DAY THIRTY SEVEN

Unit Test 7

(Modern Physics)

1 The wavelength of incident light falling on a photosensitive surface is charged from 2000 Å to 2100 Å the corresponding change in stopping potential is

(a) 0.03 V (b) 0.3 V
(c) 3 V (d) 3.3 V

2 Ultraviolet light of wavelength 350 nm and intensity 1.00 Wm^{-2} is incident on a potassium surface. If 0.5% of the photons participate in ejecting the photoelectrons, how many photoelectrons, are emitted per second, if the potassium surface has an area of $1\,cm^2$?

(a) 1.76×10^{18} photoelectrons/s
(b) 1.76×10^{14} photoelectrons/s
(c) 8.8×10^{11} photoelectrons/s
(d) The value of work function is required to complete the value of emitted photoelectrons/s

3 Electric field of an electromagnetic wave in vacuum is;

$$E = \left(3.1\,\frac{N}{C}\right).\cos\left[\left(1.8\,\frac{rad}{m}\right)y + \left(5.4\times10^{8}\,\frac{rad}{s}\right).t\right]\hat{i}$$

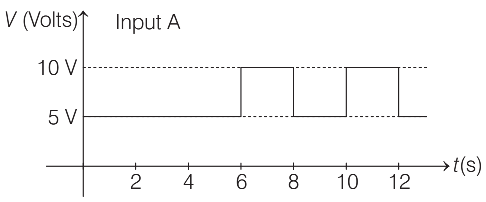
Wavelength of this wave as it passes through a medium of refractive index $\frac{3}{2}$ will be

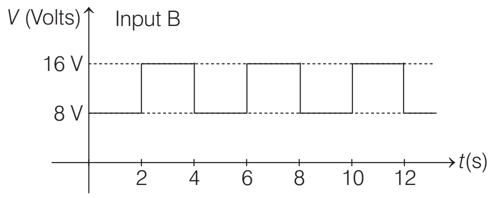
(a) 3.55 m (b) 2.33 m
(c) 1.44 m (d) 3.22 m

4 Taking the Bohr radius as $a_0 = 53$ pm, the radius of Li^{++} ion in its ground state, on the basis of Bohr's model, will be about

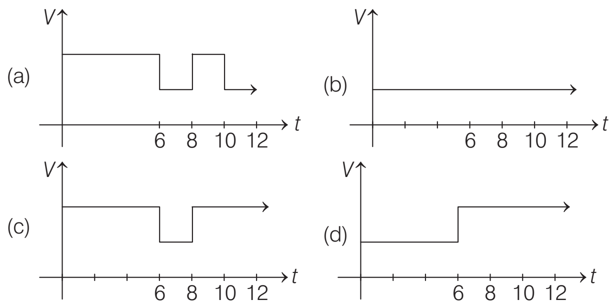
(a) 53 pm (b) 27 pm (c) 18 pm (d) 13 pm

5 Consider inputs A and B;





Output of a NAND gate on these inputs will be



6 A neutron collides with a hydrogen atom in its ground state and excites it to $n = 3$. The energy given to hydrogen atom in this inelastic collision is (Neglect the recoiling of hydrogen atom and assume that energy is not absorbed as KE of H-atom)

(a) 10.2 eV (b) 12.1 eV (c) 12.5 eV (d) None of these

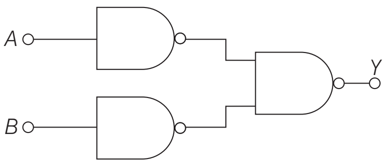
7 An X-ray tube operates at 50 kV. Consider that at each collision, an electron converts 50% of its energy into photons and 10% energy would be dissipated as thermal energy due to the collision then the wavelength of emitted by photons during 2nd collision is
(Take, $hc = 1242$ eV-nm)

(a) 1.242 nm (b) 1.242 Å (c) 4.968 nm (d) 4.968 Å

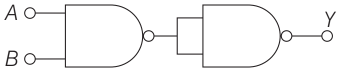
8 For the nuclear reaction, $_{88}Ra^{226} \longrightarrow {}_{86}Rn^{222} + {}_{2}He^{4}$ the radium nucleus is initially at rest and the alpha particle carries the energy 5.3 MeV. The energy released in the reaction is

