Physics · Introduction to Modern Physics · Wave-Particle Duality

Black Body Radiation

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148	3	67
questions	sets	pages

Contents

Multiple choice questions (103 questions) — Questions · p. 2 — Answers · p. 49

Essay questions (18 questions) — Questions · p. 33 — Answers · p. 61

Past exam questions (27 questions) — Questions · p. 38 — Answers · p. 64

Click a question number to jump to its answer, and an answer number to go back to the question.

Multiple choice questions — 103 questions

1 In the electromagnetic spectrum, the ratio between the wavelength of red light and the wavelength of ultraviolet rays is .....

(A) greater than one

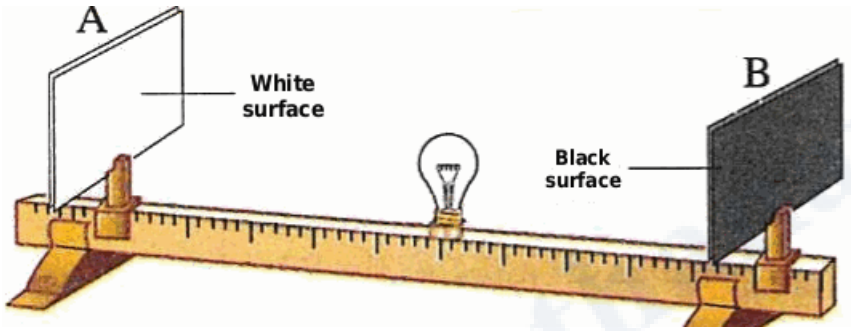
(B) less than one

(C) equal to one

(D) equal to the ratio between the speeds of the two radiations

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2 In the opposite figure, when the lamp is switched on for a certain time, which of the two surfaces A or B gets hotter?



(A) Surface A

(B) Surface B

(C) Both surfaces reach the same temperature

(D) The answer cannot be determined

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3 The dominant colour of the electromagnetic radiation emitted by an ideal black body changes with the .....

(A) mass of the body

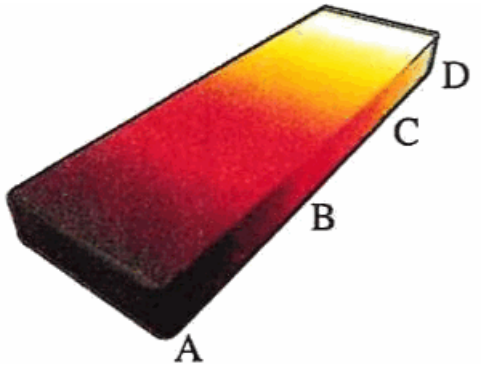
(B) density of the body's material

(C) temperature of the body

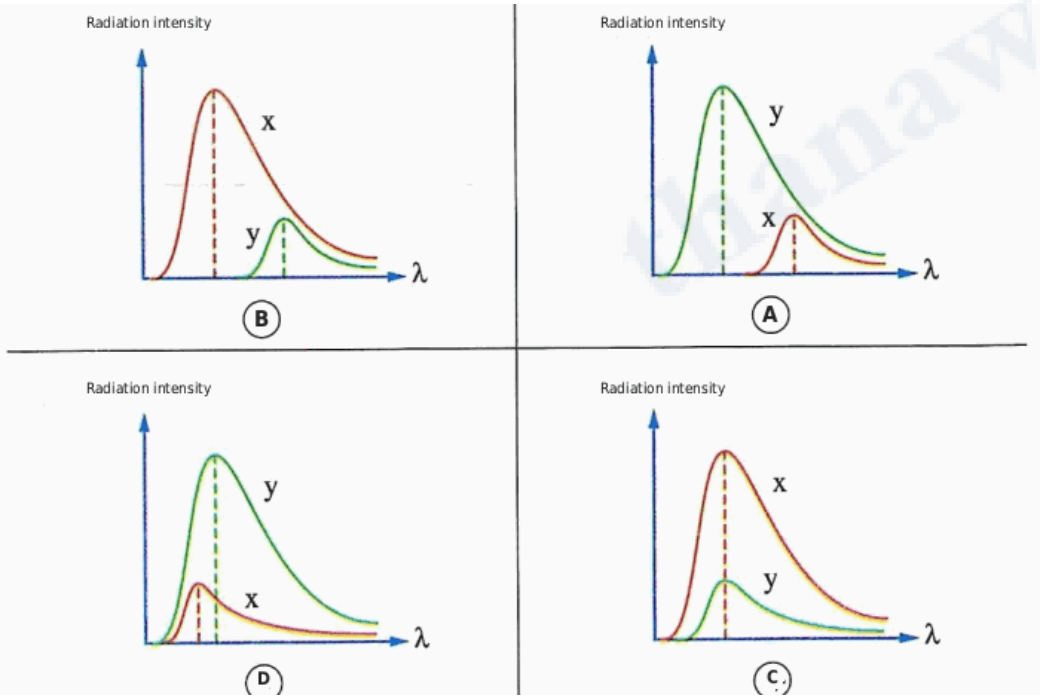
(D) type of the body's material

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4 The opposite figure shows a heated piece of iron. Which position on the piece has the lowest temperature?



5 Which of the following graphs represents Planck's curve for the radiation emitted by two identical bodies x and y kept at constant temperatures T_x and T_y respectively, where $(T_y < T_x)$?



6 In Planck's curve for black body radiation, if the temperature of the body decreases, then .....

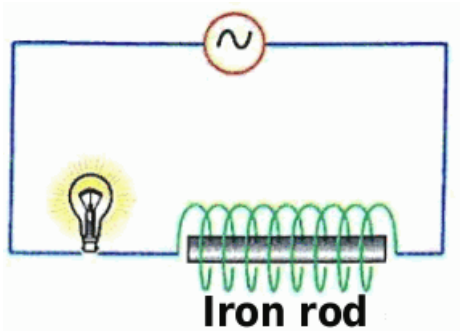
(A) the peak of the curve: shifts to higher frequencies, the area under the curve: increases

(B) the peak of the curve: shifts to higher frequencies, the area under the curve: decreases

(C) the peak of the curve: shifts to lower frequencies, the area under the curve: increases

(D) the peak of the curve: shifts to lower frequencies, the area under the curve: decreases

7 An AC circuit consists of an AC source connected to a lamp and an induction coil with an iron rod inside it, as in the opposite figure. The wavelength (λ_o) in the radiation emitted by the lamp has the maximum intensity (I_o). If the iron rod is taken out of the coil, then .....



(A) maximum radiation intensity: stays I_o, wavelength at maximum intensity: stays λ_o

(B) maximum radiation intensity: stays I_o, wavelength at maximum intensity: becomes less than λ_o

(C) maximum radiation intensity: becomes more than I_o, wavelength at maximum intensity: stays λ_o

(D) maximum radiation intensity: becomes more than I_o, wavelength at maximum intensity: becomes less than λ_o

---

8 Two identical bodies x and y, the temperature of x is higher than that of y. The ratio between the rate of total radiated energy from x and that from y is .....

(A) less than one

(B) equal to one

(C) greater than one

(D) the information is not enough to decide

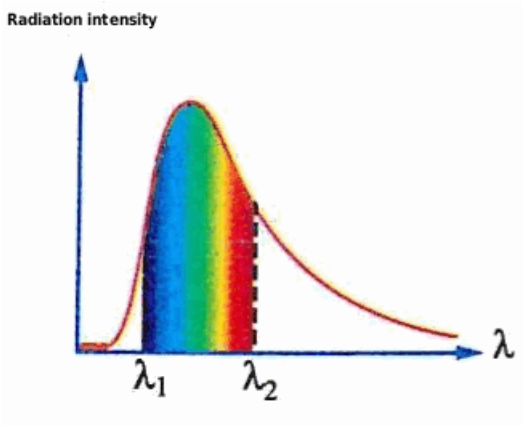
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9 In Planck's curve for black body radiation, the radiation intensity at very high frequencies .....

(A) does not change (B) is medium (C) is very large (D) approaches zero

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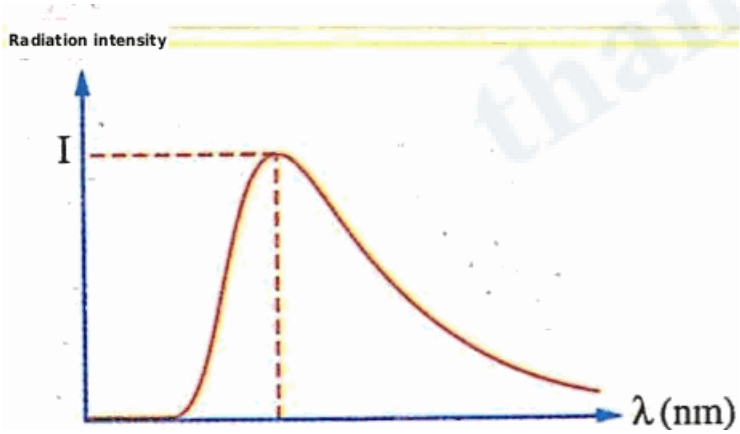
10 In the opposite graph, if λ_1 is the shortest wavelength of visible light and λ_2 is the longest wavelength of visible light, the graph may represent the radiation emitted by .....



(A) a glowing star (B) the Earth (C) a tungsten lamp (D) the human body

11 The opposite graph represents Planck's curve for a hot black body. What happens to each of the following when its temperature is raised:

(1) the number of photons emitted by the body per second?

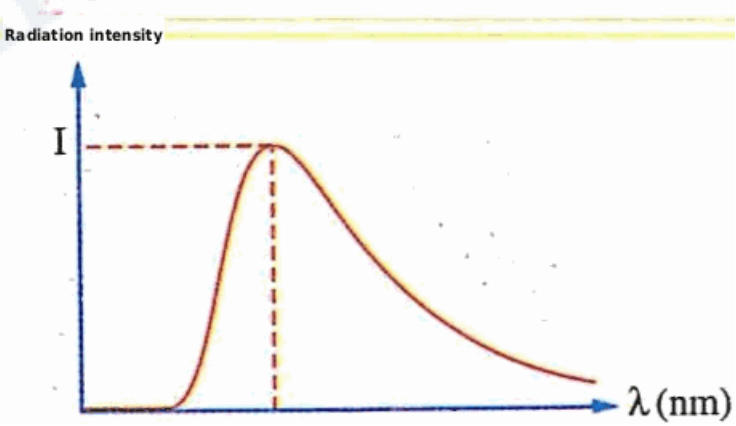


(A) increases (B) decreases

(C) does not change (D) cannot be determined

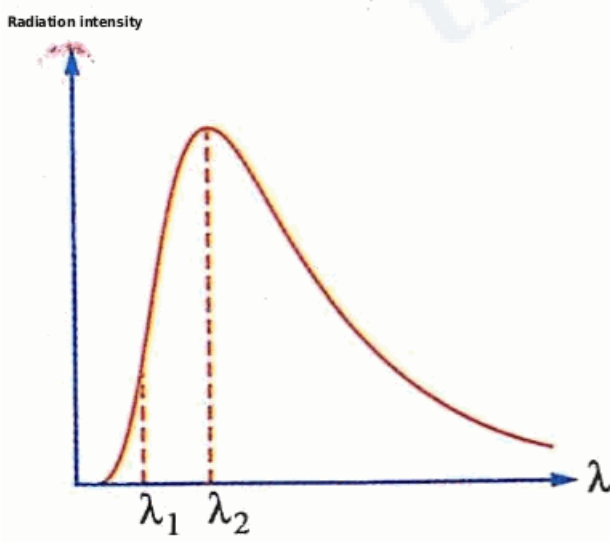
12 The opposite graph represents Planck's curve for a hot black body. What happens to each of the following when its temperature is raised:

(2) the value of the maximum radiation intensity?



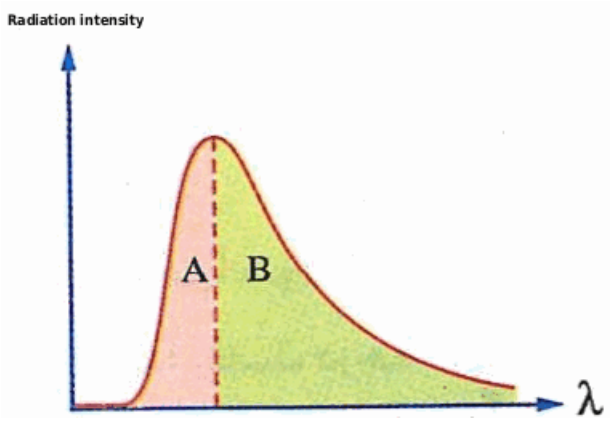
(A) becomes greater than I
(B) becomes less than I
(C) stays I
(D) cannot be determined

13 The opposite graph represents Planck's curve for the radiation of a hot ideal black body. The rate of emission of photons of wavelength (λ_1) compared to their rate of emission at wavelength (λ_2) is .....



(A) greater
(B) smaller
(C) equal
(D) cannot be determined

14 The opposite graph represents Planck's curve for the radiation of an ideal black body. Which of the two regions shown has an explanation that contradicts the principles of classical physics?



(A) Region A (B) Region B (C) Both regions (D) Neither region

15 The opposite figure shows a glowing electric lamp. The ratio between the total energy of the invisible rays it emits and the total energy of the visible rays in the same time is .....



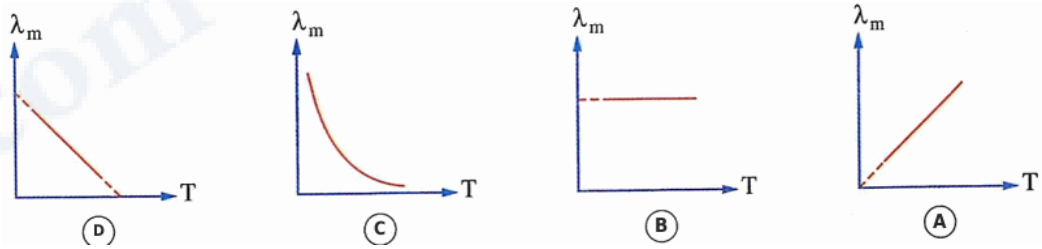
(A) greater than one

(B) less than one

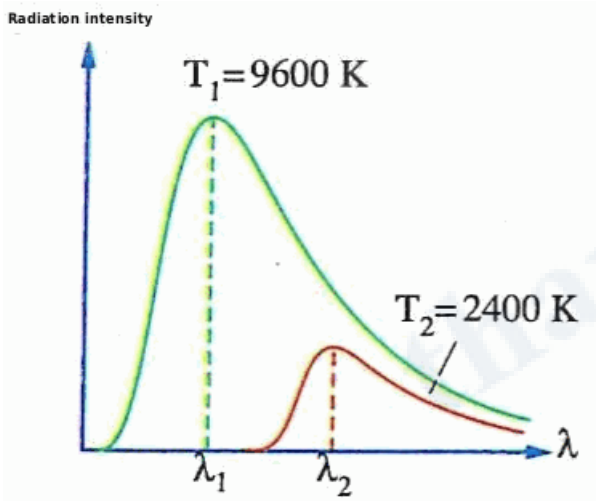
(C) equal to one

(D) unchanged when the temperature changes

16 Which of the following graphs represents the relation between the wavelength (λ_m) at maximum radiation intensity emitted by several identical hot bodies and the absolute temperature (T) of each?



17 The opposite figure shows Planck's curve of a hot black body at two temperatures T_1 and T_2. The ratio $((\lambda_1)/(\lambda_2))$ is .....

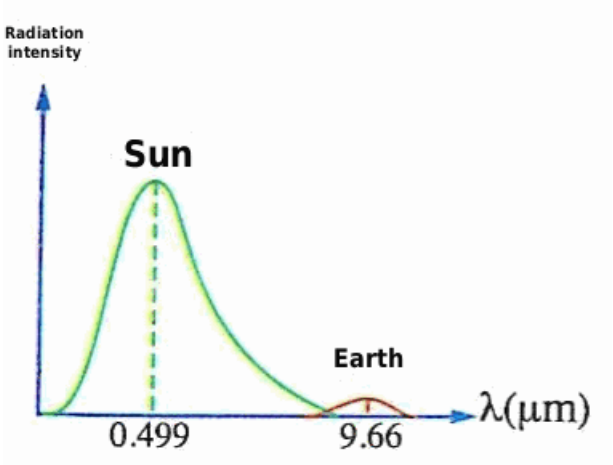


(A) *1/16* (B) *1/8* (C) *1/4* (D) *1/2*

18 A black body has a temperature of 3000 K and the wavelength of maximum radiation intensity is λ. If it is cooled to an absolute temperature T, the wavelength of maximum radiation intensity becomes 10 λ. The temperature T equals .....

(A) 300 K (B) 2700 K (C) 270 K (D) 1800 K

19 The figure in front of you shows the relation between the intensity of radiation emitted from the surfaces of the Sun and the Earth and the wavelength (λ). If the temperature of the Sun's surface is 6000 K, then using the data on the figure, the average temperature of the Earth's surface is .....

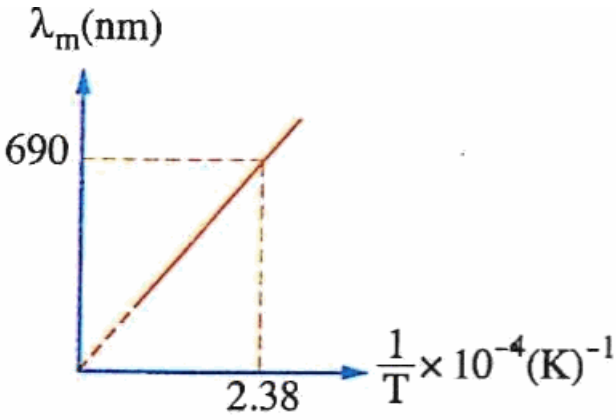


(A) 9000 K (B) 1935.9 K (C) 309.9 K (D) 200 K

20 For a black body at absolute temperature (T_o), the wavelength at maximum radiation intensity is (λ_o). If the temperature of the body is raised by 500 K, the wavelength at maximum radiation intensity decreases by $(5/8\lambda_o)$. The temperature (T_o) equals .....

