CLASS – 12

WORKSHEET- ATOMS

A. EARLY MODELS AND RUTHERFORD'S MODEL OF ATOM

(1Mark Questions)

1. According to Rutherford's atomic model, the electrons inside an atom are
   (a) stationary (b) centralized (c) non stationary (d) none of these

2. Choose the correct alternative from the clues given at the end of each statement:
   (a) The size of the atom in Thomson's model is ………. the atomic size in Rutherford's model. (much greater than/no different from/much less than.)

   (b) In the ground state of ………. electrons are in stable equilibrium, while in ………. electrons always experience a net force. (Thomson's model/ Rutherford's model.)

   (c)A classical atom based on ………. is doomed to collapse. (Thomson's model/ Rutherford's model.)

   (d) An atom has a nearly continuous mass distribution in a ……….but has a highly non-uniform mass distribution in ……….(Thomson's model/ Rutherford's model.)

   (e)The positively charged part of the atom possesses most of the mass in ………. (Rutherford's model/both the models.)

(2 Marks Questions)

3. Estimate the radius of a Gold nucleus when α-particle of energy 10MeV is scattered by it through 180°. Given: (i)Z_{gold} = 79, (ii) Z_{α} = 2 and (iii) $1/4\pi\varepsilon_0 = 9\times10^9$ nm^2 C^{-2}.

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4. A Helium nucleus of energy 10 MeV collides on with a $_{29}Cu^{64}$ nucleus and retraces its path. Calculate the radius of the Cu nucleus.

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5. Explain how Rutherford's experiment on scattering of α-particles led to the estimation of the size of the nucleus.

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6. Suppose you are given a chance to repeat the alpha-particle scattering experiment using a thin sheet of solid hydrogen in place of the gold foil. (Hydrogen is a solid at temperatures below 14 K.) What results do you expect?

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(5 Marks Questions)

7. Draw a labeled diagram for α-particle scattering experiment. Give Rutherford's observations and discuss the significance of this experiment. Obtain the expression which helps us to get an idea of the size of a nucleus, using these observations.

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B. BOHR MODEL

(1Mark Questions)

1. The ionization potential of the hydrogen atom is 13.6eV. What will be its energy in n = 2 state?

2. Taking the Bohr radius as a_0 = 53pm, the radius of Li^{++} ion in its ground state, on the basis of Bohr's model, will be about
(a) 53 pm (b) 27 pm (c) 18 pm (d) 13 pm

3. The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons. This is because
(a) of the electrons not being subject to a central force.
(b) of the electrons colliding with each other
(c) of screening effects
(d) the force between the nucleus and an electron will no longer be given by Coulomb's law.

4. Two H atoms in the ground state collide inelastically. The maximum amount by which their combined kinetic energy is reduced is
(a) 10.20 eV (b) 20.40 eV (c) 13.6 eV (d) 27.2 eV

5. The mass of a H-atom is less than the sum of the masses of a proton and electron. Why is this?

(2 Marks Questions)

6. Calculate the speed of electron revolving around the nucleus of hydrogen atom in order that it may not be pulled into the nucleus by electrostatic attraction.

7. Wavelength of first line Balmer series in hydrogen spectrum is 6563Å. Calculate the wavelength of second line in this series.

8. Calculate the radius of the smallest orbit of a H-atom.

9. The electron in a hydrogen atom having energy – 0.85eV makes a transition to a state with energy – 3.4eV. Calculate the wavelength of the emitted photon.

10. Calculate the frequency of the photon radiated by a hydrogen atom when it de-excites from the first excited state to the ground state.

11. State Bohr's postulates for explaining the spectrum of hydrogen atom.

12. The value of ground state energy of hydrogen atom is – 13.6eV. (i) What does the negative sign signify? (ii) How much energy is required to take an electron in this atom from the ground state to the first excited state?

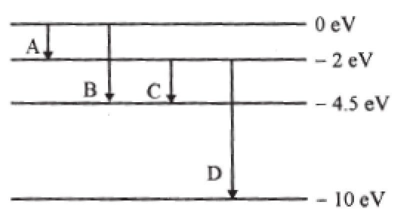
13. What is the shortest wavelength present in the Paschen series of spectral lines? [Ans. 8204.1Å]

14. A 12.5eV electron beam is used to bombard gaseous hydrogen at room temperature. What series of wavelengths will be emitted?

(3 Marks Questions)

15. A muonic hydrogen atom in bound state of a negatively charged muon (denoted by μ) of mass 207m, and a proton, and the muon orbits around the proton. Obtain (i) radius of its first Bohr orbit and (ii) its ground state energy.

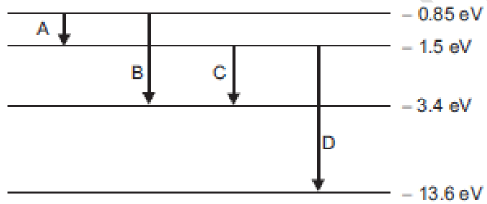
16. The energy levels of an atom are as shown below. Which one of the transitions will result in the emission of a photon of wavelength 275nm?



17. The ground state energy of hydrogen atom is – 13.6eV. (i) What is the kinetic energy of an electron in the 3rd excited state? (ii) If the electron jumps to the ground state from the 3rd excited state, calculate the wavelength of the photon emitted.

18. The ground state energy of hydrogen atom is – 13.6eV. If an electron makes a transition from an energy level – 0.85eV to – 3.4eV, calculate the wavelength of the spectral line emitted. To which series of hydrogen spectrum does this wavelength belong?

19. The energy level diagram of an element is given below. Identify by doing necessary calculations which transition corresponds to the emission of a spectral line of wavelength 102.7 nm.