(a) 5.4 MeV (b) 5.0 MeV (c) 300 MeV (d) 286 MeV

9 The combinations (M) and (N) of the NAND gates are as shown below.



(M)



(N)

The output (Y) of (M) and (N) are equivalent to the output of

(a) OR gate and AND gate respectively
(b) AND gate and NOT gate respectively
(c) AND gate and OR gate respectively
(d) OR gate and NOT gate respectively

10 The binding energy of a H-atom, considering an electron moving around a fixed nuclei (proton), is $B = -\frac{me^4}{4n^2\varepsilon_0^2 h^2}$

(m = electron mass).
If one decides to work in a frame of reference where the electron is at rest, the proton would be moving around it. By similar arguments, the binding energy would be

$B = \frac{Me^4}{8n^2\varepsilon_0^2 h^2}$ = (M = proton mass)

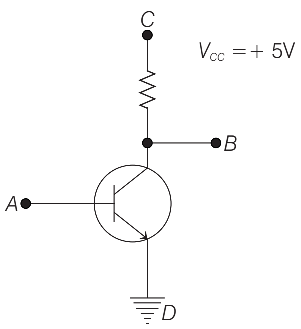
This last expression is not correct because

(a) n would not be integral
(b) Bohr-quantisation applies only to electron
(c) the frame in which the electron is at rest is non-inertial
(d) the motion of the proton would not be in circular orbits, even approximately

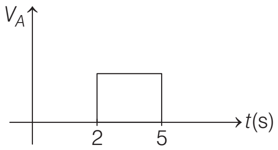
11 Light strikes a sodium surface, causing photoelectric emission. The stopping potential for the ejected electrons is 5.0 V, and the work function of sodium is 2.2 eV. What is the wavelength of the incident light?

(a) 100 nm (b) 170 nm
(c) 150 nm (d) 200 nm

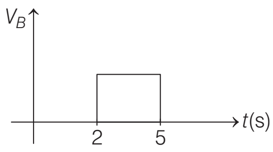
12 Consider a given circuit

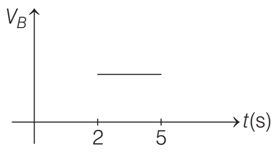


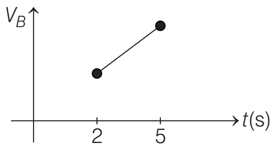
Point C is kept at a constant voltage of 5 V and point D is earthed. If input given at A is

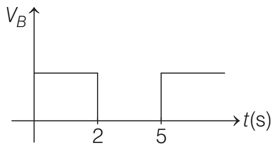


Then output obtained at B is

(a)


(b)


(c)


(d)


13 The simple Bohr's 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

14 An electron is trapped in a one dimensional infinite well of width 250 pm and is in its ground state. What is the longest wavelengths of light that can excite the electron from the ground state *via* a single photon absorption?

(a) $\lambda = \frac{4mL^2c}{h(n_i^2 - n_f^2)}$ (b) $\lambda = \frac{2mLc}{h(n_f^2 - n_i^2)}$

(c) $\lambda = \frac{8mL^2c}{h(n_f^2 - n_i^2)}$ (d) $\lambda = \frac{8mL}{h(n_f^2 - n_i^2)}$

15 What is the ratio of the shortest wavelength of the Balmer series to the shortest wavelength of the Lyman series?

(a) 1 : 4 (b) 2 : 4
(c) 4 : 1 (d) 1 : 1

16 In the ground state of the hydrogen atom, the electron has a total energy of –13.6 eV, its kinetic energy is

(a) 12.5 eV (b) 13.6 eV
(c) 14.9 eV (d) –27.2 eV

17 A particle of mass m at rest decays into two particles of m_1 and m_2 having non-zero velocities. The ratio of de-Broglie wavelengths of particles λ_1/λ_2 is

(a) $\frac{m_1}{m_2}$ (b) $\frac{m_2}{m_1}$ (c) 1 (d) $\sqrt{m_2/m_1}$

18 If there are 2 bulbs of same power, one of them gives red colour light, while other gives blue colour light.

If n_r and n_b are the number of photons per unit time emitted by bulbs, then choose correct option;
(r : red; b : blue)

