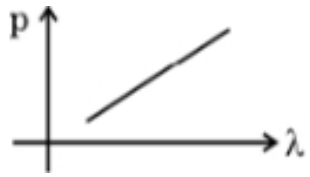
Class XII

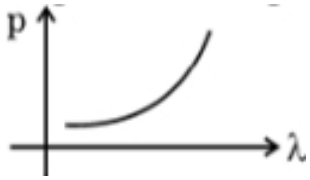
MODERN PHYSICS

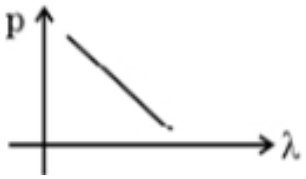
Class 12 - Physics

1. Which of the following graphs correctly represents the variation of a particle momentum with its associated de-Broglie wavelength? **[1]**

a) 

b) 

c) 

d) 

2. A photosensitive metallic surface has work function, $h\nu_0$. If photons of energy $2h\nu_0$ fall on this surface, the electrons come out with a maximum velocity of 4×10^6 m/s. When the photon energy is increased to $5h\nu_0$, then maximum velocity of photoelectrons will be **[1]**

a) 8×10^6 m/s

b) 2×10^6 m/s

c) 8×10^5 m/s

d) 2×10^7 m/s

3. If an electron accelerated from rest through a potential of 200 V acquires a speed of $8.4 \times 10^6 \mathrm{ms}^{-1}$, then its e/m is **[1]**

a) $1.96 \times 10^{11} \mathrm{Ckg}^{-1}$

b) $1.86 \times 10^{11} \mathrm{Ckg}^{-1}$

c) $1.76 \times 10^{11} \mathrm{Ckg}^{-1}$

d) $1.66 \times 10^{11} \mathrm{Ckg}^{-1}$

4. For photoelectric emission from certain metal, the cut-off frequency is ν. If radiation of frequency 2ν impinges on the metal plate, the maximum possible velocity of the emitted electron will be (m is the electron mass) **[1]**

a) $2\sqrt{\frac{h\nu}{m}}$

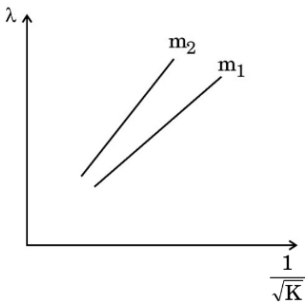
b) $\sqrt{\frac{h\nu}{(2m)}}$

c) $\sqrt{\frac{h\nu}{m}}$

d) $\sqrt{\frac{2h\nu}{m}}$

5. Show that the de Broglie wavelength λ of electrons of energy K is given by the relation: **[2]**
$\lambda = \frac{h}{\sqrt{2mK}}$.

6. de Broglie wavelength λ as a function of $\frac{1}{\sqrt{K}}$, for two particles of masses m_1 and m_2 are shown in the figure. **[2]**
Here, K is the energy of the moving particles.



a. What does the slope of a line represent?

b. Which of the two particles is heavier?

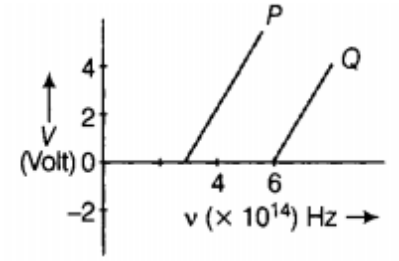
c. Is this graph also valid for a photon?

Justify your answer in each case.

7. A proton and an electron have same deBroglie wavelength. Which of them moves fast and which possesses more K.E? **[2]**

8. What two main observations in photoelectricity led Einstein to suggest the photon theory for the interaction of light with the free electron in metal? Obtain an expression for threshold frequency for photoelectric emission in terms of the work function of the metal. **[2]**

9. In the study of a photoelectric effect, the graph between the stopping potential V and frequency ν of the incident radiation on two different metals P and Q is shown below. **[3]**



i. Which one of the two metals has higher threshold frequency?

ii. Determine the work function of the metal which has greater value.

10. Radiation of frequency 10^{15} Hz is incident on three photo-sensitive surfaces A, B and C. **[3]**
Following observations are recorded:
Surface A: No photo-emission occurs.
Surface B: Photo-emission occurs but the photoelectrons have zero kinetic energy.
Surface C: Photo-emission occurs and photoelectrons have some K.E.
Based on Einstein's photo-electric equation, explain the three observations.

11. a. What is photoelectric effect? **[3]**

b. Using the photon picture of light, show how Einstein's photoelectric equation can be established.

c. What is the photo-electric effect? Write Einstein's photoelectric equation. Explain how it enables us to understand the

i. linear dependence, of the maximum kinetic energy of the emitted electrons, on the frequency of the incident radiation.

ii. existence of a threshold frequency for a given photoemitter.

iii. independence of the maximum energy of emitted photo-electrons from the intensity of incident light.

