Swiss teacher. Balmer's empirical empirical formula is

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A formula analogous to Balmer's formula applies to the series of spectral lines which arise from transition from higher energy levels to the lowest energy level of hydrogen atom. Write this formula and use it to determine the ground state energy of a hydrogen atom in eV.

A 'muonic hydrogen atom' is like a hydrogen atom in which the electron is replaced by a heavier particle, the muon. The mass of a muon is about 207 times the mass of an electron, while its charge is the same as that of an electron. A muon has a very short lifetime, but we ignore its ubstable nature here.

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91. Hydrogen Atom and Hydrogen Molecule

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Determine the loest energy and the radius of the Bohr orbit of the muonic hydrogen atom. Ignore the motion of the nucleus in your calculation. The radius of the Bohr orbit of a hydrogen atom

$$\left(\text{called the Bohr radius, } a_0 = \frac{\varepsilon_0 h^2}{m_e e^2 \Pi} \text{is} 0.53\text{Å}\right)$$

The classical picture of an "orbit" in Bohr's theory has now been replaced by the quantum mechanical nation of an 'orbital'. The orbital $\psi 1\sigma 1s(r)$ for the ground state of a hydrogen atom is given by

$$\psi 1s(r) = \frac{1}{\sqrt{\Pi a_0^3}} e^{\frac{r}{a_0}}$$

where r is the distance of the electron from the nucleus and a_0 is the Bohr radius.

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92. Hydrogen Atom and Hydrogen Molecule

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Consider a spherical shell of radius a_0 and thickness $0.001a_0$. Estimate the probability of finding the electron in this shell. Volume of a spherical shell of inner

radius r and small thickness Δr equals $4\pi r_2 \Delta r$.

The H_2 molecule can dissociate through two different channels:

(i) $H_2 \rightarrow H + H$ (two separate hydrogen atoms)

(ii) $H_2 \rightarrow H^+ + H^-$ (a proton and a hydride ion)

The graph of energy (E) vs internuclear distance (R) for H_2 is shown schematically in the figure. The atomic and molecular energies are given in the same scale.

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93. Hydrogen Atom and Hydrogen Molecule

The observed wavelengths in the line spectrum of hydrogen atom were first expressed in terms of a series by johann Jakob Balmer, a Swiss teacher. Balmer's empirical empirical formula is

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Put appropriate channel labels (i) or (ii) in the boxes below

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94. Hydrogen Atom and Hydrogen Molecule

The observed wavelengths in the line spectrum of hydrogen atom were first expressed in terms of a series by johann Jakob Balmer, a Swiss teacher. Balmer's empirical empirical formula is

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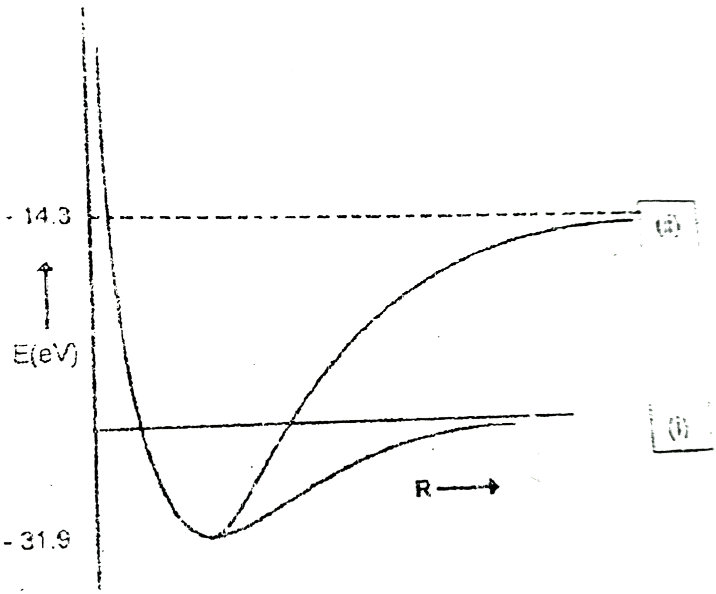
Here,

R_H is the Rydberg Constant, m_e is the mass of electron. Niels Bohr derived this expression theoretically in 1913. The formula is easily generalized to any one electron atom//ion.

Determine the values of the dissociation energies $\left(D_e ineV\right)$ of the H_2 molecule corresponding to channel (i)



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Here,

R_H is the Rydberg Constant, m_e is the mass of electron. Niels Bohr derived this expression theoretically in 1913. The formula is easily generalized to any one electron atom//ion.

From the given data, calculate the energy change for the process

$$H^- \rightarrow H + e^-$$

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96. Hydrogen Atom and Hydrogen Molecule

The observed wavelengths in the line spectrum of hydrogen atom were first expressed in terms of a series by johann Jakob Balmer, a Swiss teacher. Balmer's empirical empirical formula is

$$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{n^2}\right), \quad N = 3, 4, 5$$

$$R_H = \frac{Mee^4}{8\varepsilon_0^2 h^3 c} = 109.678 cm^{-1}$$

Here,

R_H is the Rydberg Constant, m_e is the mass of electron. Niels Bohr derived this expression theoretically in 1913. The formula is easily generalized to any one electron atom//ion.