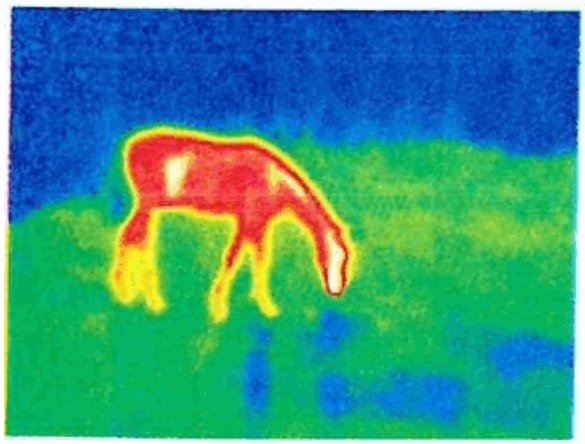
(A) 300 K (B) 500 K (C) 800 K (D) 1500 K

21 The opposite graph represents the relation between the wavelength (λ_m) at maximum radiation intensity emitted by a number of hot bodies and the reciprocal of the absolute temperature $(1/T)$ of each. The wavelength at maximum radiation intensity emitted by a body at 4830 K lies in the range of .....



(A) infrared rays (B) visible light (C) ultraviolet rays (D) X-rays

22 The opposite figure shows a picture taken by a night vision device. The device depends on receiving the ..... rays emitted by bodies.



(A) visible (B) ultraviolet (C) infrared (D) X

23 According to the assumptions of Max Planck's quantum theory:

(1) the atoms of a black body emit photons .....

(A) when they move from their ground level to a higher energy level

(B) of different wavelengths but the same intensity

(C) whose number decreases as the frequency of the radiation increases beyond a certain limit

(D) whose energy is directly proportional to the wavelength of the radiation

24 According to the assumptions of Max Planck's quantum theory:

(2) when an atom moves from a higher energy level to a lower energy level, it .....

(A) absorbs a photon of energy $h\nu$ (B) absorbs a photon of energy $h\nu^2$

(C) emits a photon of energy $h\nu$ (D) emits a photon of energy $h\nu^2$

25 According to the assumptions of Max Planck's quantum theory:

(3) the energy of a photon of frequency 5×10^{14} Hz equals .....

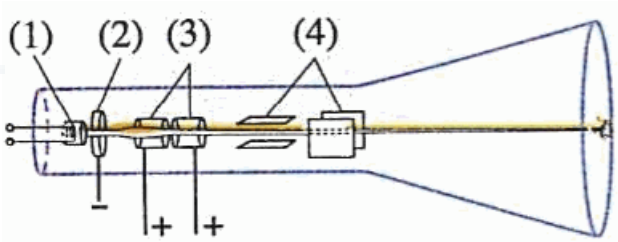
(A) 1.7×10^{-19} J (B) 3.3×10^{-19} J (C) 6.6×10^{-19} J (D) 9.9×10^{-19} J

26 One of the properties of cathode rays is that they are .....

(A) electromagnetic waves (B) of constant speed

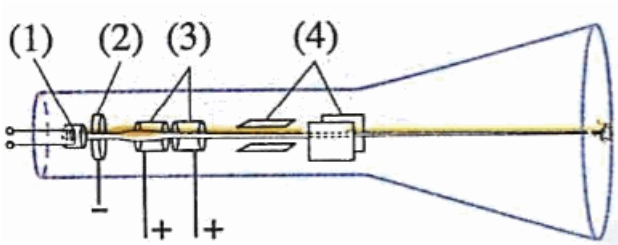
(C) charged particles (D) uncharged particles

27 The opposite figure represents a cathode ray tube. Which of the parts in the tube:
(1) is the source of electrons?



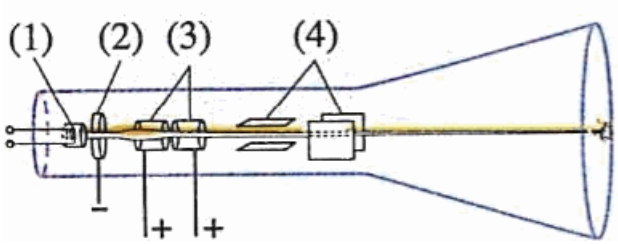
(A) Part (1) (B) Part (2) (C) Part (3) (D) Part (4)

28 The opposite figure represents a cathode ray tube. Which of the parts in the tube:
(2) is responsible for changing the position where the electron beam hits the screen?



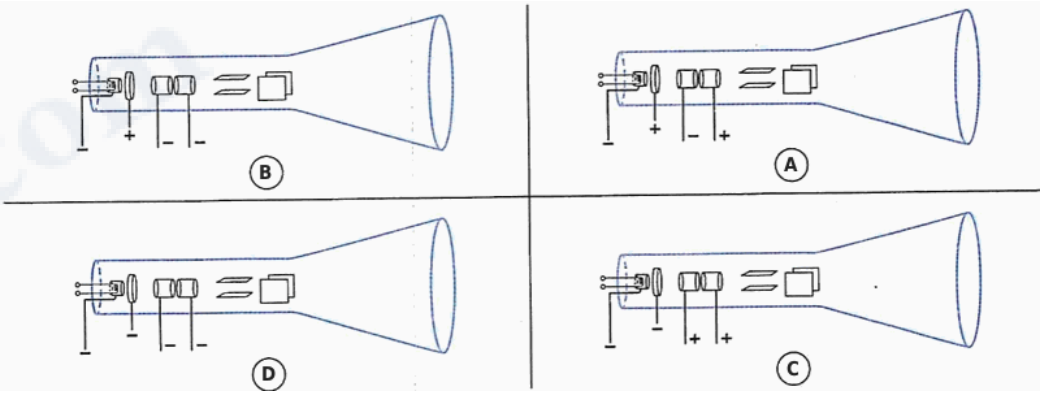
(A) Part (1) (B) Part (2) (C) Part (3) (D) Part (4)

29 The opposite figure represents a cathode ray tube. Which of the parts in the tube:
(3) controls the brightness on the fluorescent screen?



(A) Part (1) (B) Part (2) (C) Part (3) (D) Part (4)

30 Which figure shows the correct electric potentials used to form an image on the screen of a cathode ray tube?



31 In a cathode ray tube, when the grid potential is changed from −20 V to −50 V .....

(A) the brightness on the fluorescent screen increases

(B) the brightness on the fluorescent screen decreases

(C) the deflection of the electron beam increases

(D) the deflection of the electron beam decreases

32 In a cathode ray tube, when the filament is damaged .....

(A) the brightness on the fluorescent screen increases

(B) the brightness on the fluorescent screen decreases

(C) the fluorescent screen does not light up

(D) the deflection of the electron beam decreases

33 In a cathode ray tube, when the grid is not connected to any electric signal .....

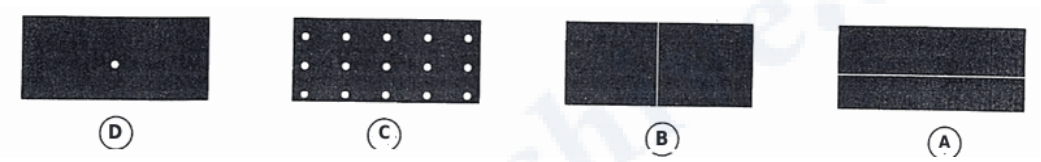
(A) the path of the electron beam to the screen cannot be controlled

(B) the fluorescent screen does not light up

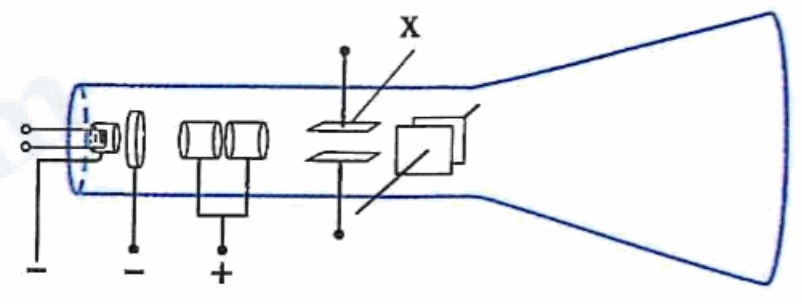
(C) the electron beam goes back to the cathode

(D) the brightness on the screen stays almost constant

34 Which of the following choices shows what appears on the screen of a cathode ray tube when the beam-moving system is not working?



35 What happens to the path of the cathode rays when a DC voltage is connected across part (X)?



(A) The electron beam is deflected towards the negative plate

(B) The electron beam is deflected towards the positive plate

(C) The electron beam is not deflected

(D) The electron beam does not pass through part (X)

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36 The kinetic energy of the electrons when they reach the anode in a cathode ray tube depends on .....

(A) the surface area of the cathode

(B) the type of the anode material

(C) the potential difference between the two plates of the beam-directing system

(D) the potential difference between the anode and the cathode

---

37 In a cathode ray tube, if the potential difference between the anode and the cathode increases while the temperature of the filament does not change, the rate of emission of electrons from the filament .....

(A) increases

(B) decreases

(C) does not change

(D) cannot be determined

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38 In a cathode ray tube, the maximum speed of an electron reaches v when it is accelerated by a potential difference V. If the potential difference acting on the electron increases to 2 V, the maximum speed of the electron becomes .....

(A) 2 v

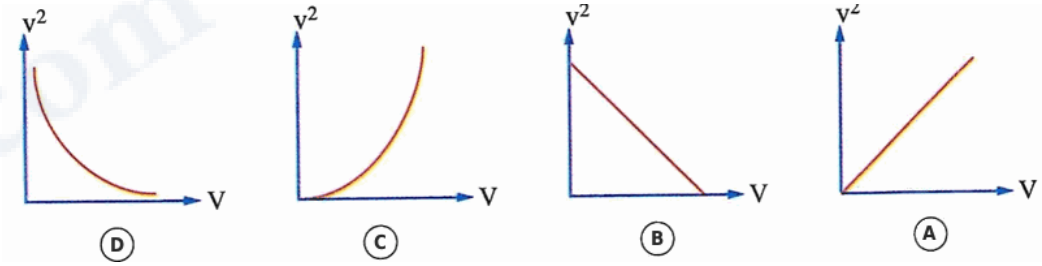
(B) $\sqrt{(2)}$ v

(C) 4 v

(D) $1/2$ v

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39 The graph that represents the relation between the square of the maximum speed (v^2) of the electrons reaching the anode in a cathode ray tube and the potential difference (V) between the anode and the cathode is .....



40 If the potential difference between the anode and the cathode in a cathode ray tube is 1000 V:
(1) the maximum kinetic energy of the electrons is .....

(A) 1.6×10^{-15} J (B) 1.6×10^{-16} J (C) 1.6×10^{-17} J (D) 32×10^{-18} J

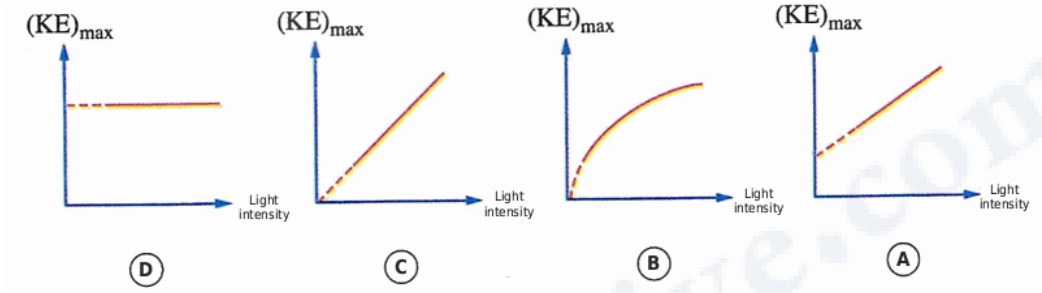
41 If the potential difference between the anode and the cathode in a cathode ray tube is 1000 V:
(2) the maximum speed of an electron emitted from the cathode when it reaches the anode equals .....

(A) 1.88×10^{6} m/s (B) 1.88×10^{7} m/s (C) 3.52×10^{5} m/s (D) 3.52×10^{4} m/s

42 The emission of electrons from the cathode surface of a photoelectric cell depends on .....

(A) the type of the anode material and the intensity of the incident light
(B) the type of the cathode material and the frequency of the incident light
(C) the type of the anode material and the frequency of the incident light
(D) the type of the cathode material and the intensity of the incident light

43 Which of the following graphs represents the relation between the maximum kinetic energy $(KE)_{max}$ of the electrons emitted from the cathode of a photoelectric cell and the intensity of the monochromatic light falling on the cathode?



44 Electromagnetic radiation of a certain frequency fell on the cathode of a photoelectric cell and electrons were emitted with a certain maximum kinetic energy. Then the radiation was replaced by radiation of a higher frequency. The quantity that does not change is .....

(A) the energy of the incident photon

(B) the speed of the incident photon

(C) the maximum energy of the emitted electron

(D) the maximum speed of the emitted electron

---

45 In the photoelectric effect, if the energy of the photon falling on the metal surface is (E_1) and the kinetic energy of the electron it frees from the surface is (E_2), the ratio (E_1/E_2) is .....

(A) greater than one (B) less than one (C) equal to one (D) undefined

---

46 In a photoelectric cell experiment, the cathode surface was lit with monochromatic light whose frequency is greater than the threshold frequency of the metal. Then the experiment was repeated using light of the same wavelength but with twice the light intensity. The quantity that doubles is .....

(A) the energy of one photon

(B) the maximum kinetic energy of the emitted electrons

(C) the work function of the metal

(D) the photoelectric current

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47 When a light beam of wavelength 591.5 nm falls on a caesium surface, photoelectrons are only just emitted. For electrons of energy 1.81 eV to be emitted, a beam of wavelength of about ..... is needed.

(A) 318 nm (B) 520 nm (C) 650 nm (D) 720 nm

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48 When monochromatic electromagnetic radiation falls on the cathode of a photoelectric cell, a photoelectric current passes in its circuit. The rate of emission of electrons from the cathode decreases but does not stop when ..... is decreased.

(A) the wavelength of the incident light (B) the frequency of the incident light

(C) the speed of the incident light (D) the intensity of the incident light

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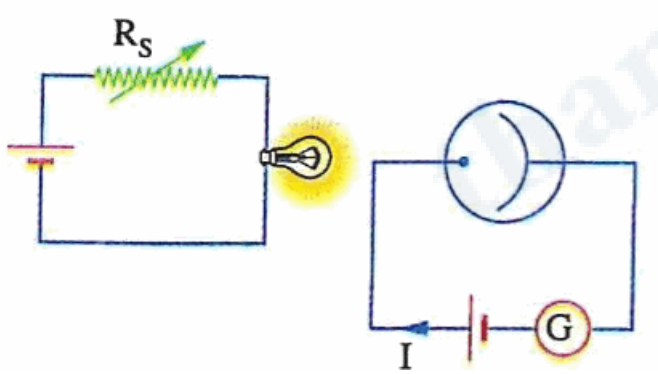
49 Which of the following factors controls the rate of emission of electrons from a metal surface when photons with a wavelength shorter than the threshold wavelength of the surface fall on it?

(A) The frequency of the photon beam
(B) The energy of the photon
(C) The intensity of the photon beam
(D) The momentum of the photon

50 Monochromatic light fell on a metal surface and electrons were freed at a certain rate. If another monochromatic light of higher frequency falls on the same metal at the same rate, the number of electrons freed per second .....

(A) increases
(B) decreases
(C) does not change
(D) cannot be determined

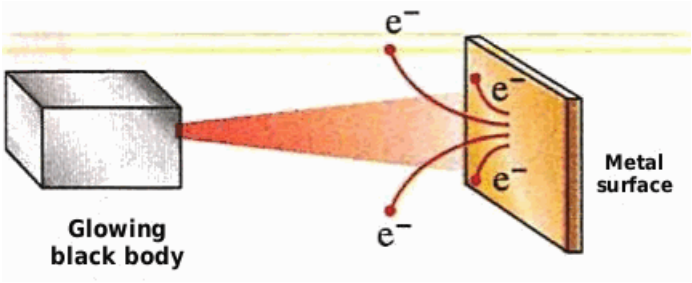
51 The opposite figure shows light from an electric lamp falling on a photoelectric cell, causing a photoelectric current. If the brightness of the lamp increases, the photoelectric current .....



(A) increases
(B) decreases but does not stop
(C) does not change
(D) stops

52 In the opposite figure, a glowing black body was placed in front of a metal surface, and the radiation from the black body caused electrons to be emitted from the metal surface. If the temperature of the black body is raised:

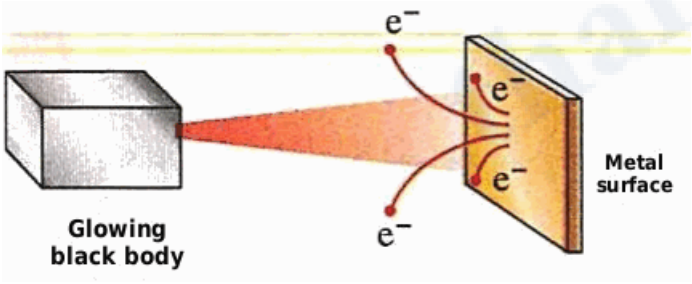
(1) the rate of emission of electrons from the metal surface .....



(A) increases (B) decreases (C) does not change (D) stops

53 In the opposite figure, a glowing black body was placed in front of a metal surface, and the radiation from the black body caused electrons to be emitted from the metal surface. If the temperature of the black body is raised:

(2) the maximum kinetic energy of the electrons emitted from the metal surface .....