12. A proton is accelerated through a potential difference V. After acceleration, the de Broglie wavelength associated with it is λ. If the proton is replaced by an alpha particle, then find the de Broglie wavelength associated with it if it were accelerated through the same potential difference V. What will be the momentum of the alpha particle? **[3]**

13. a. Write three observed features of photoelectric effect which cannot be explained by wave theory of light. **[5]**

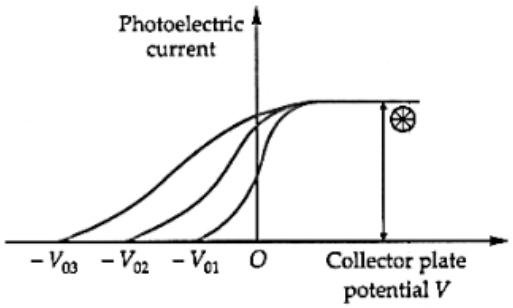
Explain how Einstein's photoelectric equation is used to describe these features satisfactorily.

b. The graphs, drawn here, are for the phenomenon of photoelectric effect.

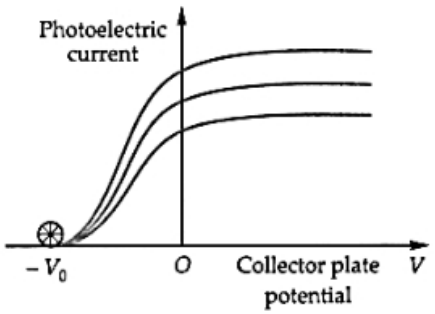
i. Identify which of the two characteristics (intensity/frequency) of incident light, is being kept constant in each case.

ii. Name the quantity, corresponding to the, mark, in each case.

Graph 1



Graph 2



iii. Justify the existence of a **threshold frequency** for a given photosensitive surface.

14. The impact parameter for an alpha particle approaching a target nucleus is maximum when the scattering angle (θ) is: **[1]**

a) 90^o b) 45^o

c) 180^o d) 0^o

15. Find the longest wavelength present in the Balmer series of hydrogen, corresponding to the H - line. **[1]**

a) 666 nm b) 656 nm

c) 686 nm d) 676 nm

16. In the following transitions of the hydrogen atom, the one which gives an absorption line of highest frequency is **[1]**

a) n = 1 to n = 2 b) n = 2 to n = 1

c) n = 3 to n = 8 d) n = 8 to n = 3

17. The energy of the electron revolving in the orbit of Bohr radius is **[1]**

a) 13.6 MeV b) -13.6 eV

c) -13.6 MeV d) 13.6 eV

18. According the Bohr principle, the relation between principle quantum number (n) and radius of orbit is **[1]**

a) $r \propto n$ b) $r \propto 1/n$

c) $r \propto 1/n^2$ d) $r \propto n^2$

19. Name the series of hydrogen spectrum lying in the ultraviolet region. **[1]**

20. State Bohr's quantisation condition in terms of de-Broglie wavelength. **[1]**

21. Write the expression for Bohr's radius in hydrogen atom. **[1]**

22. What is the maximum number of spectral lines emitted by a hydrogen atom when it is in the fourth excited state? **[1]**

23. For a given impact parameter b, does the angle of deflection increase or decrease with increase in energy? **[1]**

24. Monochromatic radiation of wavelength 975 $\overset{o}{A}$ excites the hydrogen atom from its ground state to a higher state. How many different spectral lines are possible in the resulting spectrum? Which transition corresponds to the longest wavelength amongst them. **[2]**

25. Consider two different hydrogen atoms. The electron in each atom is in an excited state possible for the electrons to have different energies, but the same orbital angular momentum according to the Bohr model? **[2]**

26. Using Bohr's atomic model, derive the expression for the velocity of electron revolving in the n^{th} orbit of hydrogen atom. **[2]**

27. Use Bohr's model of hydrogen atom to obtain the relationship between the angular momentum and the magnetic moment of the revolving electron. **[2]**

28. Define ionization energy. How would the ionization energy change when electron in hydrogen atom is replaced by a particle of mas 200 times that of the electron but having the same charge? **[2]**

29. Use Bohr's postulates to derive the expressions for the potential and kinetic energy of the electron moving in the n^{th} orbit of the hydrogen atom. How is the total energy of the electron expressed in terms of its kinetic and potential energies? **[3]**

30. a. In Geiger-Marsden experiment, calculate the distance of closest approach for an alpha particle with energy 2.56×10^{-12} J. Consider that the particle approaches gold nucleus (Z = 79) in head-on position. **[3]**
    b. If the above experiment is repeated with a proton of the same energy, then what will be the value of the distance of closest approach?