H^- is a two-electron atomic system. Assuming that the Bohr energy formula is valid for each electron with nuclear charge Z replaced by $Z_{eff'}$ calculate Z_{eff} for H^-.

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97. Beach sand mineral, monazite, is a rich source of thorium, available in large quantities in the state of Kerala in india. A typical monazite sample contains about $9\%\ ThO_2$ and $0.35\%\ U_3O_8$. ^(208)Pb and $\wedge (206)Pb$ are the stable end-products in the redioactive decay series of $\wedge (232)Th$ and $.^{238}U$, respectively. All the lead (Pb) found in monazite is of radiogenic origin.

The isotopic atom ratio $\wedge (208)Pb/^{232}Th$ and $.^{238}U$ are 1.41×10^{10} years and 4.47×10^{9} years, respectively. Assume that $\wedge (208)Pb$, ^(232)Th and $.^{238}U$ remained entirely in the monazite sample since the formation of monazite mineral.

Thorium- 232 is a fertile material for nuclear energy. In thermal neutron irradiation, it absorbs a neutron and the resulting isotope forms $\wedge (233)U$ by successive β-decays. Write the nuclear reactions for the formation of $\wedge (233)U$ from $\wedge (232)Th$.

In nuclear fission of $\wedge (233)U$ a complex mixture of radioactive decay as shown below:

$_(42)^{101}Mo \rightarrow t_{1/2}=14.6\,\text{min}$_(43)^(101)Tc underset(t_(1//2)=14.3 min)(rarr)

$\_(44)^{101}Ru$

View Text Solution

98. The muon (μ) is a subatomic particle of the lepton family which has same charge and magnetic behavioue as the electron, but has a different mass and is unstable, i.e. it disintegrates into other particles within microseconds after its creation. Here you will attempt to determine the mass of the muon using two rather different approaches.

(a) the most common spontaneous disintegration reaction for the muon is:

$\mu \rightarrow e + \bar{v}_e + v\mu$

where $\bar{v}_e$ is the electron antineutrino and v_μ the muon neutrino. In a given experiment using a stationary muon, $\bar{v}_e + v\mu$, carried away a total energy of $2.000 \times 10^{-12} J$, while the electron was moveing with a kinetic energy of $1.4846 \times 10^{-11} J$. Determine the mass of the muon.

(b) Many experiments have studied the spectroscopy of atoms that have captured a muon in place of an electron. These exotic atoms are formed in a variety of excited states. The transition from the third excited state to the first excited state of an atom consisiting of a $\wedge (1)H$ nucleus and a muon attached it was observed at a wavelength of $2.615 nm$. Determine the mass of the muon.

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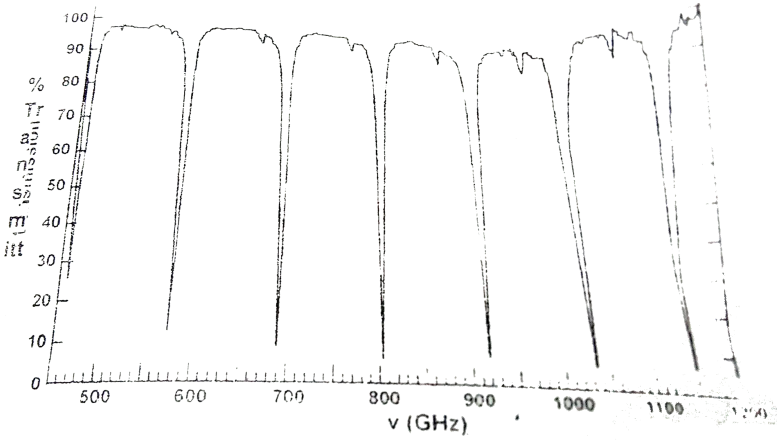
99. Rotational energy levels of diatomic molecules are well described by the formula $E_J = BJ(J + 1)$, where J is the rotational quantum number of the molecule and B its rotational constant. B is related to the reduced mass μ and the bond length R of the molecule through the equation $B = \frac{h^2}{8\pi^2 \mu R^2}$.

In general, spectroscopic transitions appear at photon energies which are equal to the energy difference between appropriate states of a molecule ($hv = \Delta E$). The observed rotational transitions occur between adjacent rotational levels, hence $\Delta E = E_{J+1} - E_J = 2B(J + 1)$. Consequently, successive rotational transitions that appear on the spectrum (such as the one shown here) follow the equation $h(\Delta \upsilon) = 2B$.