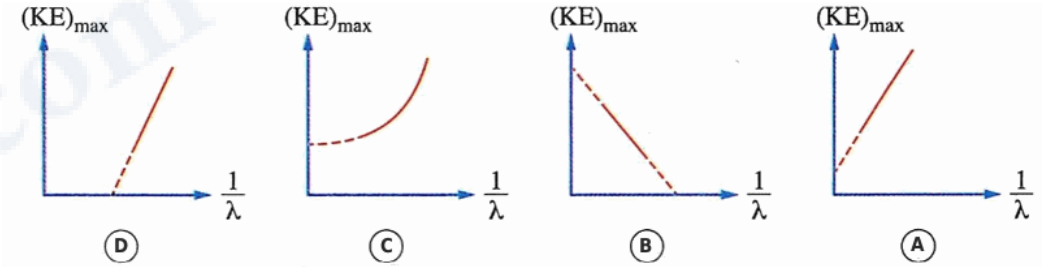
(A) increases (B) decreases (C) does not change (D) becomes zero

54 If the frequency of the light falling on a metal surface doubles, the work function of this metal .....

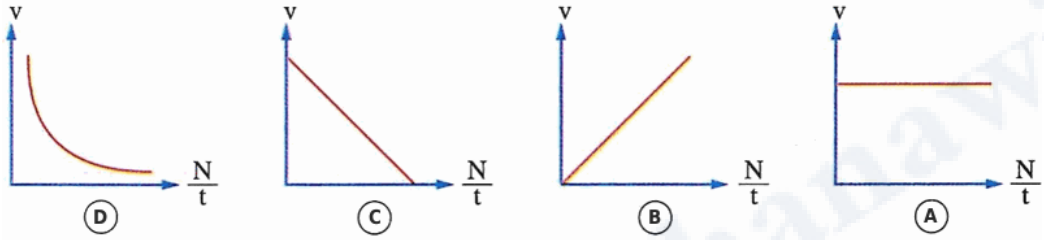
(A) doubles (B) becomes half

(C) stays constant (D) becomes four times

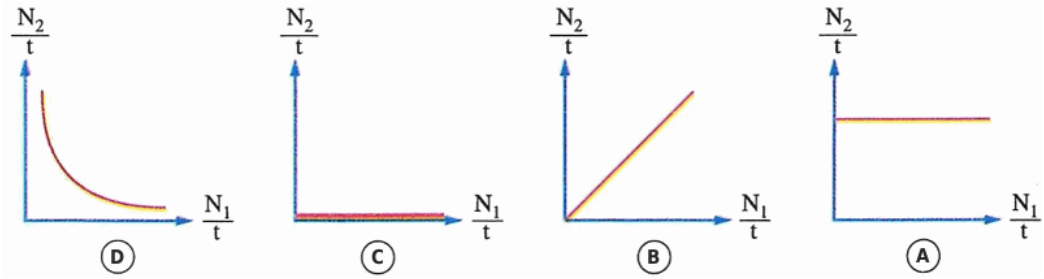
55 Which of the following graphs represents the relation between the maximum kinetic energy of the photoelectrons $(KE)_{max}$ and the reciprocal of the wavelength of the rays falling on the cathode of the photoelectric cell $(1/(\lambda))$?



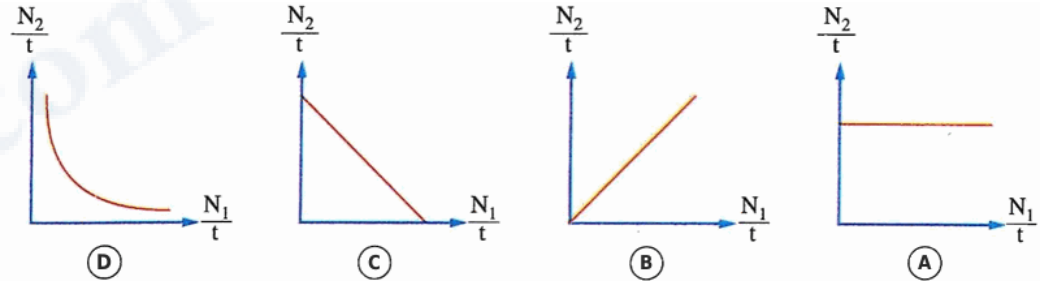
56 Light fell on a metal surface with a frequency greater than the threshold frequency of the surface. Which of the following graphs represents the relation between the speed (v) of the emitted electrons and the rate at which photons fall on the surface (N/t)?



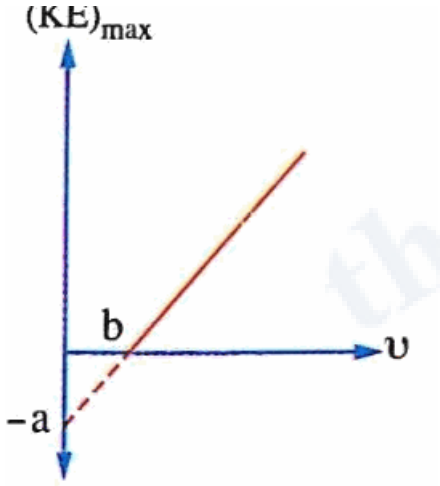
57 When light falls on a metal surface with a frequency less than the threshold frequency of the surface, which of the following graphs represents the relation between the rate of emission of electrons (N_2/t) from the surface and the rate at which photons fall on it (N_1/t)?



58 When light falls on a metal surface with a frequency greater than the threshold frequency of the surface, which of the following graphs represents the relation between the rate of emission of electrons (N_2/t) from the surface and the rate at which photons fall on it (N_1/t)?

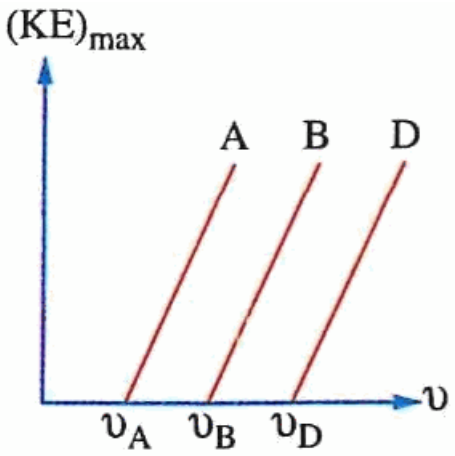


59 The opposite graph represents the relation between the maximum kinetic energy $(KE)_{max}$ of the electrons emitted from the cathode of a photoelectric cell and the frequency of the incident light (υ). The value a divided by the value b represents .....



(A) Planck's constant
(B) the threshold frequency
(C) the work function
(D) the photon energy

60 The opposite figure represents the relation between the frequency of the light falling on the surfaces of three metals A, B, D and the maximum kinetic energy of the electrons emitted from them. If the work functions of these metals are E_A, E_B, E_D, then .....

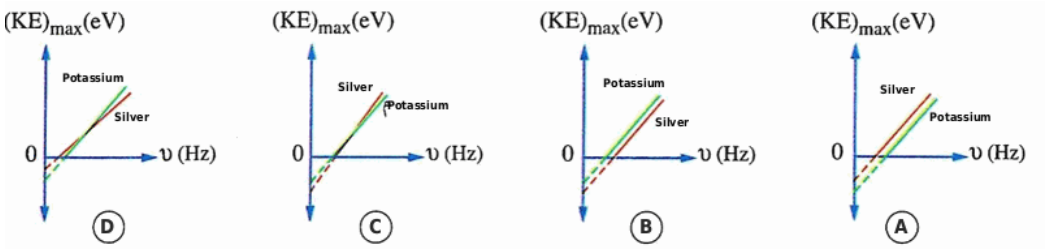


(A) $E_A < E_B < E_D$ (B) $E_A = E_B < E_D$ (C) $E_A > E_B > E_D$ (D) $E_A = E_B = E_D$

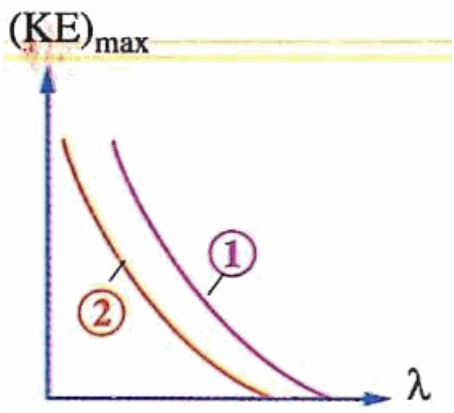
61 Three metal surfaces (x), (y), (z): surfaces (x) and (y) are caesium and surface (z) is silver. Electromagnetic radiation of wavelengths λ, $2/3\ \lambda$ and λ fell on them respectively, and photoelectrons were emitted from all three surfaces. Given that the work function of caesium is less than that of silver, the correct order of the three surfaces by the maximum speed of the electrons emitted from them is .....

(A) z < y < x (B) z > y > x (C) x = z < y (D) z < x < y

62 Given that the work functions of potassium and silver are 1.8 eV and 4.73 eV respectively, which of the following graphs represents the relation between the maximum kinetic energy $(KE)_{max}$ of the electrons emitted from each and the frequency (ν) of the light falling on each?



63 The opposite graph represents the relation between the maximum kinetic energy $(KE)_{max}$ of the electrons emitted from two metal surfaces (1) and (2) and the wavelength (λ) of the photons falling on each. Which metal has the larger work function?



(A) Metal (1)

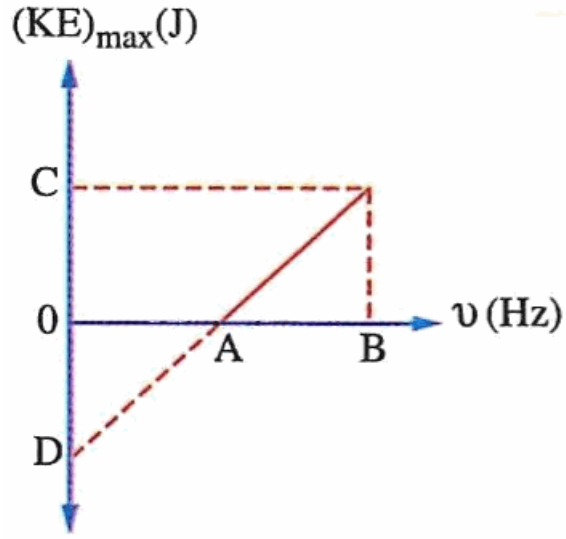
(B) Metal (2)

(C) Both metals have the same work function

(D) The answer cannot be determined

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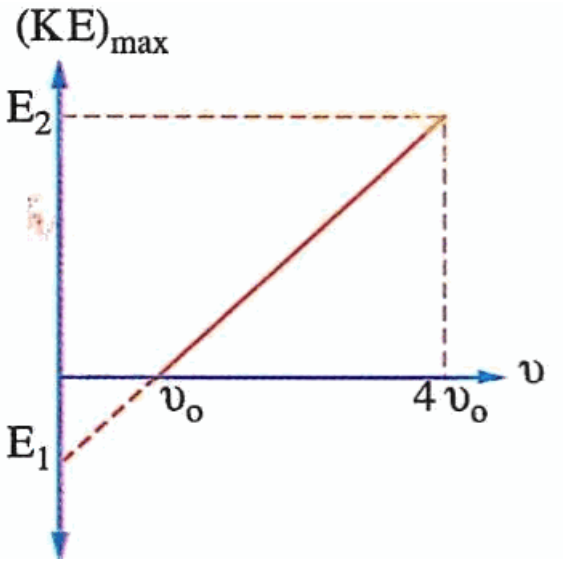
64 The opposite figure shows the relation between the maximum kinetic energy of the electrons emitted from the cathode surface of a photoelectric cell and the frequency of the light falling on it. Which of the following quantities gives Planck's constant?



(A) D (B) $D/(B + A)$ (C) A/B (D) $C/(B - A)$

---

65 The opposite graph represents the relation between the maximum kinetic energy $(KE)_{max}$ of the electrons emitted from a metal surface and the frequency (υ) of the incident light. The ratio (E_1/E_2) equals .....



(A) 1/2 (B) 1/3 (C) 1/4 (D) 1/5

66 Monochromatic electromagnetic radiation fell on a metal surface whose work function is 3 eV. Which of the following choices can represent the energy of the incident photon and the maximum kinetic energy of the electrons emitted?

(A) incident photon energy: 2 eV, maximum kinetic energy of the electrons: 1 eV
(B) incident photon energy: 2 eV, maximum kinetic energy of the electrons: 5 eV
(C) incident photon energy: 4 eV, maximum kinetic energy of the electrons: 1 eV
(D) incident photon energy: 4 eV, maximum kinetic energy of the electrons: 2 eV

67 Electromagnetic radiation of frequency ν fell on a metal surface whose work function is 3 eV, and electrons were emitted with a maximum kinetic energy of 2 eV. If the radiation is replaced by another of frequency 2 ν, the maximum kinetic energy of the emitted electrons equals .....

(A) 7 eV (B) 6 eV (C) 5 eV (D) 4 eV

68 A metal surface has a threshold frequency ν_c. A light beam of frequency $5\nu_c$ fell on it and photoelectrons were emitted with a maximum speed of 8×10^6 m/s. If the frequency of the incident light becomes $2\nu_c$, the maximum speed of the emitted electrons becomes .....

(A) 6×10^6 m/s (B) 4×10^6 m/s (C) 8×10^6 m/s (D) 1×10^6 m/s

69 Monochromatic electromagnetic radiation fell on each of two metal surfaces (x) and (y) whose work functions are 3 eV and 4 eV respectively. The maximum kinetic energies of the electrons emitted from the two surfaces respectively can be .....

(A) (x): 1 eV, (y): 2 eV
(B) (x): 2 eV, (y): 1 eV
(C) (x): 3 eV, (y): 1 eV
(D) (x): 2 eV, (y): 2 eV

---

70 In the photoelectric cell experiment, using electromagnetic radiation of wavelength λ, the maximum kinetic energy of the emitted electrons was KE. If another radiation of wavelength $(\lambda)/2$ is used, the maximum kinetic energy of the emitted electrons becomes .....

(A) zero
(B) less than 2 KE and greater than KE
(C) 2 KE
(D) greater than 2 KE

---

71 When light of wavelength 623 nm falls on a metal surface, electrons are freed with a speed of 4.6×10^5 m/s:

(1) the work function of this surface equals .....

(A) 2.23×10^{-19} J (B) 3.19×10^{-19} J (C) 4.15×10^{-19} J (D) 4.6×10^{-19} J

---

72 When light of wavelength 623 nm falls on a metal surface, electrons are freed with a speed of 4.6×10^5 m/s:

(2) the threshold frequency of this surface equals .....

(A) 6.94×10^{14} Hz (B) 6.26×10^{14} Hz (C) 4.81×10^{14} Hz (D) 3.37×10^{14} Hz

---

73 In a photoelectric cell, when yellow light falls on the cathode surface no electrons are emitted, while when blue light falls on it electrons are emitted at a certain rate. If red light falls on the same cathode surface, the rate of emission of electrons .....

(A) increases
(B) decreases but does not stop
(C) becomes zero
(D) does not change

---

74 If the threshold frequency of a metal surface lies within the frequencies of blue light, the rays falling on this metal that allow electrons to be emitted from it are in the region of ..... rays.

(A) infrared (B) ultraviolet (C) radio (D) red

---

75 Four photons x, y, z, k with energies 6 eV, 5 eV, 4 eV and 3 eV respectively fell one at a time on a metal surface whose work function is E_w, and three electrons were emitted from the surface. The work function E_w of this surface is .....

(A) $6\ eV > E_w > 5\ eV$
(B) $5\ eV > E_w > 4\ eV$
(C) $4\ eV > E_w > 3\ eV$
(D) $3\ eV > E_w$

76 Electromagnetic radiation of wavelength 3100 Å fell on the cathode of a photoelectric cell and photoelectrons were emitted with a maximum kinetic energy of 2.5 eV. The work function of the cathode material equals .....

(A) 3.1 eV
(B) 2.4 eV
(C) 1.5 eV
(D) 0.9 eV

77 If the work function of a metal surface is 3.3125×10^{-19} J, the threshold frequency of this metal equals .....

(A) 4.5×10^{14} Hz
(B) 4.8×10^{14} Hz
(C) 5×10^{14} Hz
(D) 5.5×10^{14} Hz

78 If the work function of a metal surface is 2.48 eV, the longest wavelength of incident light that frees electrons from the surface equals .....

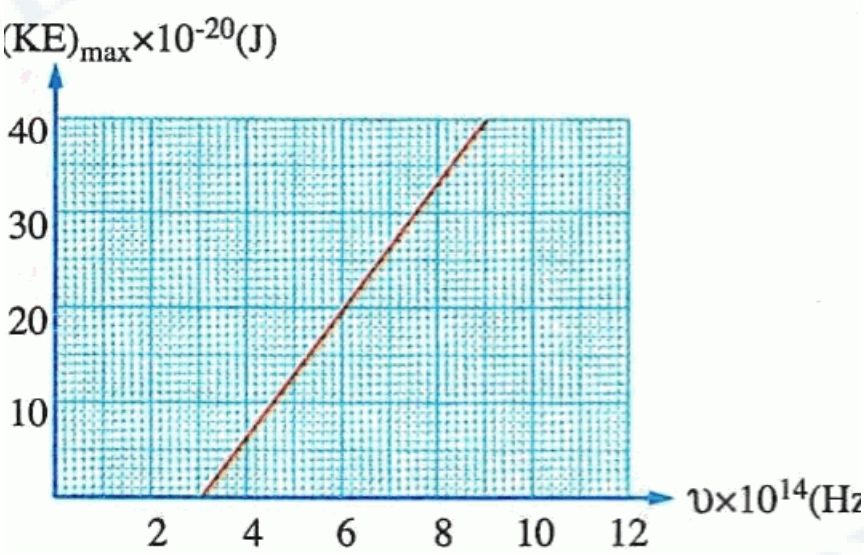
(A) 4×10^{-7} m
(B) 5×10^{-7} m
(C) 5.5×10^{-7} m
(D) 6×10^{-7} m

79 When monochromatic light (a) of wavelength 4000 Å falls on a metal surface, electrons are emitted with a speed of 5.3×10^5 m/s. If another monochromatic light (b) of wavelength 5500 Å falls on the same metal surface, then light (b) .....