31. a. Draw the graph of radius of orbit (r_n) in hydrogen atom as a function of orbit number (n). **[3]**
    b. In a hydrogen atom, find the ratio of the time taken by the electron to complete one revolution in the first excited and in the second excited states.

32. Define the term - Distance of closest approach. How will it be affected, for an α-particle, if kinetic energy of the particle is doubled? **[3]**

33. What do you mean by wave nature of an electron? How was quantisation of angular momentum of the orbiting electron in Bohr's model of hydrogen atom explained by de Broglie hypothesis? **[3]**

34. The gravitational attraction between electron and proton in a hydrogen atom is weaker than the Coulomb attraction by a factor of about 10^{-40}. An alternative way of looking at this fact is to estimate the radius of the first Bohr orbit of a hydrogen atom if the electron and proton were bound by gravitational attraction. You will find the answer interesting. **[5]**

35. Graphite and heavy water are two common moderators used in a nuclear reactor. The function of the moderator is **[1]**

    a) to absorb the neutrons and stop the chain reaction
    b) to slow down the neutrons to thermal energies
    c) to control the energy released in the reactor
    d) to cool the reactor

36. Only proton contributes positive charge for the nucleus as: **[1]**

    a) charge on neutrons balanced with charge on electrons
    b) positive charge on neutrons discharges

c) neutrons are not present inside the nucleus d) neutrons are electrically neutral entities

37. If M_o is the mass of an oxygen isotope ${}_8O^{17}$, M_p and M_n are the masses of a proton and neutron respectively, the nuclear binding energy of the isotope is: **[1]**

a) $(8\ M_p + 9\ M_n - M_o)\ c^2$ b) $(M_o - 8\ M_p)\ c^2$

c) $(M_o - 17\ M_n)\ c^2$ d) $(M_o - 8\ M_p - 9\ M_n)\ c^2$

38. The order of magnitude of density of uranium nucleus ($m_p = 1.67 \times 10^{-27}$ kg) is **[1]**

a) 10^{11} kg m^{-3} b) 10^{17} kg m^{-3}

c) 10^{14} kg m^{-3} d) 10^{20} kg m^{-3}

39. The mass density of a nucleus of mass number A is: **[1]**

a) proportional to A^3 b) independent of A

c) proportional to $A^{1/3}$ d) proportional to $A^{2/3}$

40. What is nuclear fusion? Explain, how such a large amount of energy is produced inside the sun through proton-proton cycle and carbon-carbon cycle. **[1]**

41. What is nuclear energy? **[1]**

42. What do you mean by the charge independent character of nuclear forces? **[1]**

43. Draw a graph showing the variation of potential energy of a pair of nucleons as a function of their separation. Indicate the region in which the nuclear force is (a) attractive and (b) repulsive. **[1]**

44. Why is nuclear fusion difficult to carry out? **[1]**

45. In the deuterium tritium fusion reaction find the rate at which deuterium and tritium are consumed to produce 1 MW. The Q-value of deuterium tritium reaction is 17.6 MeV. You can assume that the efficiency is 100%. **[2]**

46. i. Distinguish between nuclear fission and fusion giving an example of each. **[2]**
ii. Explain the release of energy in nuclear fission and fusion on the basis of binding energy per nucleon curve.

47. A nucleus makes a transition from one permitted energy level to another level of lower energy. Name the region of the electromagnetic spectrum to which the emitted photon belongs. What is the order of its energy in electron volts? Write four characteristics of nuclear forces. **[2]**

48. Define the terms: nucleons, atomic number, mass number, nuclear mass and nuclide, in relation to a nucleus. **[2]**

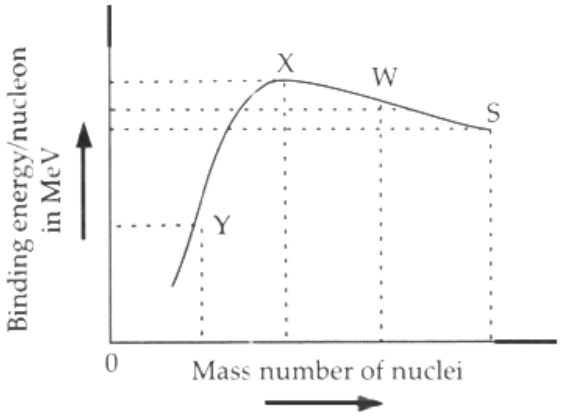
49. Draw a plot of the binding energy per nucleon as a function of mass number for a large number of nuclei. Explain the energy release in the process of nuclear fission from the above plot. Write a typical nuclear reaction in which a large amount of energy is released in the process of nuclear fission. **[2]**

