Atomic Structure JEE Main PYQ - 2

Total Time: 25 Minute **Total Marks:** 40

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Atomic Structure

1. A stream of electrons from a heated filament was passed between two charged plates kept at a potential difference V esu. If e and m are charge and mass of an electron, respectively, then the value of h/λ (where λ is wavelength associated with electron wave) is given by : **(+4, -1)**

[2016]

a. meV

b. $2meV$

c. $\sqrt{meV}$

d. $\sqrt{2meV}$

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2. At temperature T, the average kinetic energy of any particle is $\frac{3}{2}$ kT. The de Broglie wavelength follows the order : **(+4, -1)** **[Online April 11, 2015]**

a. Thermal proton > Visible photon > Thermal electron

b. Thermal proton > Thermal electron > Visible photon

c. Visible photon > Thermal electron > Thermal neutron

d. Visible photon > Thermal neutron > Thermal electron

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3. Ejection of the photoelectron from metal in the photoelectric effect experiment can be stopped by applying $0.5\,V$ when the radiation of $250\,nm$ is used. The work function of the metal is : **(+4, -1)**

[Online April 15, 2018 (I)]

a. 4 eV

b. 4.5 eV

c. 5 eV

d. 5.5 eV

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4. For emission line of atomic hydrogen from $n_i = 8$ to n_f = the plot of wave number $(\bar{v})$ against $(\frac{1}{n^2})$ will be (The Ry dberg constant, R_H is in wave number unit). (+4, -1)

[Jan. 9,2019 (I)]

a. Linear with slope - R_H

b. Linear with intercept - R_H

c. Non linear

d. Linear with slope R_H

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5. Given (A) $n = 5, m_\ell = +1$ (B) $n = 2, \ell = 1, m_\ell = 1, m_s = -\frac{1}{2}$ The maximum number of electron(s) in an atom that can have the quantum numbers as given in (A) and (B) are respectively: (+4, -1)

[Online April 25, 2013]

a. 25 and 1

b. 8 and 1

c. 2 and 4

d. 4 and 1

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6. Heat treatment of muscular pain involves radiation of wavelength of about $900\,nm$. Which spectral line of H-atom is suitable for this purpose ? $[R_H = 1 \times 10^5\ cm^{-1}, h = 6.6 \times 10^{-34}\ Js, c = 3 \times 10^8\ ms^{-1}]$ (+4, -1)

[Jan. 11, 2019 (I)]

a. Paschen, $5 \to 3$

b. Paschen, $\infty \to 3$

c. Lyman, $\infty \to 1$

d. Balmer, $\infty \to 2$

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7. If λ_0 and λ be the threshold wavelength and wavelength of incident light, the velocity of photoelectron ejected from the metal surface is : (+4, -1)

[Online April 11,2014]

a. $\sqrt{\frac{2h}{m}(\lambda_0-\lambda)}$

b. $\sqrt{\frac{2hc}{m}(\lambda_0-\lambda)}$

c. $\sqrt{\frac{2hc}{m}\left(\frac{\lambda_0-\lambda}{\lambda\lambda_0}\right)}$

d. $\sqrt{\frac{2h}{m}\left(\frac{1}{\lambda_0}-\frac{1}{\lambda}\right)}$

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8. The size of the iso-electronic species Cl^-, Ar and Ca^{2+} is affected by - **(+4, -1)**

[April 8, 2019 (I)]

a. Principal quantum number of valence shell

b. Nuclear charge

c. Azimuthal qunatum number of valence shell

d. Electron-electron interaction in the outer orbitals

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9. If the ionisation potential of the hydrogen atom is 13.6eV, then what will be the longest wavelength needed to remove an electron from the 1st Bohr's orbit of He^+ ion? **(+4, -1)**

a. (A) 2.284×10^{-10} m

b. (B) 2.284×10^{-8}

c. (C) 228.4 A

d. (D) Both (B) and (C)

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10. Which transition in the hydrogen spectrum would have the same wavelength as the Balmer type transition from $n=4$ to $n=2$ of He^+ spectrum **(+4, -1)**

[31-Jan-2023 Shift1]

a. $n=1$ to $n=3$

b. $n=1$ to $n=2$

c. $n = 2$ to $n = 1$

d. $n = 3$ to $n = 4$

Answers

1. **Answer: d**

Explanation:

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2me\,V}}$$
$$\Rightarrow \frac{h}{\lambda} = \sqrt{2me\,V}$$

Concepts:

1. **Structure of Atom:**

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Dalton's Atomic Theory

Dalton proposed that every matter is composed of atoms that are indivisible and indestructible.

The following are the postulates of his theory:

- Every matter is made up of atoms.
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- Specific elements have only one type of atoms in them.
- Each atom has its own constant mass that varies from element to element.
- Atoms undergo rearrangement during a chemical reaction.
- Atoms can neither be created nor be destroyed but can be transformed from one form to another.

Cons of Dalton's Atomic Theory

- The theory was unable to explain the existence of isotopes.
- Nothing about the structure of atom was appropriately explained.

- Later, the scientists discovered particles inside the atom that proved, the atoms are divisible.

Subatomic Particles

1. Protons - are positively charged subatomic particles.
2. Electron - are negatively charged subatomic particles.
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Atomic Structure of Isotopes

Several atomic structures of an element can exist, which differ in the total number of nucleons.These variants of elements having a different nucleon number (also known as the mass number) are called isotopes of the element. Therefore, the isotopes of an element have the same number of protons but differ in the number of neutrons. For example, there exist three known naturally occurring isotopes of hydrogen, namely, protium, deuterium, and tritium.