(A) has a frequency greater than the threshold frequency of the metal
(B) has a frequency less than the threshold frequency of the metal
(C) has a frequency equal to the threshold frequency of the metal
(D) frees electrons from the metal with a greater speed

80 The opposite graph shows the relation between the maximum kinetic energy $(KE)_{max}$ of the electrons emitted from a metal surface and the frequency (υ) of the light falling on it. Using the graph:

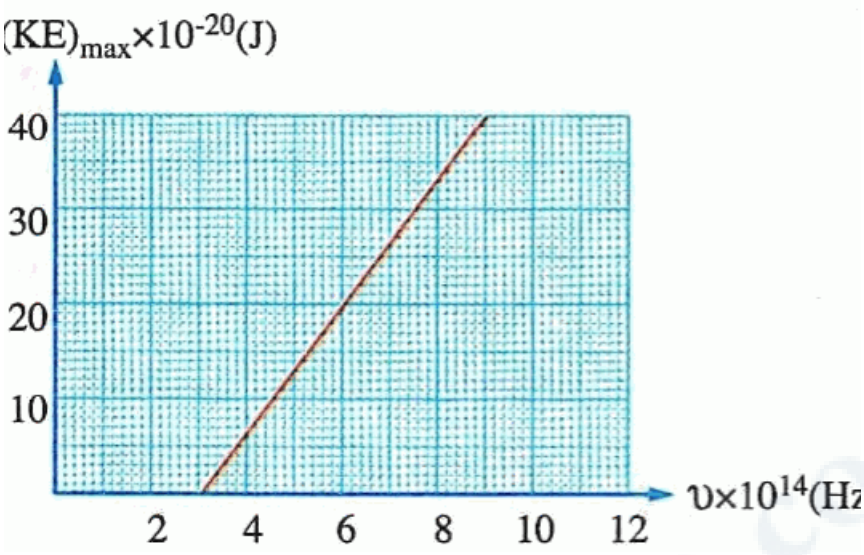
(1) the threshold frequency of the metal surface equals .....



(A) 2.4×10^{14} Hz (B) 2.5×10^{14} Hz (C) 3×10^{14} Hz (D) 4.8×10^{14} Hz

81 The opposite graph shows the relation between the maximum kinetic energy $(KE)_{max}$ of the electrons emitted from a metal surface and the frequency (υ) of the light falling on it. Using the graph:

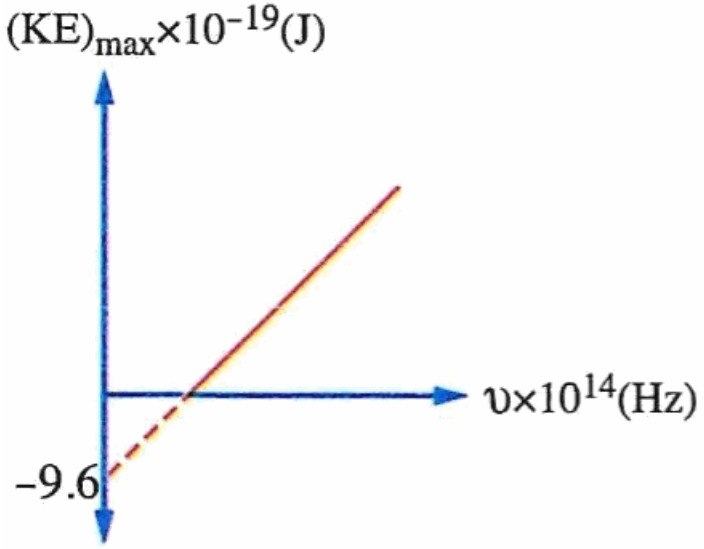
(2) the wavelength of the light that causes electrons to be emitted with a maximum kinetic energy of 20×10^{-20} J equals .....



(A) 1×10^{-6} m (B) 5×10^{-7} m (C) 1.67×10^{-15} m (D) 3×10^{-15} m

82 In a photoelectric cell, different monochromatic light rays fell on the cathode, and the opposite graph shows the relation between the maximum kinetic energy $(KE)_{max}$ of the released electrons and the frequency (υ) of the incident light:

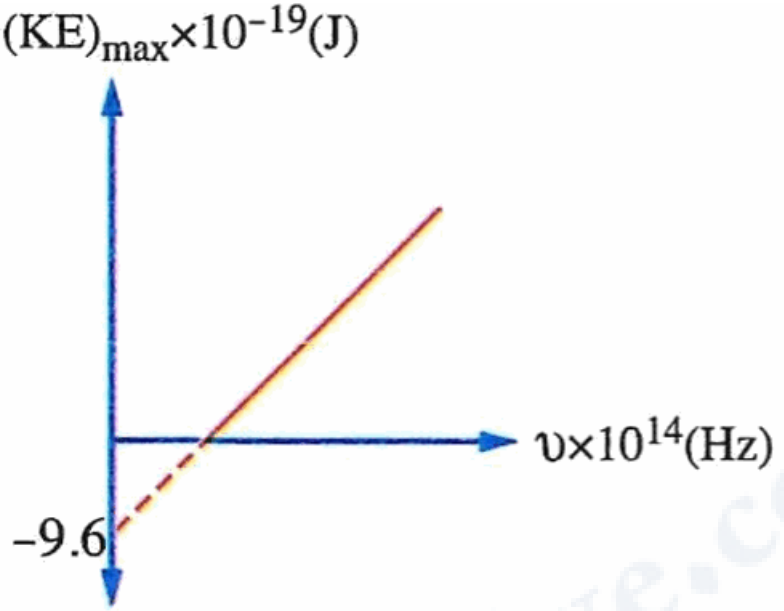
(1) the threshold wavelength of the cathode material equals .....



(A) 2.07×10^{-7} m (B) 6.9×10^{-7} m (C) 2.07×10^{-8} m (D) 6.9×10^{-8} m

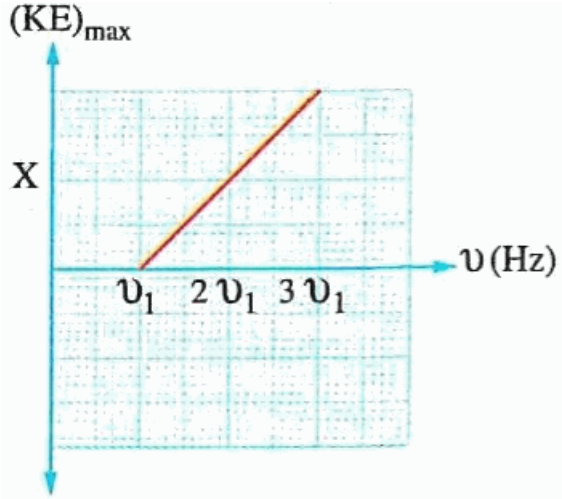
83 In a photoelectric cell, different monochromatic light rays fell on the cathode, and the opposite graph shows the relation between the maximum kinetic energy $(KE)_{max}$ of the released electrons and the frequency (υ) of the incident light:

(2) the frequency of the incident light needed for an electron to be freed from the cathode surface with a maximum kinetic energy of 9.6×10^{-19} J is .....



(A) 1.45×10^{15} Hz (B) 2.9×10^{15} Hz (C) 5.8×10^{15} Hz (D) 19.2×10^{15} Hz

84 The opposite figure represents the relation between the maximum kinetic energy $(KE)_{max}$ of the electrons emitted from a metal surface and the frequency (υ) of the light falling on it. If the work function of this metal surface is 5×10^{-19} J, the value of X equals .....



(A) 5×10^{-19} J (B) 1×10^{-19} J (C) 2×10^{-19} J (D) 3×10^{-19} J

85 A photon of energy 3 hν fell on a metal surface whose work function is hν. The number of electrons this photon can free equals .....

(A) zero (B) 1 (C) 2 (D) 3

86 Light of frequency ν fell on a metal surface whose work function is E_w, and the maximum kinetic energy of the emitted electrons was KE. If the frequency of the incident light doubles, the maximum kinetic energy of the emitted electrons becomes .....

(A) 2 KE (B) $2\ KE - E_w$ (C) $2\ KE + E_w$ (D) $2\ KE + 2\ E_w$

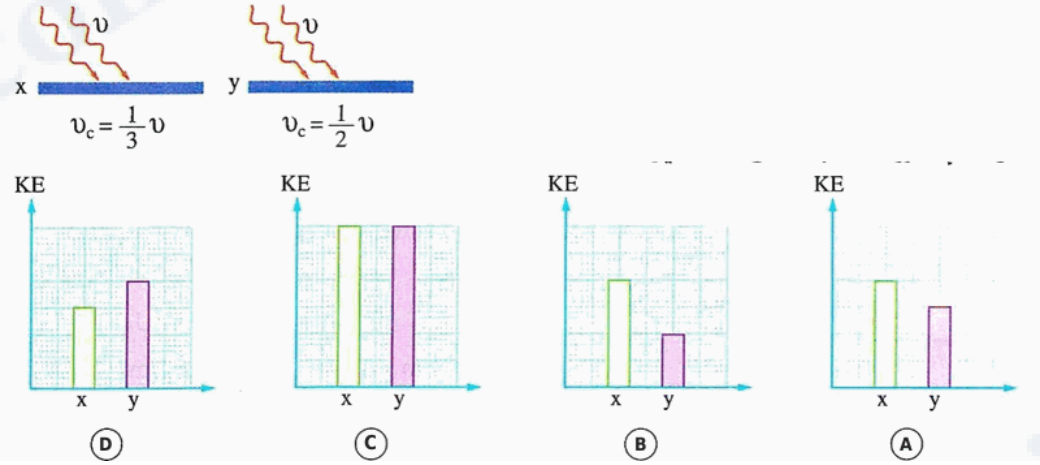
87 If the threshold wavelength of zinc is 3000 Å, its work function equals .....

(A) 4.42×10^{-19} J (B) 2.21×10^{-19} J (C) 3.3×10^{-19} J (D) 6.625×10^{-19} J

88 Radiation of wavelength 3000 Å fell on a metal surface and photoelectrons were emitted with a maximum kinetic energy of 0.5 eV. If another radiation of wavelength 2000 Å falls on the same metal surface, the maximum kinetic energy of the photoelectrons becomes .....

(A) zero (B) less than 0.5 eV and greater than zero
(C) 0.5 eV (D) greater than 0.5 eV

89 The opposite figure shows monochromatic light falling with the same intensity on two different surfaces (x, y) whose threshold frequencies are $1/3\ \upsilon$ and $1/2\ \upsilon$ respectively. Which of the following graphs represents the ratios of the kinetic energies of the electrons emitted from the two surfaces?



90 Light of frequency 6×10^{14} Hz fell on a metal surface and the maximum kinetic energy of the emitted electrons was 0.18 eV. When light of frequency 1.6×10^{15} Hz fell on the same metal surface, the maximum kinetic energy of the emitted electrons was 4.32 eV. The value of Planck's constant is .....

(A) 6.626×10^{-34} J.s
(B) 6.602×10^{-34} J.s
(C) 6.624×10^{-34} J.s
(D) 6.614×10^{-34} J.s

91 The energy needed to free an electron from a metal surface is 3.968×10^{-19} J. Three monochromatic light beams of wavelengths 7000 Å, 6200 Å and 5000 Å fall on the metal surface:

(1) the light beam that frees electrons is the one of wavelength .....

(A) 7000 Å (B) 6200 Å (C) 5000 Å (D) all of them

92 The energy needed to free an electron from a metal surface is 3.968×10^{-19} J. Three monochromatic light beams of wavelengths 7000 Å, 6200 Å and 5000 Å fall on the metal surface:

(2) the energy of the freed electron equals .....

(A) 1.14×10^{-21} J (B) 3.97×10^{-21} J (C) 7.94×10^{-22} J (D) 7×10^{-22} J

93 In two different experiments on the photoelectric effect, two beams of electromagnetic rays of frequencies 4×10^{15} Hz and 6×10^{15} Hz fell on two surfaces of the same metal, and the ratio between the maximum kinetic energies of the released electrons in the two experiments respectively was 1 : 3. The threshold frequency of this surface is .....

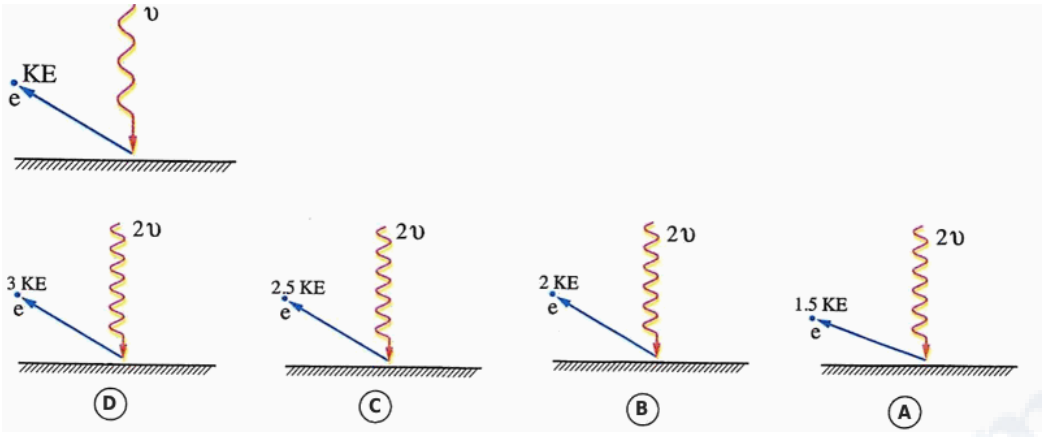
(A) 2×10^{15} Hz (B) 10^{15} Hz (C) 3×10^{15} Hz (D) 4×10^{15} Hz

94 The opposite table shows the radiation intensity and frequency of three spectra (A, B, C), each used separately to light a metal surface whose work function is 3.056×10^{-19} J. Which of these spectra (A, B, C) can free the largest number of electrons per second?

Intensity	Frequency (Hz)	Spectrum
High	3.5×10^{14}	A
Medium	5.5×10^{14}	B
Low	7.5×10^{14}	C

(A) A (B) B (C) C (D) B and C together

95 The opposite figure shows the photoelectric effect for a certain metal surface whose work function is $1/2$ hν. Which of the following figures shows a surface of the same metal?



96 Light fell on a metal surface whose work function is 3 eV:

(1) the lowest frequency of light that causes photoelectrons to be emitted equals .....

(A) 4.5×10^{15} Hz (B) 1.21×10^{15} Hz (C) 7.25×10^{14} Hz (D) 4.5×10^{14} Hz

97 Light fell on a metal surface whose work function is 3 eV:

(2) the longest wavelength of light that causes photoelectrons to be emitted is .....

(A) 1.07×10^{-7} m (B) 4.14×10^{-7} m (C) 6.67×10^{-8} m (D) 1.07×10^{-8} m

98 Light fell on a metal surface whose work function is 3 eV:

(3) the frequency of the light that causes photoelectrons to be emitted with a maximum kinetic energy of 2 eV is .....

(A) 1.5×10^{14} Hz (B) 3.03×10^{14} Hz (C) 1.21×10^{15} Hz (D) 2.71×10^{15} Hz

99 The opposite table shows the wavelengths of some colours of the visible spectrum. If these colours fall on the cathode of a photoelectric cell whose surface work function is 2.2 eV:

(1) the colours that cause photoelectrons to be emitted when they fall on the cathode are .....

Wavelength (Å)	Colour
6500	Red
5800	Yellow
5625	Green
4500	Blue
4000	Violet

(A) red and yellow only (B) blue and violet only

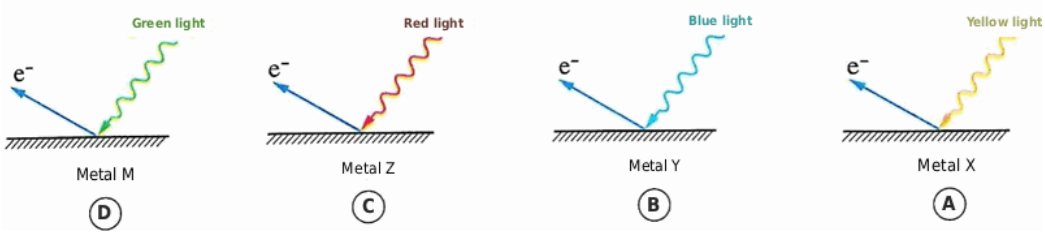
(C) violet only (D) green, blue and violet

100 The opposite table shows the wavelengths of some colours of the visible spectrum. If these colours fall on the cathode of a photoelectric cell whose surface work function is 2.2 eV:
(2) the greatest speed of the emitted electrons when these colours fall on the cathode surface is .....

Wavelength (Å)	Colour
6500	Red
5800	Yellow
5625	Green
4500	Blue
4000	Violet

(A) 445×10^3 m/s (B) 13.38×10^3 m/s (C) 5.64×10^5 m/s (D) 5.41×10^4 m/s

101 In the following figures, electrons with the same maximum kinetic energy were emitted from the surface of each metal. Which of these metals has the largest surface work function?



(A) Metal X (B) Metal Y (C) Metal Z (D) Metal M

102 Monochromatic light of wavelength λ fell on a metal surface and the kinetic energy of the emitted electrons was 1.6×10^{-19} J. When another monochromatic light of wavelength $(\lambda)/2$ fell on the same surface, the kinetic energy of the emitted electrons was 6.4×10^{-19} J. The work function of this surface equals .....

(A) 1.2×10^{-19} J (B) 1.6×10^{-19} J (C) 2.4×10^{-19} J (D) 3.2×10^{-19} J

103 When the frequency of the photons falling on the metal surface in a photoelectric cell increases by 20%, the kinetic energy of the electrons emitted from the metal surface increases from 0.5 eV to 0.8 eV. The work function of this metal is .....

(A) 6.4×10^{-19} J (B) 4.8×10^{-19} J (C) 3.2×10^{-19} J (D) 1.6×10^{-19} J

Essay questions — 18 questions

1. Compare: the radiation emitted by the Sun (a glowing body) and the radiation emitted by the Earth (a non-glowing body)
(in terms of: the region in which the wavelength of maximum radiation intensity lies).