By inspecting the spectrum provided, determine the following quantities for $\wedge$ (2)C^(p)C$withap \propto riateunits(a)$Deltaupsilon$(b)B(c)$R`

View Text Solution

100. Detection of Hydrogen

Hydrogen is prevalent in the universe. Life in the universe is ultimately based on hydrogen.

The are about 1×10^{23} atars in the universe. Assume that they are like our sun (radius $700.000 km$, density, $1.4 g/cm^{-3}3/4$ hydrogen and $1/4$ helium by mass). Estimate the number of stellar protons in the universe to one significant figure.

In the $1920s$, Cecilia Payne discovered, by spectral analysis of starlight , that hydrogen is the most abundant element in most stars.

View Text Solution

101. Detection of Hydrogen

Hydrogen is prevalent in the universe. Life in the universe is ultimately based on hydrogen.

The electronic energy of a hydrogen atom is given by $\Delta E\left(n_1 \rightarrow n\right) = -C\left(1/n_1^2 - 1/n_1^2\right)$, relative to zero energy at infinite separation between the electron and the proton (n is the principle quantum number, and C is a constant). For detection of the $\Delta E = (3 \rightarrow 2)$ transition $(656.3nm$ in the Balmer series), the electron in the ground state of the hydrogen atom needs to be excited first to the absorption line in the starlight corresponding to the $\Delta E = (1 \rightarrow 2)$ transition.

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102. Detection of Hydrogen

Hydrogen is prevalent in the universe. Life in the universe is ultimately based on hydrogen.

According to Wien's law, the wavelength (λ) corresponding to the maximum light intensity emitted from a blackbody at temperature T is given by $\lambda T = 2.9 \times 10^{-3} mK$. Calculate the surface temperature of a star whose blackbody radiation has a peak intensity corresponding to then $n = 1 \rightarrow n = 2$ excitation of hydrogen. The ground state hydrogen is split into hyperfine levels due to the interaction between the magnetic moment of the proton and that of the electron. In 1951, Purcell discovered a spectral line at $1420 MHz$ due to the hyperfine transition of hydrogen in interstellar space.

View Text Solution

103. Detection of Hydrogen

Hydrogen is prevalent in the universe. Life in the universe is ultimately based on hydrogen.

Hydrogen in interstellar space cannot be excited electronically by starlight. However, the consmic background rediation, equivalent to $2.7K$ can cause the hyperfine transition. Calculate the temperature of a blackbody whose peak intensity corresponds to the $1420MHz$ transition.

View Text Solution

104. Detection of Hydrogen

Hydrogen is prevalent in the universe. Life in the universe is ultimately based on hydrogen.

Wien generated hydrogen ions by discharge of hydrogen gas at a very low pressure and determine the $\frac{e}{m}(\text{charge/mass})$ value, which turned out to be the highest among different gases tested. In 1919, Rutherford bombarded notrogen with alpha-particles and observed emission of a positively charged particle which turned out to be the hydrogen ion observed by Wien. Rutherford named this particle the "proton". Fill in the blank.

$\wedge(14)N+$ ^(4)He rarr .... + $\wedge(1)H$

View Text Solution

105. In the table below, ul(identify) which transformations are α-decays and which are β-decays.

$|(, \alpha \text{ - } decay, \beta \text{ - } decay), \left(.^{226}Ra \rightarrow {}^{222}Rn, , \right), \left(.^{222}Rn \rightarrow {}^{218}Po, , \right), \left(.^{218}Po \rightarrow {}^{214}\right.$

^(210)Po rarr^(206)Pb,,):}|`

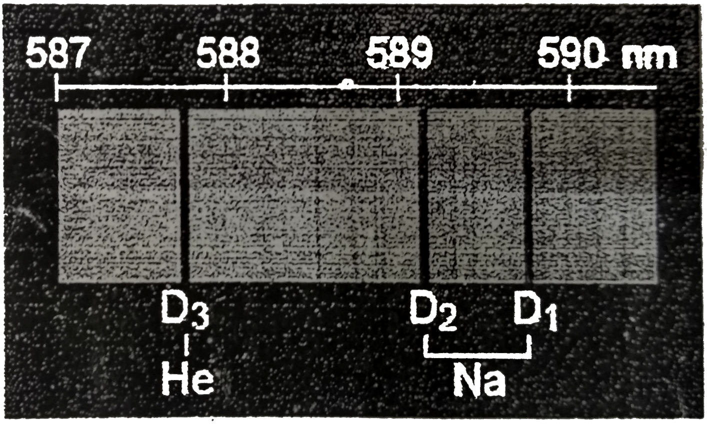
View Text Solution

106. In 1894, Lord Rayleigh reported that the mass of chemically prepared nitrogen was different from that of nitrogen extracted from the atmosphere, as shown in Tables 1 and 2. Latter, this difference was attributed to the presence of argon in atmospheric nitrogen. The masses of gases were mearsured by using a glass vessel with a known volume under atmospheric pressure $\left(1.013 \times 10^{5}Pa\right)$.