20. A difference of 2.3eV separates two energy levels in an atom. What is the frequency of radiation emitted when the atom makes a transition from the upper level to the lower level? [Ans. 5.6×10^{14} Hz]

21. The ground state energy of hydrogen atom is –13.6 eV. What are the kinetic and potential energies of the electron in this state? [Ans. 27.2 eV]

22. A hydrogen atom initially in the ground level absorbs a photon, which excites it to the n = 4 level. Determine the wavelength and frequency of photon. [Ans. 974.4Å]

23. (a) Using the Bohr's model, calculate the speed of the electron in a hydrogen atom in the n = 1, 2, and 3 levels. (b) Calculate the orbital period in each of these levels.
[Ans. 0.729×10^{6}m/s, 4.10×10^{-15}s]

24. The radius of the innermost electron orbit of a hydrogen atom is 5.3×10^{-11} m. What are the radii of the n = 2 and n =3 orbits? [Ans. 4.77×10^{-10}m]

25. In accordance with the Bohr's model, find the quantum number that characterizes the earth's revolution around the sun in an orbit of diameter 3×10^{11} m with orbital speed 3×10^{4} m/s. (Mass of earth = 6.0×10^{24} kg.) [Ans. 2.57×10^{74}]

26. The gravitational attraction amongst proton and electron in a hydrogen atom is weaker than the coulomb attraction by a component of around 10^{-40}. Another option method for taking a gander at this case is to assess the span of the first Bohr circle of a hydrogen

particle if the electron and proton were bound by gravitational attraction. You will discover the appropriate response fascinating. [Ans. 1.2×10^{29}m]

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27. Obtain an expression for the frequency of a radiation emitted when a hydrogen atom de-excites from level n to level (n – 1). For a large n, show that this frequency equals the classical frequency of revolution of the electron in the orbit.

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28. The total energy of an electron in the first excited state of the hydrogen atom is about -3.4 eV

(a) What is the kinetic energy of the electron in this state?

(b) What is the potential energy of the electron in this state?

(c) Which of the answers above would change if the choice of the zero of potential energy is changed?

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29. If Bohr's quantization postulate (angular momentum = $nh/2\pi$) is a basic law of nature, it should be equally valid for the case of planetary motion as well. Why then do we never speak of quantization of orbits of planets around the sun?

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30. Obtain the first Bohr's radius and the ground state energy of a muonic hydrogen atom [i.e., an atom in which a negatively charged muon ($\mu-$) of mass about 207me orbits around a proton].

31. Derive Rydberg's formula to derive the wavelength of spectral lines of hydrogen from n_1 orbit to n_2 orbit.

(5 Marks Questions)

32. (a) Draw the energy diagram showing the ground state, and the next few excited states for hydrogen (H) atom. Mark the transition, which corresponds of the emission of spectral lines for the Balmer series. (b) Calculate the wavelength of the first spectral line in this series.

33. State Bohr's postulates for atomic model. Derive the expression for total energy of an electron bound to hydrogen atom.

34. The electron in a given Bohr orbit has a total energy of – 1.5eV. Calculate its (i) kinetic energy (ii) potential energy and (iii) wavelength of light emitted, when the electron makes a transition to the ground state (Ground state energy = - 13.6eV).

35. Derive the expression for the radius of the ground state orbit of hydrogen atom, using Bohr's postulates. Calculate the frequency of the photon, which can excite the electron to – 3.4eV from – 13.6eV.

36. Using Bohr postulate derive the velocity of electron in nth orbit of hydrogen atom.

37. In the Auger process an atom makes a transition to a lower state without emitting a photon. The excess energy is transferred to an outer electron which may be ejected by the atom. (This is called an Auger electron). Assuming the nucleus to be massive, calculate the kinetic energy of an n = 4 Auger electron emitted by Chromium by absorbing the energy from a n = 2 to n = 1 transition.

C. CHALLENGING PROBLEMS

1. Choose a suitable solution to the given statements which justify the difference between Thomson's model and Rutherford's model
(a) In the case of scattering of alpha particles by a gold foil, average angle of deflection of alpha particles stated by Rutherford's model is (less than, almost the same as, much greater than) stated by Thomson's model.
(b) Is the likelihood of reverse scattering (i.e., dispersing of α-particles at points more prominent than 90°) anticipated by Thomson's model (considerably less, about the same, or much more prominent) than that anticipated by Rutherford's model?

(c) For a small thickness T, keeping other factors constant, it has been found that amount of alpha particles scattered at direct angles is proportional to T. This linear dependence implies?

(d) To calculate average angle of scattering of alpha particles by thin gold foil, which model states its wrong to skip multiple scattering?

2. Classify an electron can be in nay orbit around the nucleus of an atom. Then what determines the typical atomic size? Why is an atom not, say, thousand times bigger than its typical size? The question had greatly puzzled Bohr before he arrived at his famous model of the atom that you have learnt in the text. To stimulate what he might well have done before his discovery, let us play as follows with the dimensions of length that is roughly equal to the known size of an atom ($\approx 10^{-10}$ m)

(a) Construct a quantity with the dimensions of length from the fundamental constants e, m_e and c. Determine the numerical value.

(b) You will find that the length obtained in (a) in many orders of magnitude smaller than the atomic dimensions, Further, it involves c. But energies of atoms are mostly in non-realistic domain where c is not expected to play any role. That is why may have suggested Bohr to discard c and look for something else to get the right atomic size. Now, the Planck's constant h had already made its appearance elsewhere, Bohr's great insight lay in recognizing that h, m_e and e will yield the right atomic size. Construct the quantity with the dimension of length from h, m_e and e and confirm that its numerical value has indeed the correct order of magnitude.

SPACE FOR ROUGH WORK

SPACE FOR NOTES