Physics · Introduction to Modern Physics

Laser

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118	3	52
questions	sets	pages

Contents

Multiple choice questions (60 questions) — Questions · p. 2 — Answers · p. 39

Essay questions (16 questions) — Questions · p. 20 — Answers · p. 45

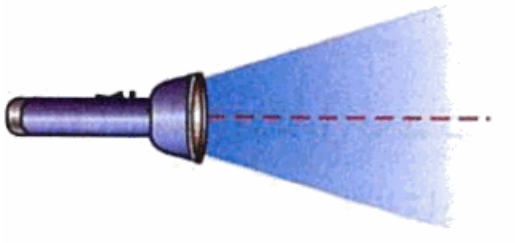
Past exam questions (42 questions) — Questions · p. 23 — Answers · p. 47

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

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Multiple choice questions — 60 questions

1 Which type of emission, spontaneous or stimulated, is dominant in the light source shown in the figure?



(A) Spontaneous emission
(B) Stimulated emission
(C) Both occur equally
(D) The information is not enough to decide

---

2 The ratio between the lifetime of an atom in an unstable excited level and its lifetime in a metastable level is .....

(A) greater than one
(B) equal to one
(C) less than one
(D) the information is not enough to decide

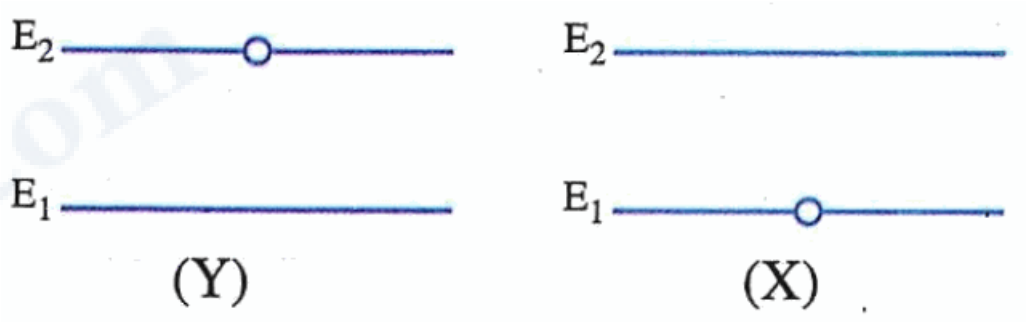
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3 In a neon lamp .....

(A) the dominant emission is photoelectric emission
(B) the dominant emission is spontaneous emission
(C) the dominant emission is stimulated emission
(D) spontaneous and stimulated emission occur equally

---

4 The opposite figure shows two atoms X and Y of an active medium. If a photon of energy $(E_2 - E_1)$ passes by each of them, the process that takes place in each is .....



(A) X: spontaneous emission, Y: stimulated emission

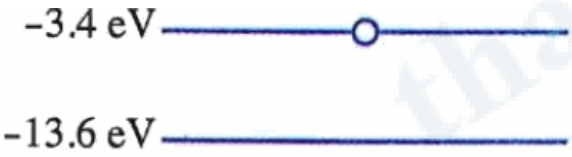
(B) X: absorption, Y: stimulated emission

(C) X: stimulated emission, Y: spontaneous emission

(D) X: spontaneous emission, Y: absorption

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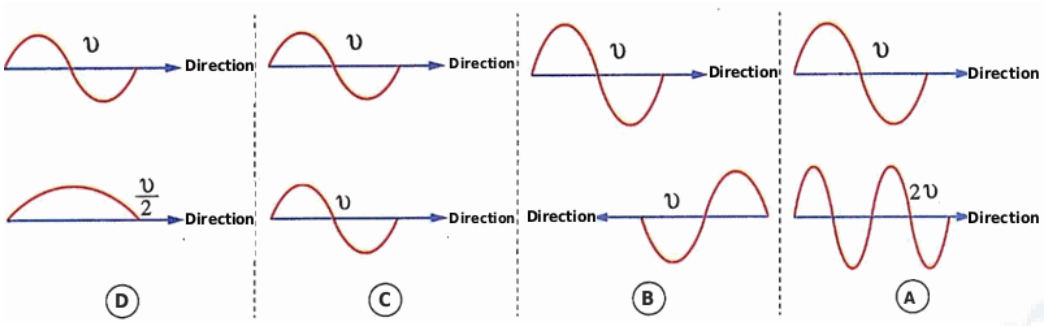
5 The opposite diagram shows an excited atom whose lifetime has not ended yet. What is the energy of the photon that causes stimulated emission from it?