(a) $n_r = n_b$ (b) $n_r < n_b$ (c) $n_r > n_b$ (d) $n_r \cdot n_b = c^2$

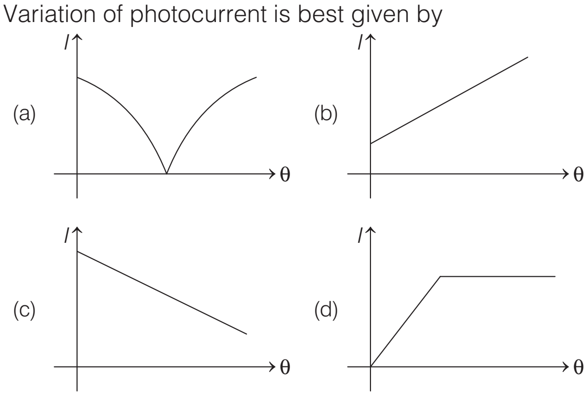
19 An α-particle makes an elastic head-on collision with a proton initially at rest.

Ratio of de-Broglie wavelength associated with α-particle and proton after collision will be

(a) 2 : 1 (b) 4 : 3 (c) 1 : 2 (d) 2 : 3

20 A beam of light is allowed to fall over cathode of a photocell after passing through two polaroids. None of the polaroid is rotated keeping other fixed.

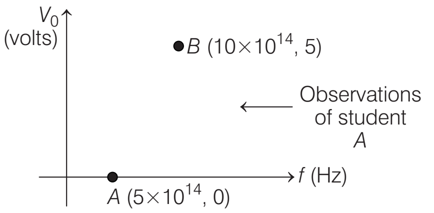
Variation of photocurrent is best given by

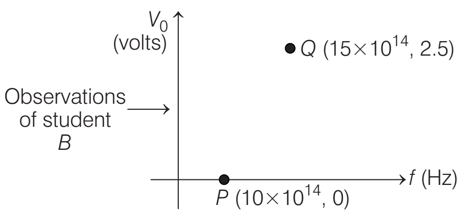


21 Two particles A_1 and A_2 of masses m_1, m_2 ($m_1 < m_2$) have the same de-Broglie wavelength. Then

(a) then masses are the same
(b) thin energies are the same
(c) energy of A_1 is less than the energy of A_2
(d) energy of A_1 is more than the energy of A_2

22 Two students makes observations of stopping potentials (V_0) and frequencies (f) and plotted their observations graphically as shown below





Now, choose the correct option;

(a) Both students gives accurate observation
(b) Readings of A are correct
(c) Readings of B are correct
(d) Reading of Both A and B are incorrect

23 Let potential energy of electron in Bohr's first orbit of hydrogen atom is zero.

Then, total energy of electron in IInd orbit is

(a) 23.80 eV (b) 27.20 eV (c) 13.6 eV (d) 26.25 eV

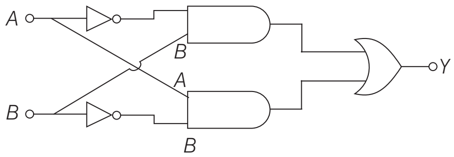
24 Consider the process;

$$^{232}_{92}\text{U} \longrightarrow \, ^{228}_{90}\text{Th} + \, ^{4}_{2}\text{He}$$

Energy released in above process is 5.40 MeV. If this energy remains mainly with 'α' and daughter nucleus then, kinetic energy of $^{228}_{90}$Th, nucleus will be

(a) 5.4 MeV (b) 5.3 MeV (c) 0.1 MeV (d) 0.4 MeV

25 The following circuit represents



(a) OR gate (b) XOR gate (c) AND gate (d) NAND gate

26 Let a sample of a radioactive substance contains N_0 number of active nuclei at $t = 0$. Then, probability that a randomly choosen nucleus is disintegrated in time t is

(a) $1 - e^{-\lambda t}$ (b) $N_0 e^{-\lambda t}$ (c) $\dfrac{e^{-\lambda t}}{N_0}$ (d) $e^{-\lambda t}$

27 Match Column I and Column II and mark correct option.

	Column I		Column II
A.	α-decay	p.	Large nucleus.
B.	β^+decay	q.	More neutrons in nucleus.
C.	β^-decay	r.	More protons in nucleus.
D.	γ - decay	s.	More energy in nucleus.
E.	k - capture	t.	Proton number is more than 83 in nucleus.