From nitric oxide	2.3001g
From nitrous oxide	2.2990g
From amonium nitrite purified at a red heat	2.2987g
From urea	2.2985g
From ammonium nitrite purified in the cold	2.2987g
Mean	2.2990g

$O_2$was removed by hot copper(1892)	2.3103g
$O_2$was removed by hot iron(1893)	2.3100g
$O_2 wasremovedbyferroushydrate$(1894) 2.3102$g$	
Mean	2.3102g

Ramsay and cleve discovered helium in cleveite (a mineral consiting of uranium oxide and oxides of lead, thorium, and rare earths, an impure variety of uraninite) independently and virtually simultaneously in 1895. The gas extracted from the rock showed a unique spectroscopic line at around 588 nm (indicated by $D3$ in Figure 1), which was fist observed in the spectrum of solar prominence during a total eclipse in 1868, near the well-known D_1 and D_2 lines of sodium.



Calcate the energy $E[J]$ of a photon with the wavelength of the D_3 line of helium shown in Figure 1

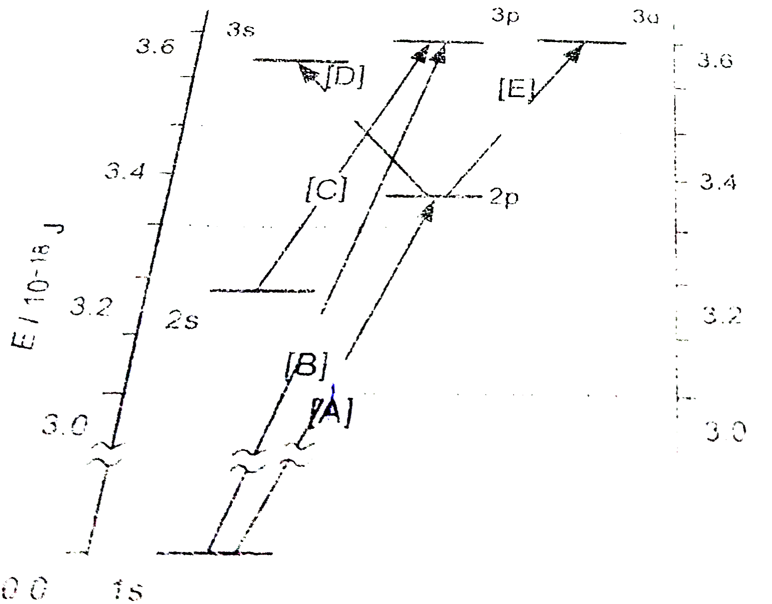


Figure 2. Energy diagram of atomic orbitals of helium when an electron resides in the 1s orbital.

Figure 2 shows an energy diagram of the atomic orbitals of helium. The arrows indicate the "allowed" transitions according to the spectroscopic principle.

View Text Solution

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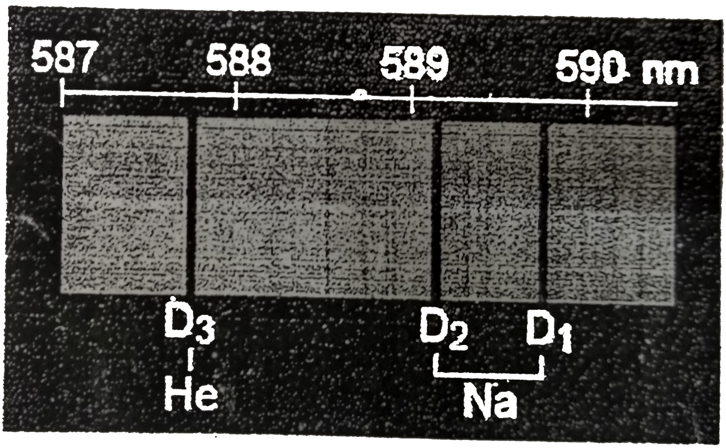
$Mean$	2.3102g

Ramsay and cleve discovered helium in cleveite (a mineral consiting of uranium oxide and oxides of lead, thorium, and rare earths, an impure variety of uraninite) independently and virtually simultaneously in 1895. The gas extracted from the rock showed a unique spectroscopic line at around 588 nm (indicated by $D3$ in Figure 1), which was fist observed in the spectrum of solar prominence during a total eclipse in 1868, near the well-known D_1 and D_2 lines of sodium.



Identify the transition relevant to the D_3 line of helium among the transitions $[A]$ to $[E]$ indicated in Figure 2. Mark one of the following:

[A] [B] [C] [D] [E]

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108. In 1894, Lord Rayleigh reported that the mass of chemically prepared nitrogen was different from that of nitrogen extracted from the atmosphere, as shown in Tables 1 and 2. Latter, this difference was attributed to the presence of argon in atmospheric nitrogen. The masses of gases were mearsured by using a glass vessel with a known volume under atmospheric pressure $\left(1.013 \times 10^5 Pa\right)$.