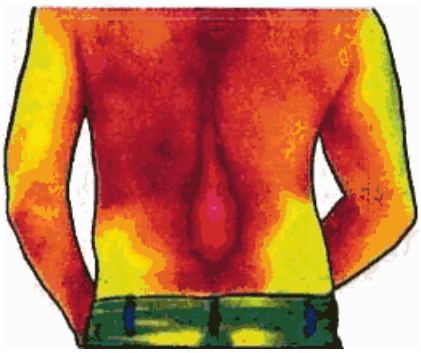
2. How did Max Planck explain the fall in the intensity of radiation emitted by a glowing body at high frequencies?

3. Give a reason: a person can see the radiation emitted by a glowing piece of coal in a dark room, while he cannot see some of the things in the room.

4. An iron rod was heated gradually and different colours of the radiation it emits were seen at different temperatures. What is the dominant visible colour that appears first while heating the rod? How do you explain this?

5. State one application (or use) of:
(1) infrared rays.
(2) micrometre waves.
(3) the thermal radiation emitted by the human body.

6. The opposite figure shows a picture taken with a special type of camera. Explain what the different colour of each part shows, and what scientific idea this type of imaging depends on.



7 The opposite diagram shows the structure of a cathode ray tube:

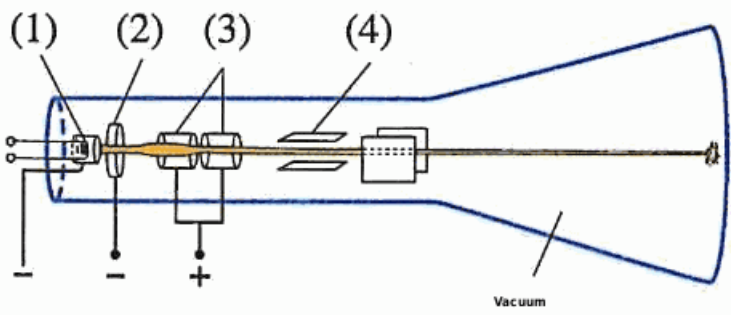
(1) Which part are the electrons emitted from? What condition is needed for their emission?

(2) How does part (2) control the brightness of the fluorescent screen from one point to another?

(3) State two functions that part (3) performs for the electron beam.

(4) What factor controls the speed of the electrons when they reach part (3)?

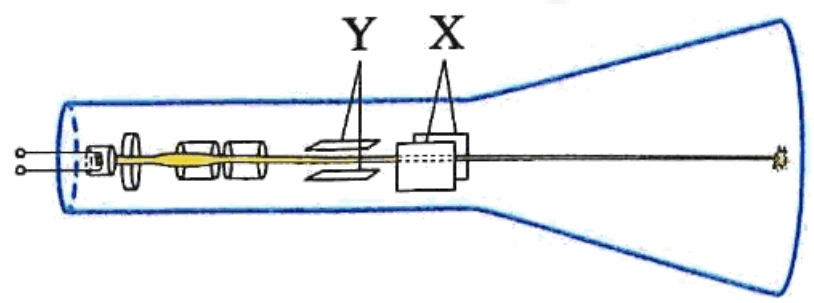
(5) Why is the tube evacuated of air?



8 The opposite figure shows a diagram of a cathode ray tube working perfectly. What happens to the cathode rays inside the tube when:

(1) the X plates stop working?

(2) the Y plates stop working?



9 The opposite figure represents a photoelectric cell:

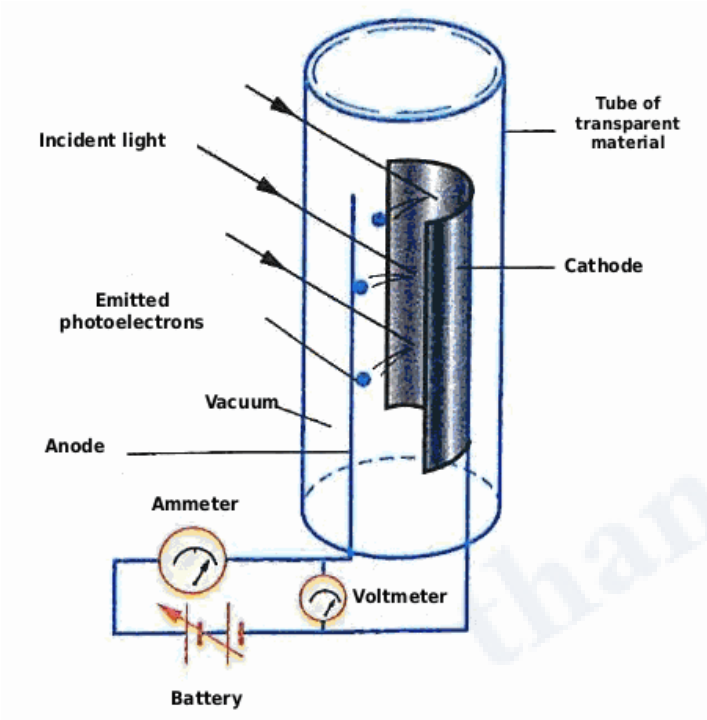
(1) Explain why the anode is made of a thin wire.

(2) Which property of the incident light can be increased to increase the ammeter reading?

(3) What are the factors that affect each of:

(a) the work function of the metal surface?

(b) the maximum kinetic energy of the electrons emitted from the cathode?



10 Explain: electrons may not be emitted from a metal surface even though it is exposed to a certain electromagnetic radiation for a long time.

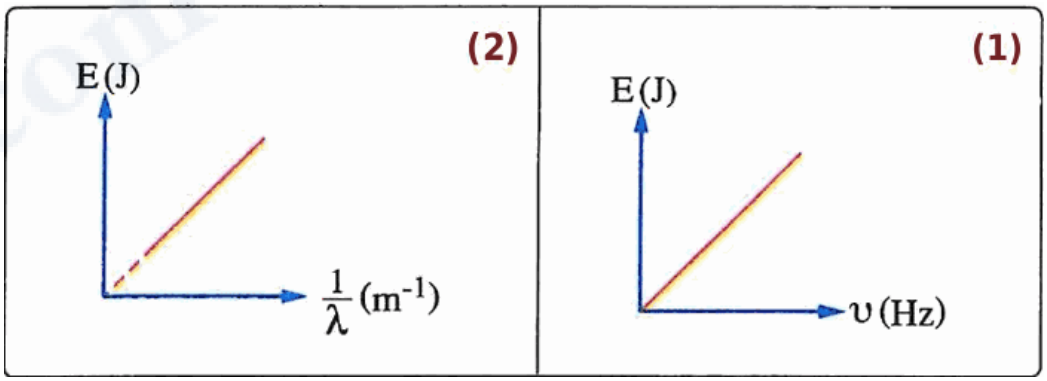
11 Explain why, when very bright red light falls on a caesium surface, no photoelectrons are emitted, while when dim blue light falls on it, photoelectrons are emitted from the surface.

12 Compare: the cathode ray tube and the photoelectric cell (in terms of: the type of energy that frees the electrons from the cathode).

13 If the work function of copper is 4.4 eV, can visible light free electrons when it is shone on a copper surface? Explain your answer.

14 Write the mathematical relation shown by the graph and what the slope of the straight line equals for each of the following:

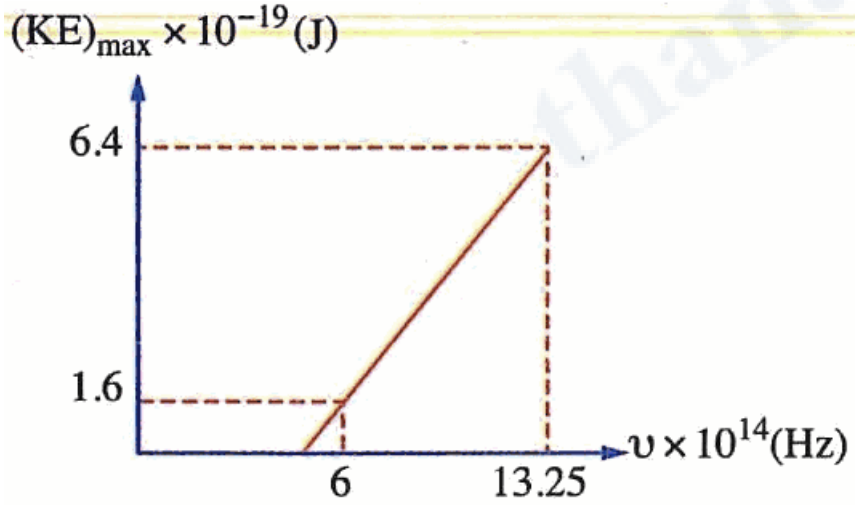
where: (υ) is the frequency, (E) the photon energy, (λ) the photon wavelength.



15 A scientist plotted the values he got in an experiment on the photoelectric effect for a metal, as in the opposite graph. Find:

(1) Planck's constant.

(2) the threshold frequency of the metal.

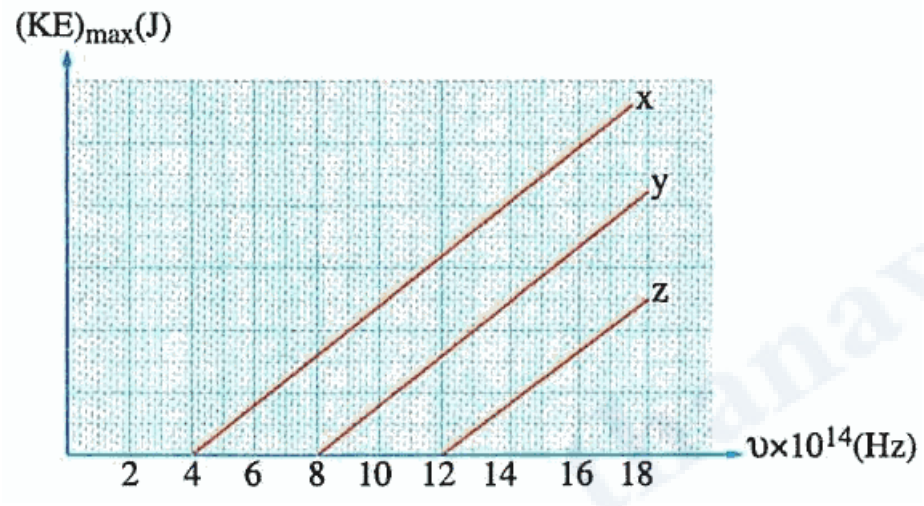


16 The opposite graph shows the relation between the maximum kinetic energy of the electrons emitted from the surfaces of three metals (x , y , z) and the frequency of the light falling on each. Using the graph:

(1) Calculate the work function of metal y.

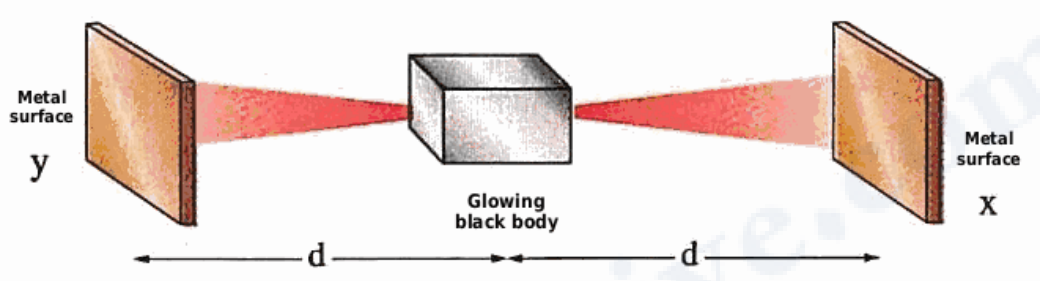
(2) What is the lowest frequency of electromagnetic radiation needed to free an electron from any of these metals?

(3) If light of a certain frequency falls so that it frees electrons from the surface of each of the three metals, which metal releases electrons with the greatest kinetic energy? Explain your answer.



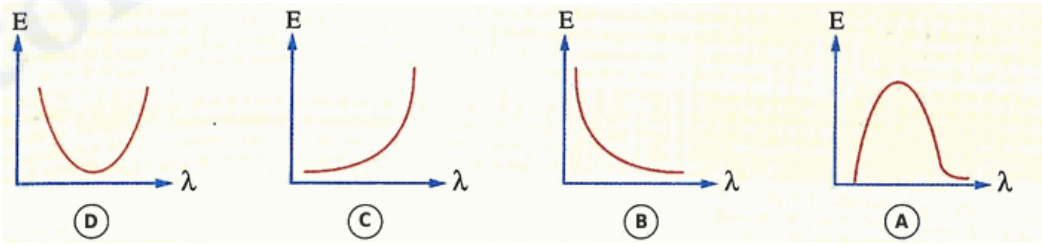
17 Light of frequency υ_1 fell on the surface of metal x whose work function is (Ew)x, and photoelectrons were emitted with a maximum kinetic energy $(KE)_1$. Another light of frequency υ_2 fell on the surface of metal y whose work function is (Ew)y, and photoelectrons were emitted with a maximum kinetic energy $(KE)_2$. Given that (Ew)y < (Ew)x and $(KE)_2 = (KE)_1$, which light has the higher frequency? Explain your answer.

18 The opposite figure shows a glowing black body placed midway between two metal surfaces (x , y). The work function of metal (x) is twice that of metal (y), and electrons were emitted from both surfaces. From which surface are electrons emitted at a greater rate? Why?

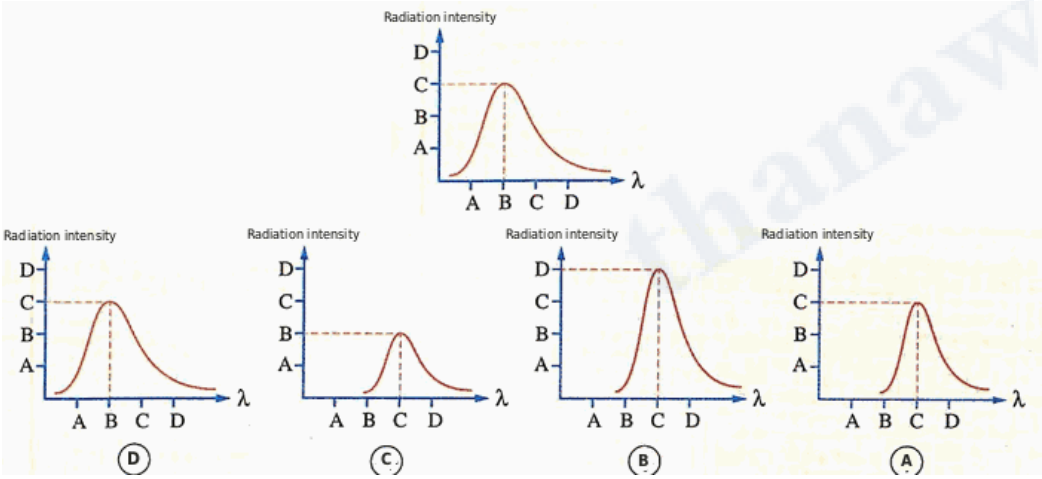


Past exam questions — 27 questions

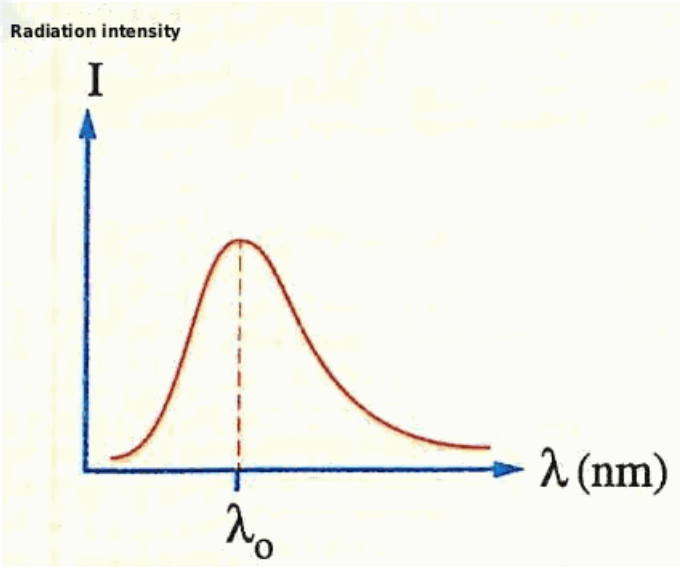
1 Which of the following graphs shows the relation between the photon energy (E) in black body radiation and its wavelength (λ)? (1st session 2023)



2 The opposite figure represents Planck's curve for the radiation emitted by a hot body. If the body is left to cool, the curve can be represented by figure ..... (2nd session 2023)
(Note: the figures are not drawn to scale)



3 The opposite graph shows Planck's curve for the radiation of a hot body at 6000 K, and the wavelength at maximum radiation intensity emitted by the body is λ_0. For the wavelength at maximum radiation intensity to become $(2\lambda_0)$, ... (2nd session 2024)



(A) the temperature must be lowered by 1500 K

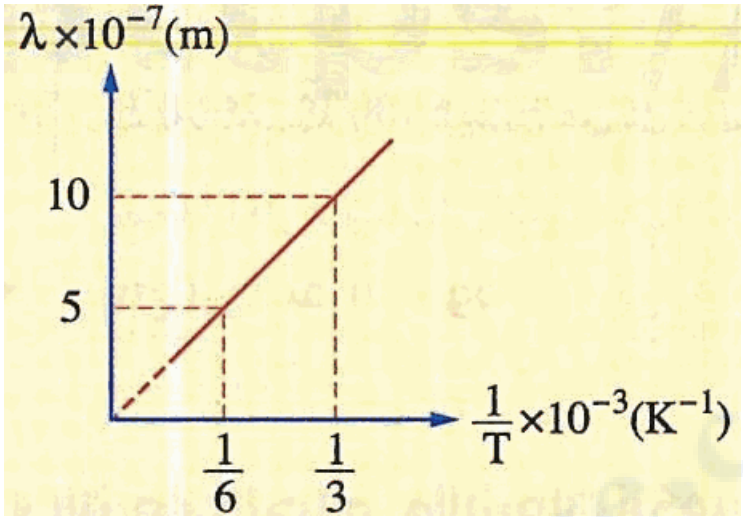
(B) the temperature must be raised by 3000 K