	A	B	C	D	E
(a)	p	q	r	s	t
(b)	p,t	r,t	q,t	s	r,t
(c)	p	t	q	s	r
(d)	t	s	r	q	p

28 On a particular day, the maximum frequency reflected from the ionosphere is 10 MHz. On another day, it was found to decrease to 8 MHz. What is the ratio of the maximum electron densities of the ionosphere on the two days?

(a) 20 : 10 (b) 30 : 15 (c) 25 : 16 (d) 24 : 11

29 A transmitting antenna at the top of a tower has a height 32 m and that of the receiving antenna is 50 m. What is the maximum distance between them for satisfactory communication in line of sight mode? Given radius of the earth 6.4×10^6m.

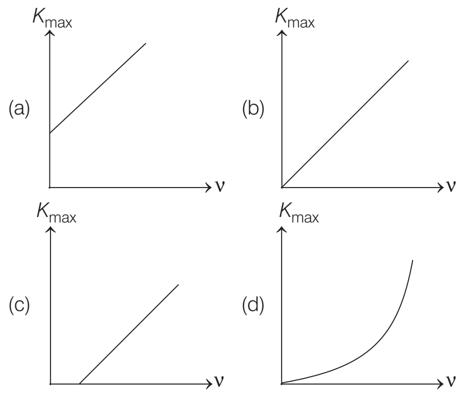
(a) 50.0 km (b) 45.5 km (c) 35.5 km (d) 30.2 km

Direction (Q. Nos. 30-31) *According to Einstein, when a photon or light of frequency* ν *or wavelength* λ *is incident on photosensitive metal surface of work function* ϕ_0, *where* $\phi_0 < h\nu$ *(here h is planck's constant) then the emission of photoelectrons takes place. The maximum kinetic energy of the emitted photoelectrons is given by* $K_{max} = h\nu - \phi_0$ *If the frequency of the incident light is* ν_0 *called threshold frequency. The photoelectrons are emitted from metal without any kinetic energy. So* $h\nu_0 = \phi_0$

30 Stopping potential of emitted photoelectron is given by

(a) $\frac{h\nu - \phi_0}{e}$ (b) $h\nu - \phi_0$ (c) $\frac{h\nu}{e}$ (d) $\frac{\phi_0 + h\nu}{e}$

31 The variation of maximum kinetic energy (K_{max}) of the emitted photoelectrons with frequency (ν) of the incident radiations can be represented by



32 Frequencies higher than 10 MHz are found not to be reflected by the ionosphere on a particular day at a place. What is the maximum electron density of the ionosphere?

(a) $\frac{10^{14}}{9}$ em^{-3} (b) 10^{14} em^{-3}

(c) $\frac{10^{14}}{81}$ em^{-3} (d) $\frac{10^{14}}{7}$ em^{-3}

Direction (Q. Nos. 33-35) *Each of these questions contains two statements : Statement* I *and Statement* II. *Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c), (d) given below*

(a) Statement I is true, Statement II is true; Statement II is the correct explanation for Statement I

(b) Statement I is true, Statement II is true; Statement II is not the correct explanation for Statement I

(c) Statement I is true; Statement II is false

(d) Statement I is false; Statement II is true

33 **Statement I** As intensity of incident light (in photoelectric effect) increases, the number of photoelectrons emitted per unit time increases.

Statement II More intensity of light means more energy per unit area per unit time.

34 **Statement I** Targets in X-ray tubes are made from high melting point metals.

Statement II Most of the energy of striking electrons is lost into collisions which simply appears as thermal energy.

35 **Statement I** The different lines of emission spectra (like Lyman, Balmer etc) of atomic hydrogen gas are produced by different atoms.

Statement II The sample of atomic hydrogen gas consists of millions of atoms.

Direction (Q. Nos. 36-37) *A beam of light has three wavelengths* 440 nm, 495 nm *and* 660 nm *with a total intensity of* 3.24×10^{-3} Wm^{-2} *equally distributed amongst the three wavelengths. The beam falls normally on an area of* 1.0 cm^2 *of a clean metallic surface of work function* 2.2 eV. *Assume that there is no loss of light by reflection and each energetically capable photon ejects one electron and take,* $h = 6.6 \times 10^{-34}$ J-s.