From nitric oxide	$2.3001g$
From nitrous oxide	$2.2990g$
From amonium nitrite purified at a red heat	$2.2987g$
From urea	$2.2985g$
From ammonium nitrite purified in the cold	$2.2987g$
Mean	$2.2990g$

$O_2$was removed by hot copper(1892)	$2.3103g$
$O_2$was removed by hot iron(1893)	$2.3100g$
$O_2 wasremovedbyferroushydrate(1894)$ $2.3102g$	
Mean	$2.3102g$

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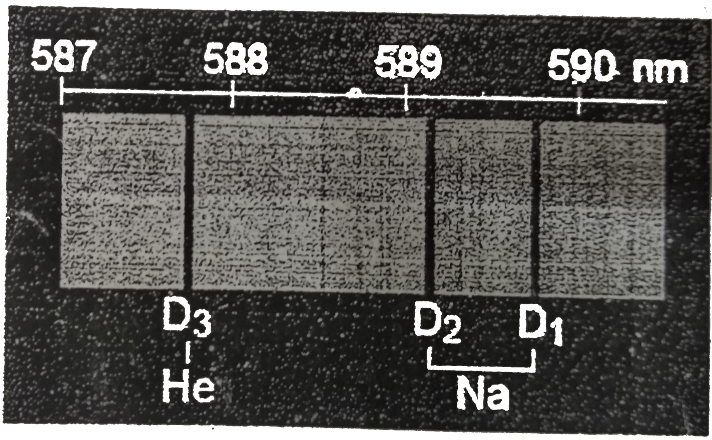

Which equation explains the occurrence of helium in cleveite among $[A]$ to $[D]$ below? Mark one.

A. $.^{238}U \rightarrow .^{234}Th + \alpha$

B. $Uhe_2 \rightarrow U + 2He$

C. $.^{240}U \rightarrow .^{240}Np + \beta^-$

D. $.^{235}U + n \rightarrow .^{95}Y + ^{139}l + 2n$

Answer: Considering that the a particle is the nucleus of helium a decay $[A]$ is the relevent source of helium in such rocks. No compounds of He such as $UHe2$ in $[B]$ is known to be stable at ambient temperature. $[C]$ is a radioactive decay of $240U$ in the thorium series. $[D]$ is a nuclear fission reaction of $235U$ occurring in nuclear reactors. Thus, the correct answer is $[A]$

View Text Solution

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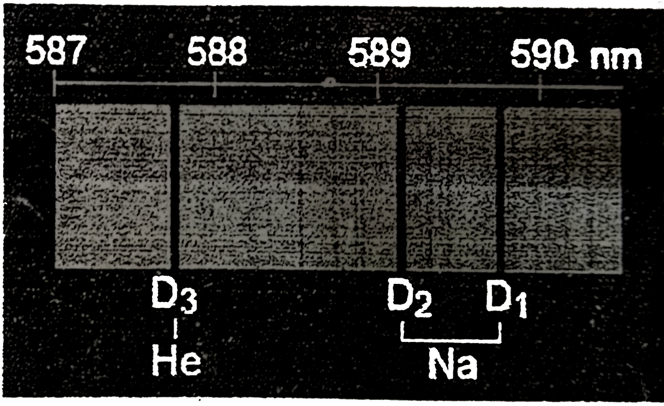


Which equation explains the occurrence of argon in rocks among [A] to [D] below? Mark one.

One of the strongest evidences for the monoatomicity of argon and helium is the ratio of the heat capacity under constant pressure to that at constant volume, $\gamma = C_p/C_v$, which is exactly $5/3(1.67 \pm 0.01)$ for a monoatomic gas. The ratio was derived from the measurement of speed of sound v_s by using the following equation, where f and the frequency and wavelength of the sound, and R, T, and M denote the molar gas constant, absolute temperature, and molar mass, respectively.

$$v_s = f\lambda = \sqrt{\frac{\gamma RT}{M}}$$

For an unknown gas sample, the wavelength of the sound was measured to be $= 0.116m$ at a frequency of $f = 3520Hz\left(Hz = s^{-1}\right)$ and temperature of $15.0\,^\circ C$ and under atmospheric pressure $\left(1.013.\ 10^5 Pa\right)$. The density of the gas for these conditions was measured to be $0.850 \pm 0.005 kgm^{-3}$.

A. $ArF_2 \quad Ar + F_2$

B. $ArXe \rightarrow Ar + Xe$

C. $\wedge\ (40)K \rightarrow$ ^(40)Ar+ epsilon//beta^(+) (electron capture//position emission)

D. $\wedge\ (126)I \rightarrow$ ^(126)Ar+beta^(-)

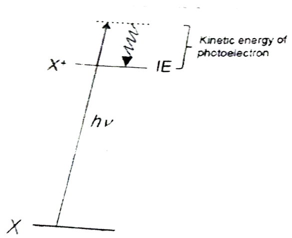
Answer: [C] is a well known radioactive decay reaction occurring with a half life of the order of the earth age. No stable compound of Ar, such as ArF_2 or $ArXe$, can be expected
Products of [D] should be $\wedge\ (126)Xe + \beta^-$. The correct answer is [C]

View Text Solution

110. When an atom X absorbs radiation with a photon energy than the ionization energy of the atom, the atom is ionized to generate an ion X^+ and the electron (called a photoelectron) is ejected at the same time. In this event, the energy is conserved as shown in Figure 1, that is,

Photon energy (h)=ionization energy (IE) of X + kinetic energy of photoelectron.