(C) the temperature must be lowered by 3000 K

(D) the temperature must be raised by 1500 K

---

4 The opposite graph shows the relation between the wavelength (λ) at maximum radiation intensity emitted by a hot body and the reciprocal of the temperature $(1/T)$ on the kelvin scale. The wavelength at maximum radiation intensity emitted by the body at 2000 K equals ..... (1st session 2024)

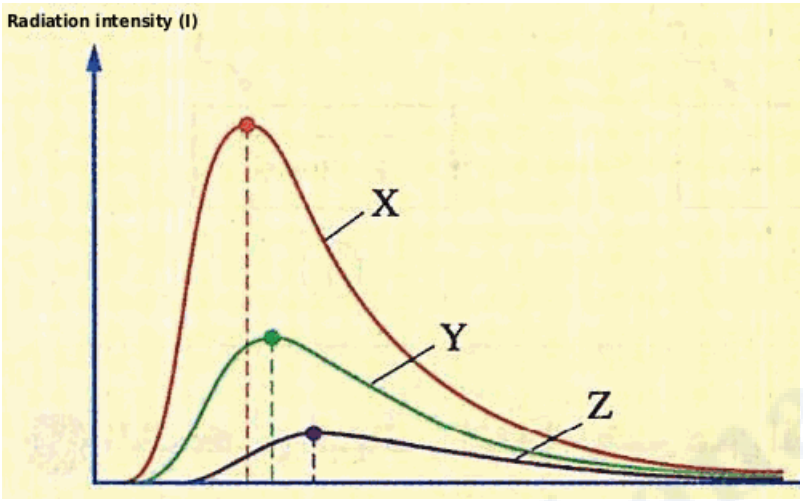


(A) *15000 AA* (B) *20000 AA* (C) *15000 nm* (D) *20000 nm*

5 A laser is emitted with a wavelength of 200 nm. How many emitted laser photons have a total energy of 1 joule? (Sample exam 2025)

(A) 8.32×10^{18} (B) 1.01×10^{18} (C) 1.36×10^{18} (D) 9.95×10^{19}

6 The graph represents the relation between the intensity of electromagnetic radiation (I) and the wavelength (λ) of the radiation emitted by three glowing bodies (X), (Y), (Z). Which of the following statements is correct? (1st session 2025)



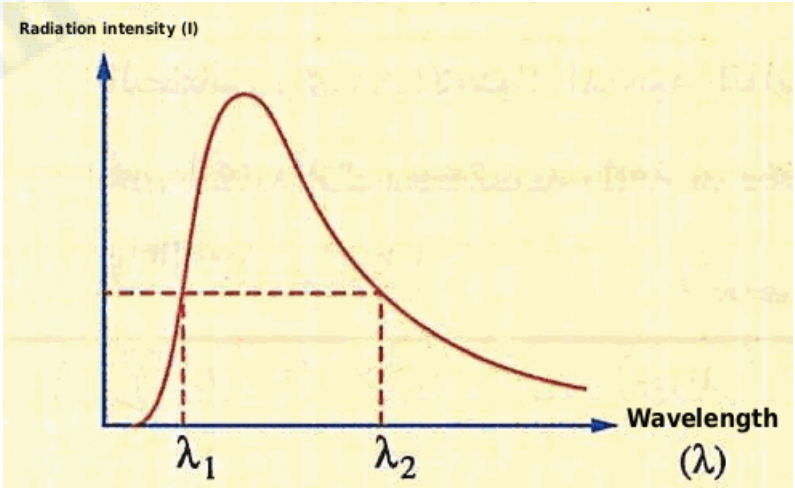
(A) Body (X) has the highest temperature of the three bodies

(B) Body (Y) has the highest temperature of the three bodies

(C) Body (Z) has the highest temperature of the three bodies

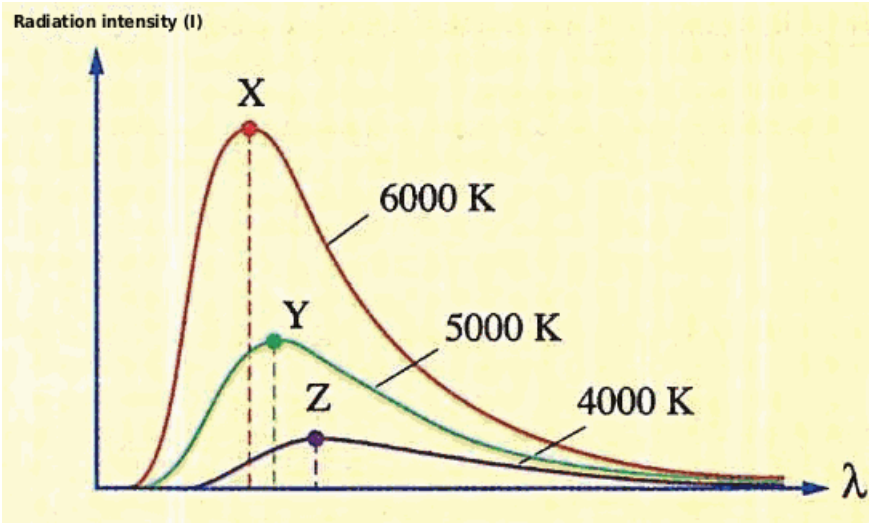
(D) The three bodies have the same temperature

7 The opposite graph represents Planck's curve for solar radiation. The radiation of wavelength λ_2 may be ..... rays, and the energy of one of its photons is ..... the energy of a photon of the radiation of wavelength λ_1 (2nd session 2025)



(A) ultraviolet , equal to
(B) ultraviolet , greater than
(C) infrared , less than
(D) infrared , equal to

8 The graph represents the relation between the intensity of electromagnetic radiation (I) and the wavelength (λ) of the radiation emitted by three glowing bodies. The ratio between the wavelengths at maximum radiation intensity $(\lambda_Z : \lambda_Y : \lambda_X)$ is ..... (Sample exam 2026)

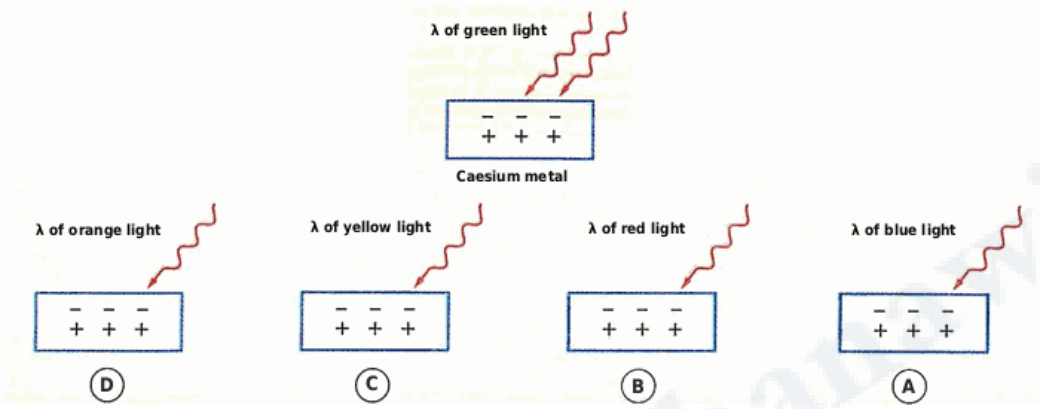


(A) *4 : 5 : 6*
(B) *6 : 5 : 4*
(C) *5 : 10 : 12*
(D) *15 : 12 : 10*

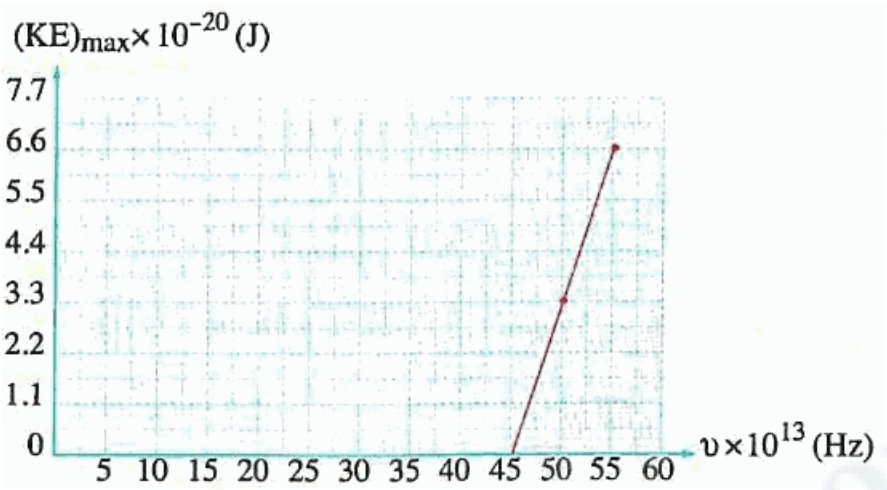
9 Two glowing bodies (X) and (Y) of the same material and the same surface area, at temperatures 2000 K and 6000 K respectively, each emit electromagnetic radiation. If the frequencies at which their maximum radiation intensity occurs are $upsilon_X$ and $upsilon_Y$ respectively, the ratio $(upsilon_X)/(upsilon_Y)$ equals ..... (Sample exam 2026)

(A) 1/3 (B) 3/1 (C) 3/4 (D) 4/3

10 In the opposite figure, when one of the wavelengths of green light falls on a caesium surface, electrons are only just freed from it. In which of the following figures are electrons freed from the caesium surface with kinetic energy? (Trial exam / June 2021)

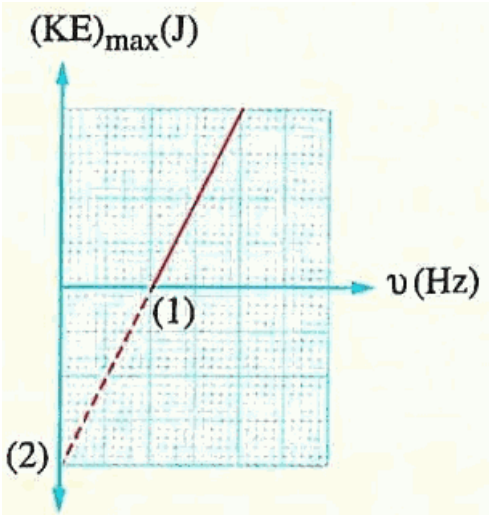


11 The opposite graph shows the relation between the maximum kinetic energy of the electrons emitted from the photoelectric cell and the frequency of the light falling on the cathode. Which of the following wavelengths frees electrons with a kinetic energy of 6.6×10^{-20} J? (Trial exam / June 2021)



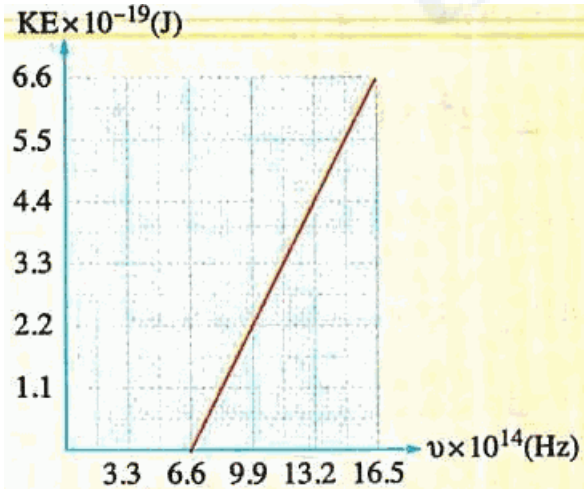
(A) 5.5×10^{-7} m (B) 5.3×10^{-7} m (C) 5.6×10^{-7} m (D) 5.7×10^{-7} m

12 The opposite graph represents the relation between the maximum kinetic energy of the electrons released from a metal surface and the frequency of the light falling on it. The unit of the value of point (2) divided by the value of point (1) is ..... (1st session 2021)



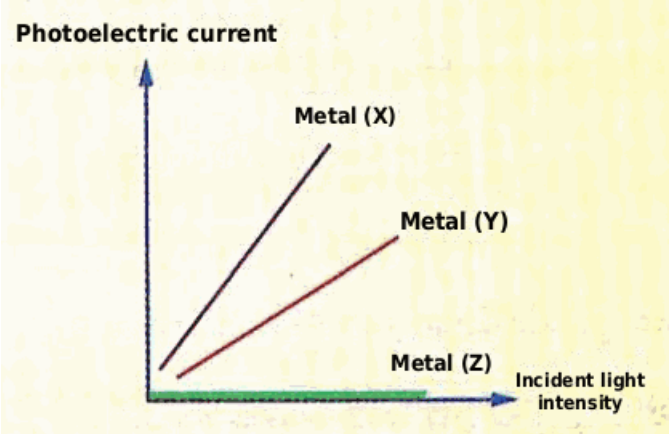
(A) $kg.m^2.s$ (B) J/s (C) $kg.m^2.s^{-1}$ (D) $kg.m.s^{-1}$

13 The opposite graph represents the relation between the maximum kinetic energy of the electrons emitted from the cathode surface of a photoelectric cell and the frequency of the incident light. The work function of the surface is ..... (1st session 2021)



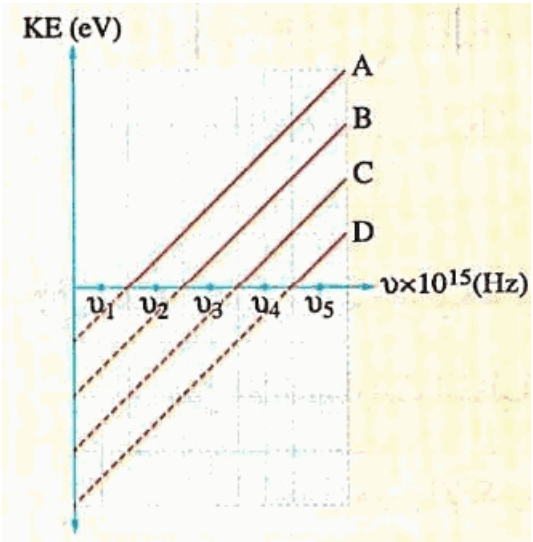
(A) 2.7 eV (B) 0.27 eV (C) 0.027 eV (D) 27 eV

14 The opposite figure shows the relation between the photoelectric current and the intensity of the light falling on the cathode of three photoelectric cells of different metals (X, Y, Z). Which metal has a threshold frequency greater than the frequency of the incident light? (2nd session 2021)



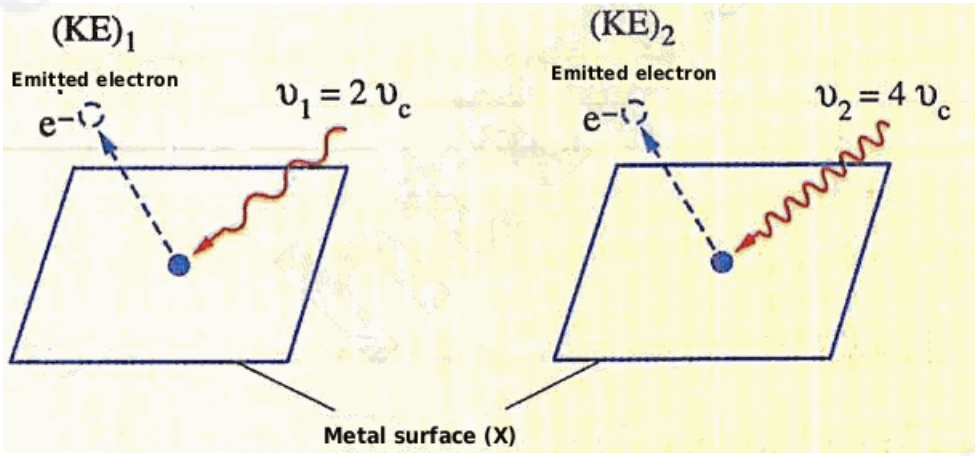
(A) Metal (X) (B) Metal (Y) (C) Metal (Z) (D) All the metals

15 The graph represents the relation between the kinetic energy of the electrons released from the surfaces of four metals (A, B, C, D) and the frequency of the light falling on each. Which frequency allows electrons to be emitted from the surfaces of metals (A, B) only and not from the surfaces of metals (C, D)? (1st session 2022)



(A) $upsilon_3$ (B) $upsilon_5$ (C) $upsilon_2$ (D) $upsilon_4$

16 The figure shows a metal surface X whose threshold frequency is $upsilon_c$. A photon of frequency $(upsilon_1 = 2upsilon_c)$ fell on it and the electron was freed with a maximum kinetic energy $(KE)_1$. When the photon was replaced by another of frequency $(upsilon_2 = 4upsilon_c)$, the electron was freed with a maximum kinetic energy $(KE)_2$. The ratio $((KE)_1)/((KE)_2)$ = ... (1st session 2022)

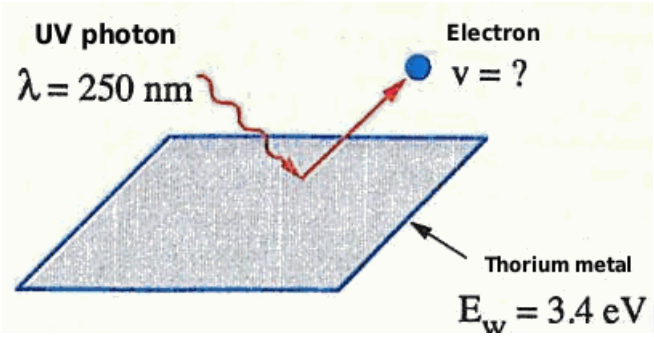


(A) 1/2 (B) 1/3 (C) 1/4 (D) 1/8

17 A metal surface has a work function (E_w). A photon of energy (E_1), equal to three times the work function, fell on it and the electron was freed with speed (v). When the first photon is replaced by another of energy (E_2), equal to seven times the work function, the electron will be freed with speed ..... (2nd session 2022)