36 Photoelectric emission is caused by

(a) light of wavelength 440 nm alone
(b) light of wavelength 660 nm alone
(c) lights of wavelengths 440 nm and 495 nm
(d) lights of wavelengths 495 nm and 660 nm

37 The incident energy (in Js^{-1}) of each wavelength is

(a) 3.24×10^{-7} (b) 1.62×10^{-7}
(c) 1.08×10^{-7} (d) 0.81×10^{-7}

Direction (Q. Nos. 38-40) *Carbon-14 (symbol* $^{14}_{6}C$*) is produced by the bombardment of atmospheric nitrogen with high energy neutrons according to the equation.*

$$^{14}_{7}N + ^{1}_{0}n \longrightarrow ^{14}_{6}C + ^{1}_{1}H$$

Radiocarbon is unstable and decays to nitrogen with a half-life of 5600 *yr. The carbon-14 is incorporated into atmospheric carbon dioxide molecules which are taken in by plants when they breathe in carbon dioxide. Animals which eat the plants also take in carbon-14. By measuring the ratio of the concentration of* ^{14}C *to* ^{12}C *in any ancient organism, say a tree, one can determine the date when the organism died.*

38 A capsule contains 8 g of $^{14}_{6}C$ whose half-life is 5600 yr. After 16800 yr, the amount of $^{14}_{6}C$ left in the capsule will be

(a) 4 g (b) 2 g (c) $\frac{8}{3}$ g (d) 1 g

39 Radiocarbon is produced in the atmosphere as a result of

(a) collisions between fast neutrons and nitrogen nuclei
(b) the action of cosmic rays on atmospheric oxygen
(c) the action of X-rays on carbon
(d) lighting discharge in atmosphere

40 Choose the only incorrect statement. In radioactive decay of an element

(a) α-particles may be emitted
(b) β-particles may be emitted
(c) γ-rays may be emitted
(d) the nucleus does not undergo any change

ANSWERS

1. (b)	**2.** (c)	**3.** (b)	**4.** (c)	**5.** (a)	**6.** (b)	**7.** (b)	**8.** (a)	**9.** (a)	**10.** (c)
11. (b)	**12.** (d)	**13.** (a)	**14.** (c)	**15.** (c)	**16.** (d)	**17.** (c)	**18.** (c)	**19.** (d)	**20.** (a)
21. (d)	**22.** (d)	**23.** (a)	**24.** (c)	**25.** (c)	**26.** (a)	**27.** (b)	**28.** (c)	**29.** (b)	**30.** (a)
31. (c)	**32.** (c)	**33.** (b)	**34.** (a)	**35.** (d)	**36.** (c)	**37.** (c)	**38.** (d)	**39.** (a)	**40.** (d)

Hints and Explanations

1 Given, $\lambda_1 = 2000\text{Å} = 2\times10^{-7}\,\text{m}$

$\lambda_2 = 2100\text{Å} = 2.1\times10^{-7}\,\text{m}$

$$\frac{hc}{\lambda_1} = W + eV_1 \quad \ldots\text{(i)}$$

$$\frac{hc}{\lambda_2} = W + eV_2 \quad \ldots\text{(ii)}$$

Subtracting Eq. (ii) from Eq. (i)

$$hc\left(\frac{1}{\lambda_1}-\frac{1}{\lambda_2}\right) = e(V_1 - V_2)$$

Change in stopping potential,

$$\Delta V = V_1 - V_2 = \frac{hc}{e}\left(\frac{1}{\lambda_1}-\frac{1}{\lambda_2}\right)$$

$$= \frac{6.6\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}}\left(\frac{1}{2\times10^{-7}}-\frac{1}{2.1\times10^{-7}}\right)$$

$$= \frac{6.6\times3\times0.1}{1.6\times2\times2.1}\,\text{V} = 0.3\,\text{V}$$

2 Energy of photon

$$E = \frac{hc}{\lambda} = \frac{1242}{350}\,\text{eV} = 3.55\,\text{eV}$$

$$= 5.68\times10^{-19}\,\text{J}$$

Let n photons, per unit area per unit time are reaching the potassium surface, then