When a molecule, for example, H_2, absorbs short-wavelength light, the photoelectron is ejected and an H_2, ion with a variety of vibrational states is produced. A photoelectron spectrum is a plot of the number of photoelectrons as a function of the kinetic energy of the photoelectrons. Figure-2 shows a typical photoelectron spectrum when H_2 in the lowest vibrational level is irradiated by monochromatic light of $21.2 eV$. No photoelectrons are detected above $6.0 eV$. (eV is a unit of energy and $1.0 eV$ is equal to $1.6 \times 10^{-19} J$)



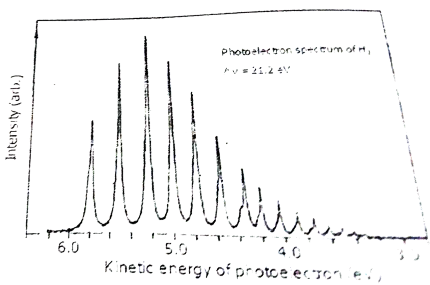


Figure 1 Schematic diagram of photoelectron spectroscopy.

Figure 2 Photoelectron spectrum of H_2. The energy of the incident light is $21.2 eV$

{:a) Determine the energy difference E_{A1} (eV) between $H_2(v = 0)$ and

$H^+(V_{ion} = 0)$ to the first decimal place. v and v_{ion} denote the vibrational quantum numbers of H_2 and H^+, respectively.

{:b) Determine the energy difference E_{A2} (eV) between $H^+(v_{ion} = 0)$ and $H^+(v_{ion} = 3)$ to the first decimal place. The electronic energy levels E_n^H of a hydrogen atom are given by the equation

$$E_n^H = -\frac{Ry}{n^2} \quad (n = 1, 2, 3....)$$

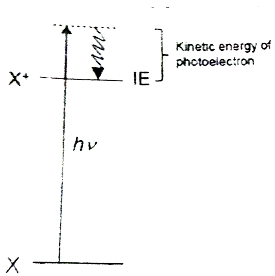
Here n is a principal quantum number, and Ry is a constant with dimensions of energy. The energy from $n = 1$ to $n = 2$ of the hydrogen atom is $10.2eV$.

View Text Solution

111. When an atom X absorbs radiation with a photon energy than the ionization energy of the atom, the atom is ionized to generate an ion X^+ and the electron (called a photoelectron) is ejected at the same time. In this event, the energy is conserved as shown in Figure 1, that is,

Photon energy (h)=ionization energy (IE) of $X +$ kinetic energy of photoelectron.

When a molecule, for example, H_2, absorbs short-wavelength light, the photoelectron is ejected and an H_2, ion with a variety of vibrational states is produced. A photoelectron spectrum is a plot of the number of photoelectrons as a function of the kinetic energy of the photoelectrons. Figure-2 shows a typical photoelectron spectrum when H_2 in the lowest vibrational level is irradiated by monochromatic light of $21.2eV$. No photoelectrons are detected above $6.0eV$. (eV is a unit of energy and $1.0eV$ is equal to $1.6 \times 10^{-19}J$)



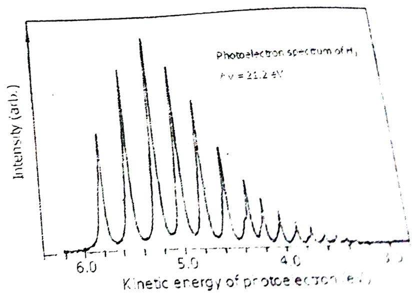


Figure 1 Schematic diagram of photoelectron spectroscopy.

Figure 2 Photoelectron spectrum of H_2. The energy of the incident light is $21.2eV$

Calculate the ionization energy $E_B(eV)$ of the hydrogen atom to the first decimal place.

The energy threshold for the generation of two electronically excited hydrogen atoms $H^*(n = 2)$ from $H_2(v = 0)$ has been derived to be $24.9eV$ by an experiment.

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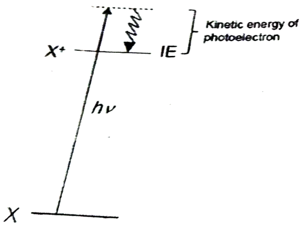
112. When an atom X absorbs radiation with a photon energy than the ionization energy of the atom, the atom is ionized to generate an ion X^+ and the electron (called a photoelectron) is ejected at the same time. In this event, the energy is conserved as shown in Figure 1, that is,

Photon energy (h)=ionization energy (IE) of $X +$ kinetic energy of photoelectron.