(A) 3.4 eV (B) 10.2 eV (C) 13.6 eV (D) 17 eV

---

6 The following figures show the waves accompanying the motion of photons. Which pair of these waves belongs to two coherent photons?



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7 The opposite figure represents the process of .....



(A) spontaneous emission
(B) spontaneous absorption
(C) stimulated emission
(D) stimulated absorption

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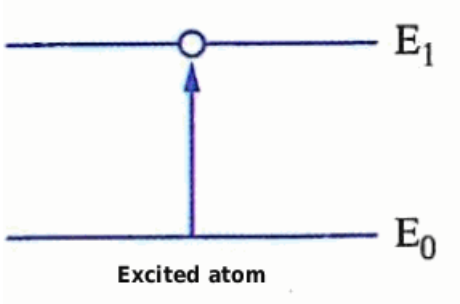
8 The opposite figure represents a case of .....



(A) spontaneous emission
(B) stimulated emission
(C) absorption
(D) population inversion

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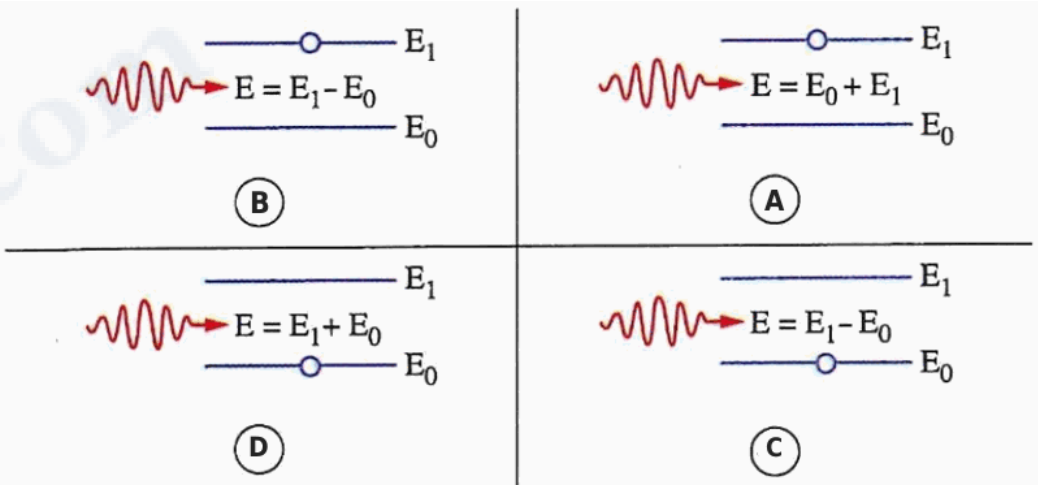
9 The opposite figure shows an atom excited to the energy level E_1. Which of the following statements gives the condition needed for stimulated emission from this atom?



(A) Its lifetime in level E_1 ends
(B) A free electron of energy $(E_1 - E_0)$ collides with it
(C) A photon of energy $(E_1 - E_0)$ falls on it
(D) Another atom excited to level E_1 collides with it

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10 Which of the following cases can represent an atom in which stimulated emission takes place by a photon of energy E?