$$n = \frac{1.00}{5.68\times10^{-19}} = 1.76\times10^{18}$$

So, number of photons received by potassium surface per unit time is,

$n\times$ Area of potassium surface

$= 1.76\times10^{18}\times1\times10^{-4} = 1.76\times10^{14}$

Required number of photoelectrons emitted per unit time

$$= 1.76\times10^{14}\times\frac{0.5}{100} = 8.8\times10^{11}$$

3 Phase of wave is '$ky + \omega t$',

So, $\quad k = 1.8$ or $\dfrac{2\pi}{\lambda} = 1.8$

$$\Rightarrow \quad \lambda_1 = \frac{2\pi}{1.8}$$

When this wave passes through a medium of refractive index, $\frac{3}{2}$; its wavelength will be

$$\lambda_2 = \frac{\lambda_1}{n} = \frac{2\pi/1.8}{3/2} = \frac{2}{3}\times2\times\frac{22}{7}\times\frac{10}{18}$$

$$= 2.33\,\text{m}$$

4 On the basis of Bohr's model,

$$r = \frac{n^2h^2}{4\pi^2 mKZe^2} = a_0\frac{n^2}{Z}$$

For Li^{++} ion, $Z = 3$; $n = 1$ for ground state.

Given, $a_0 = 53$ pm

$$\therefore \quad r = \frac{53\times1^2}{3} = 18\,\text{pm}$$

5 For a NAND gate, output is

A	B	Y
0	0	1
1	0	1
0	1	1
1	1	0

So, output waveform is like option (a).

6 The energy taken by hydrogen atom corresponds to its transition from $n = 1$ to $n = 3$ state.

ΔE (given to hydrogen atom)

$$= 13.6\left(1-\frac{1}{9}\right) = 13.6\times\frac{8}{9} = 12.1\,\text{eV}$$

7 During first collision, Initial energy of electron = 50 keV

Energy appearing as photon

= 50% of 50 keV = 25 keV

Energy lost in collision

= 10% of 50 keV = 5 keV

Energy left for second collision

= (50 − 25 − 5) keV = 20 keV

For second collision, Initial energy

= 20 keV

Energy of the emitted photon

= 50% of 20 keV = 10000 eV

So, required wavelength, $\lambda = \dfrac{1242}{10000}\,\text{nm}$

$= 1.242$ Å

8 As parent nucleus is at rest and emitted particle (α) carries some energy, daughter nucleus (Rn) recoils to conserve the momentum.

The energy released in the reaction appears in the form of kinetic energy of α-particle and the daughter nucleus.

$$Q = K_\alpha + K_D$$

From momentum conservation,

$$p_\alpha = p_D$$

Solving above equation, we have

$$K_\alpha = \frac{M_D}{M_D + M_\alpha}\times Q$$

$$\Rightarrow \quad Q = \frac{M_D + M_\alpha}{M_D}\times K_\alpha$$

$$= \frac{222+4}{222}\times5.3$$

$$= 5.4\,\text{MeV}$$

9 It follows from the logic symbol (A) that

$X = \overline{\overline{A}\,\overline{B}}$

for which the truth table is as follows

A	B	$\overline{A}$	$\overline{B}$	$\overline{A}\cdot\overline{B}$	$X = \overline{\overline{A}\,\overline{B}}$
0	0	1	1	1	0
1	0	0	1	0	1
0	1	1	0	0	1
1	1	0	0	0	1

This truth table satisfies the Boolean expression $X = A + B$, which is the OR gate. Hence, the logic symbol (A) is equivalent to an OR gate. It follows from logic symbol (B) that

$$X = \overline{\overline{A\cdot B}} = A\cdot B$$

which is the Boolean expression for AND gate.

10 If electron is considered at rest, then photons are accelerating around COM of system. Thus, with respect to COM electrons are also accelerating and hence frame is non-inertial.

11 The energy of an incident photon $E = hf = hc/\lambda$, kinetic energy of the most energetic electron emitted $K_m = E - \phi = (hc/\lambda) - \phi, eV_0$ is related to kinetic energy by $eV_0 = K_m$,

so, $eV_0 = (hc/\lambda) - \phi$ and

$$\lambda = \frac{hc}{eV_0 + \phi}$$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{5 \times 1.6 \times 10^{-19} + 2.2 \times 1.6 \times 10^{-19}}$$

$$= 171.8 \times 10^{-9} \text{ m}$$

$$= 171.8 \text{ nm}$$

$$\approx 170 \text{ nm}$$

12 Given circuit is a transistorized 'NOT' gate. When A is made positive, transistor is ON and it draws maximum current to collector.