When a molecule, for example, H_2, absorbs short-wavelength light, the photoelectron is ejected and an H_2, ion with a variety of vibrational states is produced. A photoelectron spectrum is a plot of the number of photoelectrons as a function of the kinetic energy of the photoelectrons. Figure-2 shows a typical photoelectron spectrum when H_2 in the lowest vibrational level is irradiated by monochromatic light of $21.2eV$. No photoelectrons are detected above $6.0eV$. (eV is a unit of energy and $1.0eV$ is equal to $1.6 \times 10^{-19}J$)



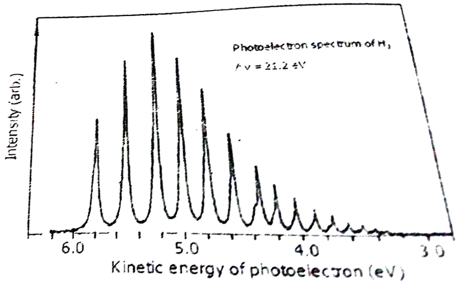


Figure 1 Schematic diagram of photoelectron spectroscopy.

Figure 2 Photoelectron spectrum of H_2. The energy of the incident light is

$21.2eV$

Determine the bond energy $E_C(eV)$ of H_2 to the first decimal place.

113. When an atom X absorbs radiation with a photon energy than the ionization energy of the atom, the atom is ionized to generate an ion X^+ and the electron (called a photoelectron) is ejected at the same time. In this event, the energy is conserved as shown in Figure 1, that is,

Photon energy (h)=ionization energy (IE) of $X +$ kinetic energy of photoelectron.

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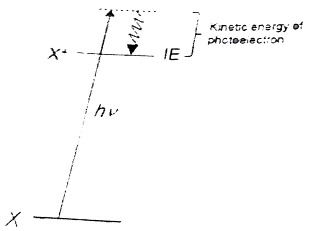


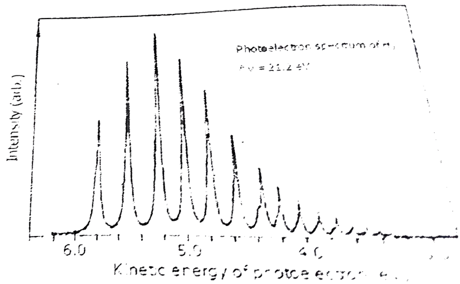


Figure 1 Schematic diagram of photoelectron spectroscopy.

Figure 2 Photoelectron spectrum of H_2. The energy of the incident light is $21.2 eV$

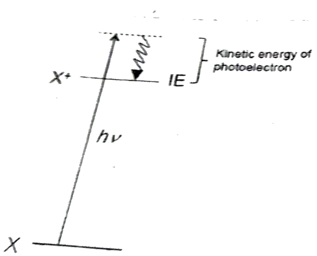
Considering an energy cycle, determine the bond energy $E_D(eV)$ of H_2^+ to the first decimal place. If you were unable to determine the values for E_B and E_C, then use $15.0 eV$ and $5.0 eV$ for E_B and E_C, respectively.

View Text Solution

114. When an atom X absorbs radiation with a photon energy than the ionization energy of the atom, the atom is ionized to generate an ion X^+ and the electron (called a photoelectron) is ejected at the same time. In this event, the energy is conserved as shown in Figure 1, that is,

Photon energy (h)=ionization energy (IE) of $X +$ kinetic energy of photoelectron.

When a molecule, for example, H_2, absorbs short-wavelength light, the photoelectron is ejected and an H_2, ion with a variety of vibrational states is produced. A photoelectron spectrum is a plot of the number of photoelectrons as a function of the kinetic energy of the photoelectrons. Figure-2 shows a typical photoelectron spectrum when H_2 in the lowest vibrational level is irradiated by monochromatic light of $21.2 eV$. No photoelectrons are detected above $6.0 eV$. (eV is a unit of energy and $1.0 eV$ is equal to $1.6 \times 10^{-19} J$)



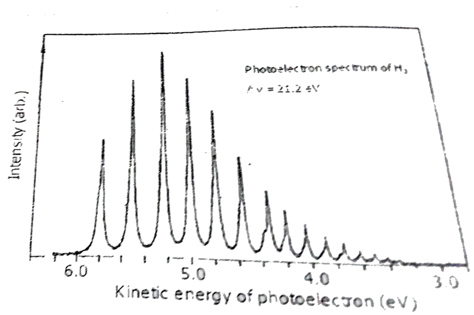


Figure 1 Schematic diagram of photoelectron spectroscopy.

Figure 2 Photoelectron spectrum of H_2. The energy of the incident light is $21.2eV$

Calculate the threshold energy E_E (eV) of the following dissociative reaction to the first decimal place:

$H_2 \rightarrow H^*(n = 2) + H^+ + e^-$

If you were unable to determine the values for E_B and E_C, then use $15.0eV$ and $5.0eV$ for E_B and E_C respectively.