50. Define the terms (i) mass defect (ii) binding energy for a nucleus and state the relation between the two for a given nuclear reaction for which the B.E. / nucleon of the product nucleus/nuclei is more than that for the original nucleus/nuclei. Is this nuclear reaction exothermic or endothermic in nature? Justify your choice. **[3]**

51. How are protons, which are positively charged, held together inside a nucleus? Explain the variation of the potential energy of a pair of nucleons as a function of their separation. State the significance of negative potential energy in this region? **[3]**

52. Draw a graph showing the variation of binding energy per nucleon with mass number of different nuclei. Write any two salient features of the curve. How does this curve explain the release of energy both in the processes of nuclear fission and fusion? **[3]**

53. Binding energy per nucleon versus mass number curve is as shown. ${}^{A}_{Z}S$, ${}^{A1}_{Z1}W$, ${}^{A2}_{Z2}X$, and ${}^{A3}_{Z3}Y$ are four nuclei indicated on the curve. **[3]**



Based on the graph:

i. Arrange X, W, and S in the increasing order of stability.

ii. Write the relation between the relevant A and Z values for the following nuclear reaction. S $\rightarrow$ X + W

iii. Explain why binding energy for heavy nuclei is low.

54. Obtain the binding energy of the nuclei ${}^{56}_{26}Fe$ and ${}^{209}_{83}Bi$ in units of MeV from the following data: **[3]**

m (${}^{56}_{26}Fe$) = 55.934939 u

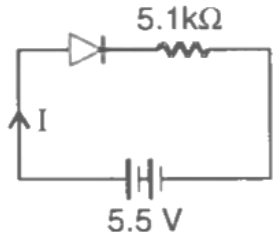
m (${}^{209}_{83}Bi$) = 208.980388 u

55. Differentiate between nuclear fission and nuclear fusion. Which one of these processes produces energy **[5]**

i. in nuclear reactor and

ii. in the sun

56. A p-n junction diode is connected to a battery of emf 5.5 V and external resistance 5.1 kΩ. The barrier potential in the diode is 0.4 V. The current in the circuit is: **[1]**



a) 1 mA

b) 1.08 mA

c) 0.08 mA

d) 1 A

57. In case of diamond, the forbidden gap is about **[1]**

a) 1.2 eV

b) 0.8 eV

c) 6.0 eV

d) 8.2 eV

58. In a semiconductor the forbidden energy gap between the valence band and the conduction band is of the order of: **[1]**

a) 5 eV

b) 1 eV

c) 1 MeV

d) 1 KeV

59. Drift current in a p-n junction is due to **[1]**

a) charge not carriers density

b) electric field

c) collision of electrons

d) charge carriers density

60. For forward biasing a p-n junction, the positive terminal of the battery is connected to **[1]**

a) n-type crystal
b) either p-type or n-type crystal
c) p-type crystal
d) neither p-type nor n-type crystal

61. Name two intrinsic semiconductors. **[1]**

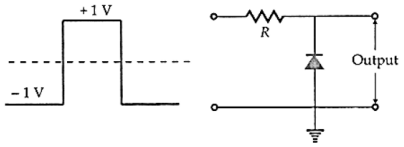
62. Why is p-type semiconductor so called? **[1]**

63. Is there any hole in an n-type semiconductor? **[1]**

64. What is the difference between an n-type and a p-type extrinsic semiconductor? **[1]**

65. When a p-n junction diode is forward biased, how will its barrier potential be affected? **[1]**

66. A square wave (-1V to 1V) is applied to the p-n junction diode as shown below. Draw the output waveform. **[2]**



67. On the basis of energy band diagrams, distinguish between (i) an insulator, (ii) a semiconductor, and (iii) a conductor. **[2]**

68. n-type semiconductor has large number of electrons but still it is electrically neutral. Explain. **[2]**

69. Give two differences between a half-wave rectifier and a full-wave rectifier. **[2]**

70. Name the type of bias that results in very high resistance of a p-n junction diode. In the given circuit, a voltmeter **V** is connected across bulb **B**. What changes would occur in bulb **B** and voltmeter **V**, if the resistor **R** is increased in value? Give reason for your answer. **[2]**

71. Write any two distinguishing features between conductors, semiconductors and insulators on the basis of energy band diagrams. **[3]**

72. Draw the circuit diagram of a full wave rectifier. Explain its working showing its input and output waveforms. **[3]**

73. a. Why is an intrinsic semiconductor deliberately converted into an extrinsic semiconductor by adding impurity atoms? **[3]**
    b. Explain briefly the two processes that occur in p-n junction region to create a potential barrier.

74. Explain with the help of a diagram, how a depletion layer and barrier potential are formed in a junction diode. **[3]**

75. a. Explain the formation of a p-n junction. **[3]**
    b. Can we take one slab of p-type semiconductor and physically join it to another n-type semiconductor to get a p-n junction? Explain.