So, $V_B = 0$ for the time A remains positive.

14 Energy levels are $E_n = n^2 h^2 8/mL^2$,

$f = \Delta E/h = (h/8mL^2)(n_f^2 - n_i^2)$ and the wavelength of the light is

$$\lambda = \frac{c}{f} = \frac{8mL^2 c}{h(n_f^2 - n_i^2)}$$

15 The energy E of the photon emitted

$$E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Frequency f of the electromagnetic wave $f = E/h$ and the wavelength $\lambda = c/f$.

Thus, $\dfrac{1}{\lambda} = \dfrac{f}{c} = \dfrac{E}{hc}$

$$= \frac{13.6}{hc}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

For which $n_2 = \infty$. For the Balmer series, $n_1 = 2$ and the shortest wavelength is $\lambda_B = 4hc/13.6$. For the Lyman series, $n_1 = 1$ and the shortest wavelength is $\lambda_L = hc/13.6$. The ratio is $\lambda_B/\lambda_L = 4$

17 Initial momentum = 0

$\therefore$ Final momentum = 0

$$\mathbf{p} + \mathbf{p} = 0$$

$$p_1 = p_2 \quad \text{(numerically)}$$

$$\lambda = \frac{h}{p} \propto \frac{1}{p}$$

$$\Rightarrow \quad \frac{\lambda_1}{\lambda_2} = \frac{p_2}{p_1} = 1$$

18 Power, $P = \dfrac{\text{Energy radiated}}{\text{time}}$

So, number of photons,

$$n = \frac{E}{hf \times \Delta t} = \frac{P}{hf}$$

As, $f_{\text{blue}} > f_{\text{red}}$

$\Rightarrow \quad n_{\text{red}} > n_{\text{blue}}$

19 Let initial speed of α is v_0 and final speeds of α and proton are v_α and v_p. Then, momentum conservation gives

$$4m_p v_i = 4m_p v_\alpha + m_p v_p \quad \{\because m_\alpha = 4m_p\}$$

Also, $e = 1$; elastic collision

$\Rightarrow \quad v_i - 0 = v_p - v_\alpha$

Elimination of v_i gives,

$$v_\alpha = \frac{3}{8} v_p$$

Now, $\dfrac{\lambda_\alpha}{\lambda_p} = \dfrac{h}{m_\alpha v_\alpha} \times \dfrac{m_p v_p}{h}$

$$= \frac{m_p}{m_\alpha} \cdot \frac{v_p}{v_\alpha}$$

$$= \frac{1}{4} \times \frac{8}{3} = \frac{2}{3}$$

20 In figure (a) following Malus' law, intensity reduces upto $\theta = \dfrac{\pi}{2}$ and then increases.

Also, intensity $\propto$ photocurrent.

21 Masses of particles A_1 and A_2 are m_1 and m_2.

where, $m_1 < m_2$

$$\Rightarrow \quad \frac{m_1}{m_2} < 1 \quad \text{...(i)}$$

Since, both particles have same de-Broglie wavelength.

Hence, momentum, $p = \dfrac{h}{\lambda}$ will be same for both particles.

$\therefore$ Energy, $E = \dfrac{p^2}{2m}$

$$\frac{E_2}{E_1} = \frac{m_1}{m_2}$$

$$\frac{E_2}{E_1} < 1 \quad \text{[from Eq. (i)]}$$

$$E_2 < E_1$$

22 As slope of V_0 and f graph $= \dfrac{h}{e}$

So, $h = e \times$ slope of graph.

From readings of A,

$$h = \frac{1.6 \times 10^{-19} \times (5 - 0)}{(10 - 5) \times 10^{14}}$$

$$= 16 \times 10^{-34} \text{ J-s}$$

From readings of B,

$$h = \frac{1.6 \times 10^{-19} \times (2.5 - 0)}{(15 - 10) \times 10^{14}}$$

$$= 8 \times 10^{-34} \text{ J-s}$$

Hence, both of the readings are incorrect.