When H_2 absorbs monochromatic light of $21.2eV$, the following dissociation process occurs at the same time.

$H_2 \xrightarrow{21.2eV} H(n = 1) + H(n = 1)$

Two hydrogen atoms move in opposite direction with the same speed.

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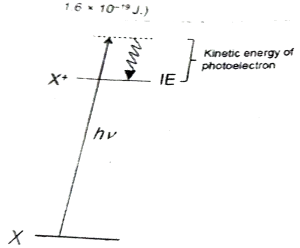
115. When an atom X absorbs radiation with a photon energy than the ionization energy of the atom, the atom is ionized to generate an ion X^+ and the electron (called a photoelectron) is ejected at the same time. In this event, the energy is conserved as shown in Figure 1, that is,

Photon energy (h)=ionization energy (IE) of $X +$ kinetic energy of photoelectron.

When a molecule, for example, H_2, absorbs short-wavelength light, the photoelectron is ejected and an H_2, ion with a variety of vibrational states is produced. A photoelectron spectrum is a plot of the number of photoelectrons as a function of the kinetic energy of the photoelectrons. Figure-2 shows a typical photoelectron spectrum when H_2 in the lowest vibrational level is irradiated by monochromatic light of $21.2eV$. No photoelectrons are detected above $6.0eV$. (eV is a unit of energy and $1.0eV$ is equal to $1.6 \times 10^{-19} J$)



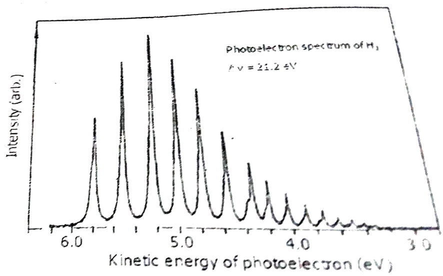


Figure 1 Schematic diagram of photoelectron spectroscopy.

Figure 2 Photoelectron spectrum of H_2. The energy of the incident light is $21.2eV$

Calculate the speed $u\left(ms^{-1}\right)$ of the hydrogen atoms generated in the above reaction. H_2 is assumed to be at rest. If you were unable to determine the value for E_C, then use $5.0eV$ for E_C

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116. At a temperature of $0K$, the total energy of a gaseous diatomic molecule AB is approximately given by:

$E = E_o + E_{vib}$

where E_o is the electronic energy of the ground state, and E_{vib} is the vibrational energy.

Allowed values of the vibrational energies are given by the expression:

$$E_{vid} = \left(v - \frac{1}{2}\right)\varepsilon \quad v = 0, 1, 2, ... \quad \varepsilon = \frac{h}{2\pi}\sqrt{\frac{k}{\mu}} \quad \mu(AB) = \frac{m_A m_B}{m_A + m_B}$$

where h is the planck's constant, is the vibration quantum number, k is the force constant, and is the reduced mass of the molecule. At $0K$, it may be safely assumed that is zero, and E_o and k are independent of isotopic substitution in the molecule.

Deuterium, D, is an isotope of hydrogen atom with mass number 2. For the H_2 molecule, k is $575.11Nm^{-1}$, and the isotopic molar masses of H and D are 1.0078 and $2.0141gmol^{-1}$, respectively.

At a temperature of $0K$: $\varepsilon_{H_2} = 1.1546\varepsilon_{HD}$ and $\varepsilon_{D_2} = 0.8167\varepsilon_{HD}$

Calculate the dissociation energy, ΔE, in eV of a hydrogen molecule in its ground state such that both H atoms are produced in their ground states.

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A molecule H_2 in the ground state dissociates into its atoms after absorbing a photon of wavelength $77.0 nm$. Determine all possibilities for the electronic states of hydrogen atoms produced. For each case calculate the total kinetic energy, KE, in eV of the disociated hydrogen atoms.

View Text Solution

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At a temperature of $0K$: $\varepsilon_{H_2} = 1.1546\varepsilon_{HD}$ and $\varepsilon_{D_2} = 0.8167\varepsilon_{HD}$

Calculate the electron affinity, EA, of H_2^+ ion in eV if its dissociation energy is $2.650 eV$. If you have been unable to calculate the value for the dissociation energy of H_2 then use $4.500 eV$ for the calculate.

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119. Calculate the frequency in s^{-1} of infrated photons that can be absorbed by HD molecule.

(If you have been unable to calculate the value for ε_{HD} then use 8.000×10^{-20} the calculation)

The allowed electronic energies of H atom of H atom are given by the expression:

$E = -\frac{R_H}{n^2}, n = 1, 2, ...$ where $R_H = 13.5984eV$ and $1eV = 1.602 \times 10^{-19}J$

The total energy of H_2 molecules in its ground state is $-31.675eV$, relative to the same refrence as that of hydrogen atom.

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