(A) $\sqrt{(3)}\ v$ (B) $3\ v$ (C) $\sqrt{(6)}\ v$ (D) $6\ v$

18 Given that the electron mass = $9.1 \times 10^{-31}\ kg$, the electron charge = $1.6 \times 10^{-19}\ C$, Planck's constant = $6.625 \times 10^{-34}\ J.s$ and the speed of light in vacuum = $3 \times 10^{8}\ m/s$, and using the data on the drawing, the maximum speed of the electron emitted when a UV photon falls on a thorium surface equals ..... (2nd session 2022)



(A) $7.43 \times 10^{4}\ m/s$ (B) $7.43 \times 10^{6}\ m/s$ (C) $7.43 \times 10^{5}\ m/s$ (D) $7.43 \times 10^{3}\ m/s$

19 Electromagnetic radiation fell on three surfaces of different metals A, B, C, and photoelectrons were freed from each surface. If the order of the work functions of these metals is $(E_w)_C > (E_w)_B > (E_w)_A$, which of the following choices gives the correct order of the maximum kinetic energy of the photoelectrons? (Trial exam 2023)

(A) $(KE)_B < (KE)_A < (KE)_C$
(B) $(KE)_C < (KE)_B < (KE)_A$
(C) $(KE)_A < (KE)_C < (KE)_B$
(D) $(KE)_C < (KE)_A < (KE)_B$

20 When the grid potential in a cathode ray tube is changed from $(-12\ V)$ to $(-4\ V)$ while the potential difference between the anode and the cathode stays constant, which of the following choices is correct? (1st session 2024)

(A) rate of electrons passing through the grid: decreases , screen brightness: increases
(B) rate of electrons passing through the grid: increases , screen brightness: increases
(C) rate of electrons passing through the grid: decreases , screen brightness: decreases
(D) rate of electrons passing through the grid: increases , screen brightness: decreases

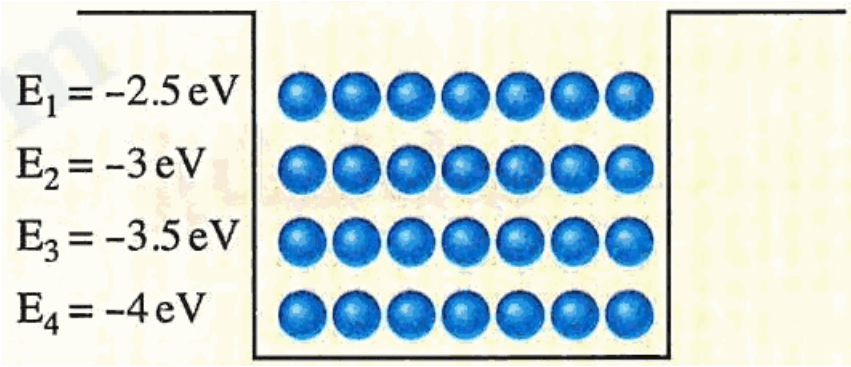
21 When photons of light of frequency (υ) fell at a rate φ_L on the cathode of a photoelectric cell, the photoelectric current produced was 3 mA. When the rate at which photons of the same light fall on the cathode is doubled, ... (1st session 2024)

(A) current: 3 mA , work function: stays the same
(B) current: 3 mA , work function: becomes half
(C) current: 6 mA , work function: stays the same
(D) current: 9 mA , work function: doubles

22 If the potential difference used between the anode and the cathode in a cathode ray tube is 500 V, the maximum kinetic energy of the electrons emitted from the cathode equals ..... (Sample exam 2025)

(A) $4 \times 10^{-17}\ J$
(B) $8 \times 10^{-17}\ J$
(C) $12 \times 10^{-17}\ J$
(D) $16 \times 10^{-17}\ J$

23 The opposite figure represents a diagram of the binding energy of the electrons in a metal surface. The work function of the metal surface equals ..... (Sample exam 2025)

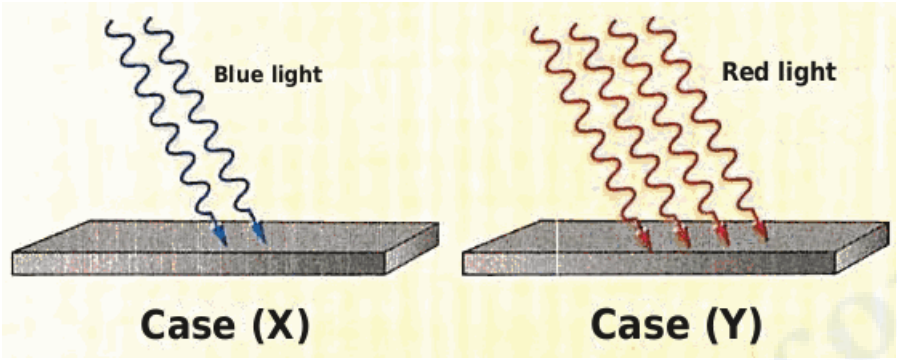


(A) 2.5 eV (B) 3 eV (C) 3.5 eV (D) 4 eV

24 Photoelectrons are emitted from a metal surface when a certain light falls on it. What happens to the work function and to the maximum kinetic energy of the emitted electrons when another light of higher frequency falls on the metal? (Trial exam 2023)

25 Monochromatic light of frequency $6 \times 10^{14}\ Hz$ fell on the cathode of a photoelectric cell and electrons were emitted with a maximum kinetic energy of 1 eV. When another light of frequency (X) hertz fell on the same cathode, the maximum kinetic energy of the emitted electrons was 0.38 eV. Calculate the frequency of light (X). (1st session 2023)

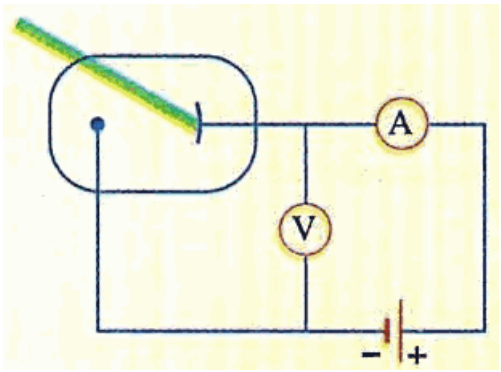
26 The figure shows the photoelectric effect in two cases (X, Y). In case (X), dim blue light falls on the metal surface, and in case (Y), high-intensity red light falls on the same metal surface. Assuming electrons are emitted from the metal surface in both cases, compare the photoelectrons emitted in the two cases (in terms of: their maximum speed - their rate of emission). (1st session 2025)



27 The figure shows a photoelectric cell circuit on which a beam of monochromatic light falls. The ammeter reads a weak photoelectric current in the circuit. To increase the photoelectric current in the circuit, what must be done about: (2nd session 2025)

(1) the way the battery is connected in the circuit?

(2) the properties of the light falling on the cell?



Answer key and solutions

Multiple choice questions

1 A	2 B	3 C	4 A	5 B	6 D	7 D	8 C	9 D	10 A
11 A	12 A	13 B	14 A	15 A	16 C	17 C	18 A	19 C	20 A
21 B	22 C	23 C	24 C	25 B	26 C	27 A	28 D	29 B	30 C
31 B	32 C	33 D	34 D	35 B	36 D	37 C	38 B	39 A	40 B
41 B	42 B	43 D	44 B	45 A	46 D	47 A	48 D	49 C	50 C
51 A	52 A	53 A	54 C	55 D	56 A	57 C	58 B	59 A	60 A
61 D	62 B	63 B	64 D	65 B	66 C	67 A	68 B	69 B	70 D
71 A	72 D	73 C	74 B	75 C	76 C	77 C	78 B	79 B	80 C
81 B	82 A	83 B	84 A	85 B	86 C	87 D	88 D	89 A	90 C
91 C	92 D	93 C	94 B	95 D	96 C	97 B	98 C	99 D	100 C
101 B	102 D	103 D							

1 **Answer (A)**

Red light has a longer wavelength than ultraviolet,
so the ratio $(\lambda_{red})/(\lambda_{UV})$ is greater than one.

2 **Answer (B)**

A black surface absorbs more radiation than a white one,
so surface B gets hotter.

3 **Answer (C)**

The dominant colour of black body radiation changes with its temperature only,
and does not depend on its material or mass.

4 **Answer (A)**

The colour shows the temperature: yellowish white is the hottest and dark red is the coolest, so position A is the coolest.

5 **Answer (B)**

The hotter body (x) has a higher peak, shifted to a shorter wavelength, and the cooler body (y) has a lower peak at a longer wavelength.

6 **Answer (D)**

When the temperature decreases:
the peak shifts to lower frequencies,
and the area under the curve (the total energy) decreases.

7 **Answer (D)**

Taking out the iron rod decreases the inductive reactance of the coil, so the current increases and the lamp glows more brightly.
I_0 increases and λ_0 decreases

8 **Answer (C)**

The total radiated energy is proportional to T^4.
Body x is hotter, so the ratio of its energy to that of y is greater than one.

9 **Answer (D)**

At very high frequencies the radiation intensity approaches zero, and this is what Planck explained.

10 **Answer (A)**

A peak in the visible region means a very hot body, such as a glowing star.

11 **Answer (A)**

Raising the temperature increases the number of photons emitted per second.

12 **Answer (A)**

Raising the temperature increases the intensity, so the value of I becomes greater.

13 **Answer (B)**

At λ_1 the intensity is lower and the photon energy is greater,
so fewer photons are emitted at λ_1 than at λ_2.

14 **Answer (A)**

Classical physics predicted that the intensity increases without limit at short wavelengths,
and this contradicts the curve in region A.

15 **Answer (A)**

Most of the energy of a glowing lamp is infrared (invisible),
so the ratio of invisible to visible energy is greater than one.

16 **Answer (C)**

Wien's law: $\lambda_m T = const$
An inverse relation: the graph is a hyperbola.

17 **Answer (C)**

$\lambda_m T = const$
$(\lambda_1)/(\lambda_2) = T_2/T_1 = 2400/9600 = 1/4$

18 **Answer (A)**

$\lambda_m T = const$
$\lambda' = 10\lambda \Rightarrow T' = 3000/10 = 300\ K$

19 **Answer (C)**

$\lambda_1 T_1 = \lambda_2 T_2$
$T_{Earth} = (6000 \times 0.499)/9.66 = 309.9\ K$

20 **Answer (A)**

Raising the temperature decreases λ by $5/8\lambda_0$, so it becomes $3/8\lambda_0$
$T_0\lambda_0 = (T_0 + 500)3/8\lambda_0$
$T_0 = 300\ K$

21 **Answer (B)**

From the graph: $\lambda_m \propto 1/T$
$\lambda_m = 690/(2.38 \times 10^{-4}) \cdot 1/4830 = 600\ nm$
which is in the visible region.

22 **Answer (C)**

Warm bodies emit infrared rays,
so night vision devices depend on them.

23 **Answer (C)**

As the frequency increases beyond a certain limit, fewer photons are emitted,
and this explains why the curve falls at high frequencies.

24 **Answer (C)**

The atom moves from a higher to a lower level, so it emits a photon.
$E = h\nu$

25 **Answer (B)**

$E = h\nu = 6.625 \times 10^{-34} \times 5 \times 10^{14} = 3.3 \times 10^{-19}\ J$

26 **Answer (C)**

Cathode rays are charged particles (electrons).

27 **Answer (A)**

Part (1) is the filament from which the electrons are emitted.

28 **Answer (D)**

Part (4) is the deflecting plates, responsible for changing where the beam hits the screen.

29 **Answer (B)**

Part (2) is the grid, which controls the number of electrons and so the brightness.

30 **Answer (C)**

The filament (cathode) is negative and the grid slightly negative,
and the two anodes are positive to accelerate the electrons.

31 **Answer (B)**

Making the grid more negative decreases the number of electrons passing,
so the brightness decreases.

32 **Answer (C)**

The filament is the source of electrons,
so if it is damaged no electrons are emitted and the screen does not light up.

33 **Answer (D)**

The grid is what changes the brightness,
and with no signal on it the brightness stays almost constant.

34 **Answer (D)**

When the moving system is not working the beam is not deflected,
so a single bright spot appears on the screen.

35 **Answer (B)**

Electrons are negative, so they are attracted to the positive plate,
and the beam is deflected towards it.

36 **Answer (D)**

The kinetic energy of the electrons at the anode depends on the potential difference between the anode and the cathode.

$KE = eV$

37 **Answer (C)**

The rate of emission from the filament is controlled by heating it,
so it does not change when the potential difference changes.

38 **Answer (B)**

$KE = eV = 1/2mv^2$

$v \propto \sqrt{(V)}$

$v' = \sqrt{(2)}\, v$

39 **Answer (A)**

$v^2 = 2eV/m$

A direct linear relation through the origin.

40 **Answer (B)**

$KE = eV = 1.6 \times 10^{-19} \times 1000 = 1.6 \times 10^{-16}\ J$

41 **Answer (B)**

$v = \sqrt{(2eV/m)} = \sqrt{((2 \times 1.6 \times 10^{-19} \times 1000)/(9.1 \times 10^{-31}))}$

$v = 1.88 \times 10^{7}\ m/s$

42 **Answer (B)**

Emission depends on the type of the cathode material (work function) and the frequency of the incident light.

43 **Answer (D)**

KE_{max} does not depend on the light intensity,
so the graph is a horizontal line.

44 **Answer (B)**

The speed of a photon is always constant (c), whatever its frequency.

45 **Answer (A)**

$E_1 = \varphi + KE = E_2 + \varphi$
so the photon has more energy than the freed electron.
$E_1/E_2 > 1$

46 **Answer (D)**

Doubling the intensity doubles the number of photons,
so the number of electrons doubles, that is the photoelectric current.

47 **Answer (A)**

The work function:
$\varphi = 1240/591.5 = 2.096\ eV$
The energy of the photon needed:
$E = 2.096 + 1.81 = 3.906\ eV$
$\lambda = 1240/3.906 \approx 318\ nm$

48 **Answer (D)**

The rate decreases when the light intensity decreases,
so the number of photons decreases but does not become zero.

49 **Answer (C)**

The rate of emission depends on the intensity of the beam (the number of photons),
provided the frequency is above the threshold frequency.

50 **Answer (C)**

The number of electrons is proportional to the number of incident photons,
which has not changed, so the number of electrons does not change.

51 **Answer (A)**

Increasing the lamp's brightness increases the number of photons,
so the photoelectric current increases.

52 **Answer (A)**

Raising the temperature increases the total energy and the photons per second,
so the rate of emission increases.

53 **Answer (A)**

Raising the temperature shifts the peak to higher frequencies,
so the maximum kinetic energy increases.

54 **Answer (C)**

The work function is a property of the metal,
and does not depend on the frequency of the light, so it stays constant.

55 **Answer (D)**

$KE_{max} = hc/(\lambda) - \varphi$
A straight line that cuts the $1/(\lambda)$ axis at a positive value.

56 **Answer (A)**

The speed does not change when the intensity changes,
so the relation is a horizontal line.

57 **Answer (C)**

The frequency is below the threshold, so no electrons are emitted.
$N_2/t = 0$ for any value of N_1/t

58 **Answer (B)**

The frequency is above the threshold: each photon frees one electron.
$N_2/t \propto N_1/t$, a straight line from the origin.

59 **Answer (A)**

$KE = h\nu - \varphi$
The slope $= h$ and the intercept on the KE axis is $-\varphi = -a$
$a/b = (\varphi)/(\nu_0) = h$

60 **Answer (A)**

The lines are parallel (slope h).

The work function $\varphi = h\nu_0$

$\nu_A < \nu_B < \nu_D \Rightarrow E_A < E_B < E_D$

61 **Answer (D)**

x, y are caesium and z is silver (larger work function)

$KE = hc/(\lambda) - \varphi$

y has a shorter wavelength than x, so its speed is greater.

z has the lowest speed because its work function is larger.

$z < x < y$

62 **Answer (B)**

Potassium has the smaller work function $(1.8\ \text{eV})$, so its threshold frequency is lower.

The two lines are parallel (slope h) and the potassium line is on the left.

63 **Answer (B)**

At the same wavelength the kinetic energy for metal (2) is smaller,

so its work function is larger.

64 **Answer (D)**

$h = slope = C/(B - A)$

65 **Answer (B)**

$\varphi = h\nu_0$

At $4\nu_0$: $KE = 4h\nu_0 - h\nu_0 = 3\varphi$

$E_1/E_2 = (\varphi)/(3\varphi) = 1/3$

66 **Answer (C)**

$KE = E_{photon} - \varphi$

The photon energy must be greater than 3 eV.

$4 - 3 = 1\ eV$

67 **Answer (A)**

$h\nu = \varphi + KE = 3 + 2 = 5\ eV$

$2h\nu = 10\ eV$

$KE' = 10 - 3 = 7\ eV$

68 **Answer (B)**

$KE \propto (\nu - \nu_c)$ and $v \propto \sqrt{(KE)}$

$KE_2/KE_1 = (2-1)/(5-1) = 1/4$

$v_2/v_1 = 1/2$

$v_2 = 4 \times 10^6\ m/s$

69 **Answer (B)**

The same photon falls on both surfaces:

$KE_x - KE_y = \varphi_y - \varphi_x = 4 - 3 = 1\ eV$

so the surface with the smaller work function gives 1 eV more kinetic energy.

70 **Answer (D)**

$KE = hc/(\lambda) - \varphi$

$KE' = 2hc/(\lambda) - \varphi = 2KE + \varphi$

so it is greater than $2KE$.

71 **Answer (A)**

$E = 1240/623 = 1.99\ eV$

$KE = 1/2mv^2 = 9.6 \times 10^{-20}\ J$

$\varphi = E - KE = 2.23 \times 10^{-19}\ J$

72 **Answer (D)**

$\nu_0 = (\varphi)/h = (2.23 \times 10^{-19})/(6.625 \times 10^{-34})$

$\nu_0 = 3.37 \times 10^{14}\ Hz$

73 **Answer (C)**

Red has a lower frequency than yellow, which freed no electrons,

so no electrons are emitted and the rate becomes zero.

74 **Answer (B)**

The threshold frequency is in the blue region,

so the rays that free electrons have higher frequencies: they are ultraviolet.