23 PE of electron in Ist orbit = – 27.20 eV

Now, in IInd orbit,

Total energy of electron $= -\dfrac{13.6}{n^2}$

$$= -\frac{13.6}{2^2}$$

$$= -3.4 \text{ eV}$$

In IInd orbit, KE = 3.4 eV and

PE = – 2 × 3.4 = – 6.8 eV

To make PE = 0 in Ist orbit, energy must be increased by 27.20 eV.

So, PE in IInd orbit = 27.20 + (–6.8)

= 20.40 eV

Hence total energy = PE + KE

= 20.40 + 3.4

= 23.80 eV.

24 Energy is distributed in inverse ratio of masses of products,

So, $\dfrac{k_\alpha}{k_{\text{Th}}} = \dfrac{228}{4}$

where $(228 + 4)x = 5.40$ MeV

$\therefore \ x = \dfrac{5.40}{232}$

So, $k_\alpha = \dfrac{228}{232} \times 5.40$

$= 5.30$ MeV

So, $k_{\text{Th}} = 0.1$ MeV

25 Output of upper AND gate $= A\overline{B}$

Output of lower AND gate $= B\overline{A}$,

Output $Y = A\overline{B} + B\overline{A}$

26 Probability of surviving after time t

$$= \frac{\text{Number undecayed in time } (t)}{\text{Total number}}$$

$$= \frac{N_0 e^{-\lambda t}}{N_0} = e^{-\lambda t}$$

$\therefore$ Probability of decay

= 1 – Probability of survival

$= 1 - e^{-\lambda t}$

27 For α-decay, electrostatic repulsion must be greater than nuclear force; this happens when nucleus is large.

In β^+ decay, a proton is changed to a neutron. This occurs when protons are more.

In β^- decay, a neutron is changed to a proton. This happens when neutrons are more.

In k-capture, if protons are large, a proton and an electrons forms a neutron.

28 $f_c = 10$ MHz, $f'_c = 8$ MHz

$$\frac{N_{\max}}{N'_{\max}} = \left(\frac{f_c}{f'_c}\right)^2 = \left(\frac{10}{8}\right)^2 = 25:16$$

29 $d_m = \sqrt{2 \times 64 \times 10^5 \times 32} + \sqrt{2 \times 64 \times 10^5 \times 50}$ m

$= 64 \times 10^2 \times \sqrt{10} + 8 \times 10^3 \times \sqrt{10}$ m

$= 144 \times 10^2 \sqrt{10}$ m $= 45.5$ km

32 Critical frequency,

$$f_c = 10 \text{ MHz} = 10^7 \text{ Hz}$$

$$f_c = 9(N_{max})^{1/2}$$

or $$(N_{max})^{1/2} = \frac{f_c}{9}$$

or $$N_{max} = \left(\frac{f_c}{9}\right)^2$$

or $$N_{max} = \left(\frac{10^7}{9}\right)^2 \text{ em}^{-3}$$

$$= \frac{10^{14}}{81} \text{ em}^{-3}$$

33 Intensity $\propto$ number of photons.

34 When energy lost in a collision is less, it appears in form of heat radiation.

35 In one particular sample, atoms can be excited only upto a particular level.

36 The threshold wavelength is

$$\lambda_0 = \frac{hc}{W_0}$$

$$= \frac{(6.6 \times 10^{-34}) \times (3 \times 10^8)}{2.2 \times 1.6 \times 10^{-19}}$$

$$= 6 \times 10^{-7} \text{ m}$$

$$= 600 \text{ nm}$$

Out of the three given wavelength, two wavelengths $\lambda_1 = 440$ nm and $\lambda_2 = 495$ nm will cause photoelectric emission as these wavelengths are less than λ_0.

37 Intensity of each wavelength is

$$I = \frac{1}{3} \times 3.24 \times 10^{-3}$$

$$= 1.08 \times 10^{-3} \text{ Wm}^{-2}.$$

Area of metal surface is

$$A = 1 \text{cm}^2$$

$$= 1 \times 10^{-4} \text{ m}^2.$$

Therefore, energy of each wavelength is

$$E = I \times A$$

$$= 1.08 \times 10^{-7} \text{ J - s}^{-1}$$

38 Number of half-lives $n = \frac{16800}{5600} = 3$

Therefore, the amount of C - 14 left

$$= \frac{8 \text{ g}}{(2)^n}$$

$$= \frac{8 \text{ g}}{(2)^3}$$

$$= 1 \text{ g}$$