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2. Answer: c

Explanation:

Kinetic energy of any particle $= \frac{3}{2}KT$

Also $K.E. = \frac{1}{2}mv^2$

$\frac{1}{2}mv^2 = \frac{3}{2}KT$

$\Rightarrow v^2 = \frac{3KT}{m}$

$v = \sqrt{\frac{3KT}{m}}$

De-broglie wavelength

$= \lambda = \frac{h}{mv} = \frac{h}{m\sqrt{\frac{3KT}{m}}}$

$\lambda = \frac{h}{\sqrt{3KTm}} \lambda \propto \frac{1}{\sqrt{m}}$

Mass of electron < mass of neutron λ(electron) > λ (neutron)

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3. **Answer: b**

Explanation:

From photoelectric experiment, we have

$$hv = hv_0 + (K.E.)_{\max}$$
$$\frac{hv}{\lambda} = W + (K.E.)_{\max}$$

where $\frac{hv}{\lambda}$ is the energy of incident radiation, W is the work function and $(K.E.)_{\max}$ is the kinetic energy of the ejected electrons.

$$\frac{hv}{\lambda} = W + (K.E.)_{\max}$$
$$\frac{6.6\times10^{-34}\times3\times10^{8}}{256.7\times10^{9}\times1.6\times10^{-19}} = W + 0.5 \text{ (As } 1\,V = 1\,eV \text{)}$$

$$4.95\,eV = W + 0.5\,eV \Rightarrow W = 4.45\,eV$$

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4. Answer: d

Explanation:

$$\frac{1}{\lambda} = \bar{V} = R_H Z^2 \left(\frac{1}{\eta_1^2} - \frac{1}{\eta_2^2}\right)$$
$$\bar{V} = R_H \times \left(\frac{1}{\eta_1^2} - \frac{1}{8^2}\right)$$
$$\bar{V} = R_H \times \frac{1}{\eta^2} - \frac{R_H}{8^2}$$
$$\bar{V} = R_H \times \frac{1}{\eta^2} - \frac{R_H}{64}$$

$m = R_H$
Linear with slope R_H

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5. **Answer: b**

Explanation:

The correct option is(B): 8 and 1.

(i) n = 5 means l= 0,1,2,3,4 since m = + 1

hence

total no. of electrons will be

=0 (from s) + 2 (from p) + 2 (from d) + 2 (from f) + 2 (from g)

= 0 + 2 + 2 + 2 + 2 = 8

(ii) n=2, l=1, $m_t = 1, m_s = \frac{1}{2}$ represent
2p orbital with one electron

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6. Answer: b

Explanation:

We have,

$\frac{1}{\lambda} = RZ^2 \left(\frac{1}{{n_l}^2} - \frac{1}{{n_f}^2}\right)$

Here if $n_l = 3$ and $n_f = \infty$

$\frac{1}{\lambda} = 10^{-7} \times 1^2 \left(\frac{1^2}{3} - \frac{1}{\infty^2}\right) = \frac{10^{-7}}{9} = 900\,mm$

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7. **Answer: c**

Explanation:

$$E = W + \frac{1}{2}mv^2$$
$$\Rightarrow \frac{hc}{\lambda} = \frac{hc}{\lambda_0} + \frac{1}{2}mv^2$$
$$\Rightarrow v^2 = \frac{2hc}{m}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$$
$$\Rightarrow v = \sqrt{\frac{2hc}{m}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]}$$
$$\Rightarrow v = \sqrt{\frac{2hc}{m}\left[\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right]}$$

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---

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Explanation:

For isoelectronic species the size is compared by nuclear charge.

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---

9. Answer: d

Explanation:

Explanation:
Given:Ionisation potential of the H-atom = 13.6 We have to find out the longest wavelength needed to remove an electron from the first Bohr's orbit of He+ ion.According to Bohr's model of an atom, the energy of a hydrogen-like ion is given as: $= -2.18 \times 10^{-18} (\frac{2}{2})$ / atomwhere Z = Nuclear charge (equal to atomic number)n = No. of the orbitIonisation potential (I.P) is given as: = $_{\infty}$ − $= 0 - [-2.18 \times 10^{-18} (\frac{2}{2})] = 2.18 \times 10^{-18} (\frac{2}{2})$ / atom.....(i)For hydrogen atom, I.P. $= 13.6eV = 13.6 \times 1.6 \times 10^{-19}$ (,1 $= 1.6 \times 10^{-19}$) $= 21.76 \times 10^{-19}$ For He+ ion,Number of the orbit, n = 1Atomic number, Z of He+ ion = 2Substituting values in equation (i), we getI.E $= 2.18 \times 10^{-18} (\frac{2^2}{1^2}) = 8.72 \times 10^{-18}$ Now,According to Planck's quantum theory of radiation, energy is givenas: = —....(ii)where, = Planck's constant $= 6.63 \times 10^{-34}$ c = Speed of light $= 3 \times 10^8$ m / s = WavelengthSubstituting the values in equation (ii), we get$8.72 \times 10^{-18} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{}$ max $= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{8.72 \times 10^{-18}} = 2.2809 \times 10^{-8}$ m $= 228.09 \times 10^{-10}$ mÅÅ = 228.09Å (, 1Å = 10^{-10})Hence, the correct option is (D).

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10. Answer: c

Explanation:

He^+ ion :

$\frac{1}{\lambda(H)} = R(1)^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\frac{1}{\lambda(He^+)} = R(2)^2 \left[\frac{1}{2^2} - \frac{1}{4^2}\right]$

Given $\lambda(H) = \lambda(He^+)$

$R(1)^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = R(4) \left[\frac{1}{2^2} - \frac{1}{4^2}\right]$

$\frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{1}{1^2} - \frac{1}{2^2}$

On comparing $n_1 = 1 \& n_2 = 2$

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