75 **Answer (C)**

The 4, 5 and 6 eV photons freed electrons and the 3 eV photon did not.

$3 < \varphi < 4\ eV$

76 **Answer (C)**

$E = 12400/3100 = 4\ eV$

$\varphi = E - KE = 4 - 2.5 = 1.5\ eV$

77 **Answer (C)**

$\nu_0 = (\varphi)/h = (3.3125 \times 10^{-19})/(6.625 \times 10^{-34}) = 5 \times 10^{14}\ Hz$

78 **Answer (B)**

$\lambda = 1240/2.48 = 500\ nm = 5 \times 10^{-7}\ m$

79 **Answer (B)**

Light (a):

$E = 12400/4000 = 3.1\ eV$

$KE = 0.8\ eV \Rightarrow \varphi = 2.3\ eV$

Light (b):

$E = 12400/5500 = 2.25\ eV < \varphi$

so its frequency is less than the threshold frequency.

80 **Answer (C)**

The line cuts the frequency axis at $3 \times 10^{14}\ Hz$,

which is the threshold frequency.

81 **Answer (B)**

$\varphi = h\nu_0 = 6.625 \times 10^{-34} \times 3 \times 10^{14} = 2 \times 10^{-19}\ J$

$E = KE + \varphi = 20 \times 10^{-20} + 20 \times 10^{-20} = 4 \times 10^{-19}\ J$

$\lambda = hc/E = 5 \times 10^{-7}\ m$

82 **Answer (A)**

$\varphi = 9.6 \times 10^{-19}\ J$ from the intercept on the KE axis

$\lambda_0 = hc/(\varphi) = (6.625 \times 10^{-34} \times 3 \times 10^{8})/(9.6 \times 10^{-19})$

$\lambda_0 = 2.07 \times 10^{-7}\ m$

83 **Answer (B)**

$\varphi = 9.6 \times 10^{-19}\ J$

$h\nu = KE + \varphi = 19.2 \times 10^{-19}\ J$

$\nu = (19.2 \times 10^{-19})/(6.625 \times 10^{-34}) = 2.9 \times 10^{15}\ Hz$

84 **Answer (A)**

The line starts at ν_1, which is the threshold frequency, so $\varphi = h\nu_1 = 5 \times 10^{-19}\ J$

At $2\nu_1$: $KE = 2h\nu_1 - h\nu_1 = h\nu_1$

$X = 5 \times 10^{-19}\ J$

85 **Answer (B)**

Each photon frees only one electron,

however large its energy.

86 **Answer (C)**

$h\nu = KE + E_w$

$h(2\nu) = 2KE + 2E_w$

$KE' = 2KE + 2E_w - E_w = 2KE + E_w$

87 **Answer (D)**

$\varphi = hc/(\lambda_0) = (6.625 \times 10^{-34} \times 3 \times 10^8)/(3000 \times 10^{-10})$

$\varphi = 6.625 \times 10^{-19}\ J$

88 **Answer (D)**

$\varphi = 12400/3000 - 0.5 = 3.63\ eV$

$KE' = 12400/2000 - 3.63 = 2.57\ eV$

greater than $0.5\ eV$

89 **Answer (A)**

$KE = h\nu - h\nu_c$

$KE_x = h\nu(1-1/3) = 2/3h\nu$

$KE_y = h\nu(1-1/2) = 1/2h\nu$

$KE_x/KE_y = 4/3$

90 **Answer (C)**

$h = (\Delta KE)/(\Delta\nu) = ((4.32-0.18) \times 1.6 \times 10^{-19})/(1.6 \times 10^{15}-6 \times 10^{14})$

$h = 6.624 \times 10^{-34}\ J \cdot s$

91 **Answer (C)**

$\lambda_0 = hc/(\varphi) = (6.625 \times 10^{-34} \times 3 \times 10^8)/(3.968 \times 10^{-19}) \approx 5000\ mathringA$

The beam that frees electrons has a wavelength shorter than or equal to λ_0: 5000 Å

92 **Answer (D)**

$E = hc/(5000 \times 10^{-10}) = 3.975 \times 10^{-19}\ J$

$KE = 3.975 \times 10^{-19} - 3.968 \times 10^{-19} = 7 \times 10^{-22}\ J$

93 **Answer (C)**

$KE_1/KE_2 = (6 \times 10^{15} - \nu_0)/(4 \times 10^{15} - \nu_0) = 3$

$6 \times 10^{15} - \nu_0 = 12 \times 10^{15} - 3\nu_0$

$\nu_0 = 3 \times 10^{15}\ Hz$

94 **Answer (B)**

$\nu_0 = (3.056 \times 10^{-19})/(6.625 \times 10^{-34}) = 4.6 \times 10^{14}\ Hz$

Spectrum A has a frequency below the threshold, so it frees none.

B and C free electrons, and the number of electrons is proportional to the intensity, so spectrum B (the medium intensity) frees more than C.

95 **Answer (D)**

$\varphi = 1/2h\nu$

$KE = h\nu - 1/2h\nu = 1/2h\nu$

At 2ν: $KE' = 2h\nu - 1/2h\nu = 3/2h\nu = 3KE$

96 **Answer (C)**

$\nu_0 = (\varphi)/h = (3 \times 1.6 \times 10^{-19})/(6.625 \times 10^{-34}) = 7.25 \times 10^{14}\ Hz$

97 **Answer (B)**

$\lambda_{max} = hc/(\varphi) = 12400/3 \approx 4140\ mathringA$

$= 4.14 \times 10^{-7}\ m$

98 **Answer (C)**

$E = \varphi + KE = 3 + 2 = 5\ eV$

$\nu = (5 \times 1.6 \times 10^{-19})/(6.625 \times 10^{-34}) = 1.21 \times 10^{15}\ Hz$

99 **Answer (D)**

$\lambda_0 = 12400/2.2 = 5636\ mathringA$

The colours with shorter wavelengths than this: green (5625), blue and violet.

100 **Answer (C)**

The greatest speed is for the colour with the shortest wavelength (violet, 4000 Å).

$KE = 12400/4000 - 2.2 = 0.9\ eV = 1.44 \times 10^{-19}\ J$

$v = \sqrt{(2KE/m)} = 5.64 \times 10^{5}\ m/s$

101 **Answer (B)**

$\varphi = E_{photon} - KE$ with the same KE

so the largest work function is for the highest photon energy (blue), which is metal Y.

102 **Answer (D)**

$KE_1 = E - \varphi = 1.6 \times 10^{-19}$

$KE_2 = 2E - \varphi = 6.4 \times 10^{-19}$

Subtracting: $E = 4.8 \times 10^{-19}\ J$

$\varphi = 4.8 - 1.6 = 3.2 \times 10^{-19}\ J$

103 **Answer (D)**

$E - \varphi = 0.5$ and $1.2E - \varphi = 0.8$

Subtracting: $0.2E = 0.3 \Rightarrow E = 1.5\ eV$

$\varphi = 1.5 - 0.5 = 1\ eV = 1.6 \times 10^{-19}\ J$

Essay questions

1 **Model answer**

Radiation emitted by the Sun: the visible light region.

Radiation emitted by the Earth: the infrared region.

2 **Model answer**

In black body (glowing) radiation, at frequencies higher than the frequency of maximum intensity, as the frequency increases the photon energy increases, so fewer photons carrying that energy are emitted and the radiation intensity decreases.

3 **Model answer**

Because part of the radiation emitted by the piece of coal lies in the visible range since its temperature is high, while the radiation emitted by some things in the room lies in the invisible infrared range because their temperature is low.

4 **Model answer**

Red appears first while heating, because as the temperature of the iron rod rises, the maximum radiation intensity shifts gradually from the longer wavelengths of the infrared region towards shorter wavelengths, so red appears as the first visible radiation of the rod, then the colours with shorter wavelengths appear after it.

5 **Model answer**

(1) Exploring the Earth's resources, remote sensing, or night vision devices.
(2) Radar.
(3) Thermal imaging in medicine, especially for tumours.

6 **Model answer**

Each part has a different colour because its temperature is different, and this imaging depends on the thermal radiation emitted by bodies.

7 **Model answer**

(1) Part (1). It must be heated to a suitable temperature that gives its free electrons enough energy to overcome the surface potential barrier, so those electrons are emitted from it.
(2) Part (2) is the grid. Changing the negative potential of the grid changes the brightness of the screen: making this potential more negative increases the repulsion between the emitted electrons and the grid, so fewer electrons pass through the grid and reach the screen, and the brightness of the fluorescent screen decreases. The opposite happens when the negative potential of the grid is reduced.
(3) It accelerates the electrons, and lets a narrow beam of electrons pass through and directs it towards the screen.
(4) The potential difference between part (1), the cathode, and part (3), the anode.
(5) To stop the electrons colliding with air molecules as they move, which prevents them from scattering.

8 **Model answer**

(1) The path of the electron beam cannot be directed horizontally, and a vertical line appears on the screen.
(2) The path of the electron beam cannot be directed vertically, and a horizontal line appears on the screen.

9 **Model answer**

(1) So that it does not block the light falling on the cathode while the anode collects the electrons emitted from the cathode, which make a current pass through the external circuit.

(2) The intensity of the incident light.

(3) (a) The type of the surface material.

(b) The type of the surface material and the energy of the incident photons.

10 **Model answer**

Because the highest frequency in this electromagnetic radiation may be less than the threshold frequency of the metal surface. The condition for electrons to be emitted from the surface is that the frequency of the radiation falling on it is greater than or equal to the threshold frequency of the surface, and it does not depend on how long the surface is exposed to the radiation.

11 **Model answer**

Because the work function of caesium is greater than the energy of red light photons and less than the energy of blue light photons, so no electrons are emitted from the metal surface when red light falls on it, and they are emitted when blue light falls on it.

12 **Model answer**

Cathode ray tube: thermal energy.

Photoelectric cell: light energy.

13 **Model answer**

$\lambda_c = hc/E_w = (6.625 \times 10^{-34} \times 3 \times 10^8)/(4.4 \times 1.6 \times 10^{-19}) = 2.82 \times 10^{-7}\ m = 282\ nm$

Visible light ranges from 400 nm to 700 nm, so its wavelength is greater than λ_c and its frequency is less than $upsilon_c$.

Visible light cannot free electrons from the copper surface.

14 **Model answer**

(1) The relation: $E = hupsilon$, the slope: $(\Delta E)/(\Delta\ upsilon) = h$

(2) The relation: $E = hc/(\lambda)$, the slope: $(\Delta E)/(\Delta\ (1/\lambda)) = hc$

15 **Model answer**

(1) Planck's constant equals the slope of the straight line.

$h = (\Delta (KE)_{max})/(\Delta upsilon) = ((6.4 - 1.6) \times 10^{-19})/((13.25 - 6) \times 10^{14}) = 6.62 \times 10^{-34}\ J.s$

(2) From the graph, at $upsilon = 6 \times 10^{14}\ Hz : (KE)_{max} = 1.6 \times 10^{-19}\ J$

$upsilon_c = (hupsilon - (KE)_{max})/h = ((6.62 \times 10^{-34} \times 6 \times 10^{14}) - 1.6 \times 10^{-19})/(6.62 \times 10^{-34}) = 3.58 \times 10^{14}\ Hz$

16 **Model answer**

(1) $(E_w)_y = h(upsilon_c)_y = 6.625 \times 10^{-34} \times 8 \times 10^{14} = 5.3 \times 10^{-19}\ J$

(2) The lowest frequency needed to free an electron from any of these metals equals the largest threshold frequency $(upsilon_c)_z = 12 \times 10^{14}\ Hz$

(3) Metal x, because it has the smallest work function of the three metals. From $(KE)_{max} = E_{ph} - E_w$, with the photon energy constant, the smaller E_w is, the larger $(KE)_{max}$ is.

17 **Model answer**

$KE = hupsilon - E_w$ and $(KE)_1 = (KE)_2$

$hupsilon_1 - (E_w)_x = hupsilon_2 - (E_w)_y$

Since $(E_w)_x > (E_w)_y$, then $upsilon_1 > upsilon_2$

18 **Model answer**

The surface of metal (y), because the black body emits photons of different wavelengths (a continuous spectrum). When its radiation falls on the surface of metal y, which has the smaller work function, more of the incident photons per second can cause electrons to be emitted from the surface, so electrons are emitted at a greater rate.

Past exam questions

1	2	3	4	5	6	7	8	9	10
B	C	C	A	B	A	C	D	A	A
11	12	13	14	15	16	17	18	19	20
A	C	A	C	A	B	A	C	B	C
21	22	23	24	25	26	27			
C	B	A	—	—	—	—			

1 **Answer (B)**

$E = hc/(\lambda)$

so the photon energy is inversely proportional to its wavelength.

2 **Answer (C)**

On cooling, the maximum radiation intensity decreases and its wavelength shifts towards longer wavelengths (Wien's law).

3 **Answer (C)**

$\lambda_m T = const$

$T_2 = 6000/2 = 3000\ K$, so it is lowered by 3000 K

4 **Answer (A)**

The slope $= \lambda_m T = (10 \times 10^{-7})/(1/3 \times 10^{-3}) = 3 \times 10^{-3}\ m.K$

$\lambda_m = (3 \times 10^{-3})/2000 = 1.5 \times 10^{-6}\ m = 15000\ AA$

5 **Answer (B)**

$N = (E\lambda)/hc = (1 \times 200 \times 10^{-9})/(6.625 \times 10^{-34} \times 3 \times 10^{8}) = 1.01 \times 10^{18}$

6 **Answer (A)**

Body (X) has the highest radiation intensity and the shortest wavelength at that maximum, so its temperature is the highest.

7 **Answer (C)**

λ_2 is longer than the wavelength of maximum intensity, so it may be infrared.

$E = hc/(\lambda)$ and $\lambda_2 > \lambda_1$, so its photon energy is less.

8 **Answer (D)**

$\lambda_m \propto 1/T$

$\lambda_Z : \lambda_Y : \lambda_X = 1/4000 : 1/5000 : 1/6000 = 15 : 12 : 10$

9 **Answer (A)**

The frequency at maximum radiation intensity is directly proportional to the temperature.

$(upsilon_X)/(upsilon_Y) = 2000/6000 = 1/3$

10 **Answer (A)**

Green light only just frees electrons (its frequency = the threshold frequency).

Blue light has a higher frequency, so the electrons are freed with kinetic energy.

11 **Answer (A)**

From the graph $upsilon_c = 45 \times 10^{13}\ Hz$

$upsilon = upsilon_c + KE/h = 45 \times 10^{13} + (6.6 \times 10^{-20})/(6.625 \times 10^{-34}) \approx 55 \times 10^{13}\ Hz$

$\lambda = c/(upsilon) = (3 \times 10^8)/(5.5 \times 10^{14}) = 5.5 \times 10^{-7}\ m$

12 **Answer (C)**

Point (2) = $-E_w$ (J) and point (1) = $upsilon_c$ (Hz)

$E_w/(upsilon_c) = h$ and its unit is $J.s = kg.m^2.s^{-1}$

13 **Answer (A)**

From the graph $upsilon_c = 6.6 \times 10^{14}\ Hz$

$E_w = hupsilon_c = 6.625 \times 10^{-34} \times 6.6 \times 10^{14} = 4.37 \times 10^{-19}\ J = 2.7\ eV$

14 **Answer (C)**

No current is produced from metal (Z) however much the light intensity increases, so its threshold frequency is greater than the frequency of the incident light.

15 **Answer (A)**

The threshold frequency of metal B is between $upsilon_2$ and $upsilon_3$, and that of metal C is between $upsilon_3$ and $upsilon_4$,

so frequency $upsilon_3$ frees electrons from A and B only.

16 **Answer (B)**

$KE = hupsilon - hupsilon_c$

$(KE)_1 = hupsilon_c$, $(KE)_2 = 3hupsilon_c$

$((KE)_1)/((KE)_2) = 1/3$

17 **Answer (A)**

$KE = E - E_w$

$1/2mv^2 = 2E_w$ and $1/2mv'^2 = 6E_w$

$v' = \sqrt{(3)}\ v$

18 **Answer (C)**

$E = hc/(\lambda) = (6.625 \times 10^{-34} \times 3 \times 10^8)/(250 \times 10^{-9}) = 7.95 \times 10^{-19}\ J$

$KE = E - E_w = 7.95 \times 10^{-19} - 3.4 \times 1.6 \times 10^{-19} = 2.51 \times 10^{-19}\ J$

$v = \sqrt{(2KE/m)} = \sqrt{((2 \times 2.51 \times 10^{-19})/(9.1 \times 10^{-31}))} = 7.43 \times 10^5\ m/s$

19 **Answer (B)**

The same radiation, and $KE = E - E_w$

so the larger the work function, the smaller the kinetic energy: $(KE)_C < (KE)_B < (KE)_A$

20 **Answer (C)**

21 **Answer (C)**

The current is proportional to the rate at which photons fall, so it becomes 6 mA,

and the work function is a property of the cathode material, so it does not change.

22 **Answer (B)**

$KE = eV = 1.6 \times 10^{-19} \times 500 = 8 \times 10^{-17}\ J$

23 **Answer (A)**

The work function = the least energy needed to free an electron = the binding energy of the highest level = 2.5 eV

24 **Model answer**

Work function: does not change.

Maximum kinetic energy of the emitted electrons: increases.

25 **Model answer**

$E_1 - (KE)_1 = E_2 - (KE)_2$

$h(upsilon_1 - upsilon_2) = (KE)_1 - (KE)_2$

$6.625 \times 10^{-34}(6 \times 10^{14} - X) = (1 - 0.38) \times 1.6 \times 10^{-19}$

$X = 4.5 \times 10^{14}\ Hz$

26 **Model answer**

Maximum speed of the emitted electrons: case (X), blue light, is greater; case (Y), red light, is less.

Rate of emission of electrons: case (X) is less; case (Y) is greater.

27 **Model answer**

(1) Connect the anode of the cell to the positive terminal of the battery and the cathode of the cell to the negative terminal, that is, reverse the battery terminals shown in the figure.

(2) Increase the intensity of the light falling on the photoelectric cell.