11 Spontaneous emission of a photon from an excited atom takes place .....

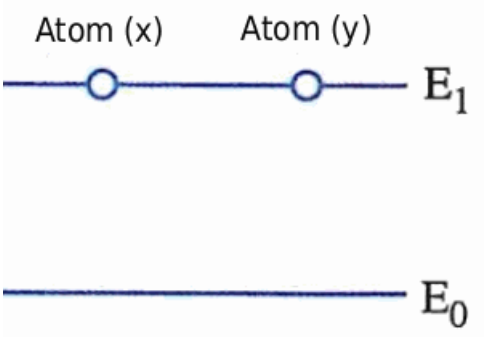
(A) when a photon falls on an excited atom

(B) by the effect of a low-frequency photon

(C) without any external effect

(D) by the effect of a high-frequency photon

12 In the opposite figure, two atoms (x) and (y) of the same element were excited together at the same instant to level (E_1). When they return to their ground level (E_0), atom (x) returns and emits a photon by spontaneous emission, and atom (y) returns by the effect of an external photon and emits a photon by stimulated emission. Which of the following is different for the two atoms (x) and (y)?



(A) The energy of the photon emitted from the atom

(B) The time the atom spends in level (E_1)

(C) The speed of the photon emitted from the atom

(D) All of the above are the same for both atoms

13 Two atoms (1) and (2) of the same element were each excited to an energy level whose lifetime is 10^{-3} s. If they returned to the ground level after spending 10^{-5} s and 10^{-3} s respectively in the excited level, this happened .....

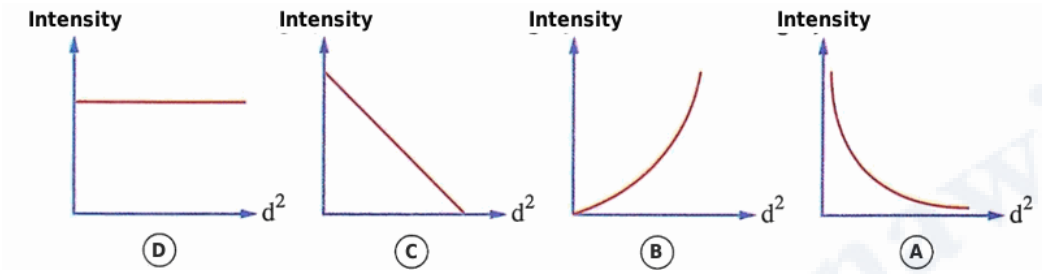
(A) atom (1): by an external photon, atom (2): by an external photon

(B) atom (1): by an external photon, atom (2): without any external effect

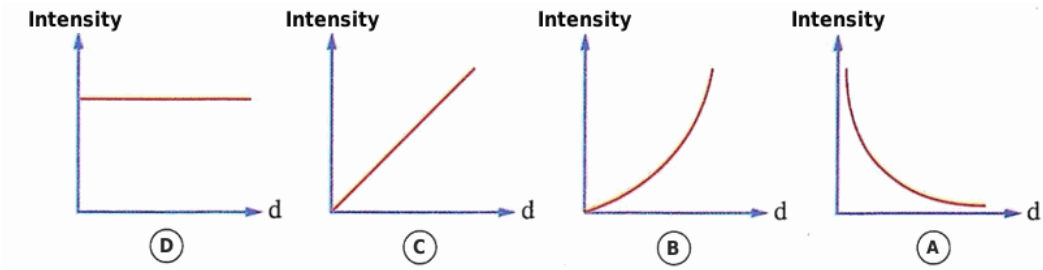
(C) atom (1): without any external effect, atom (2): by an external photon

(D) atom (1): without any external effect, atom (2): without any external effect

14 The graph that represents the relation between the radiation intensity of an electric lamp and the square of the distance (d^2) the radiation travels away from the lamp is .....



15 The graph that represents the relation between the radiation intensity of a laser source and the distance (d) the radiation travels away from the source is .....



16 The ratio between the speed of a laser beam in vacuum and the speed of light from ordinary sources in vacuum is .....

(A) greater than one

(B) less than one

(C) equal to one

(D) cannot be determined

17 The property common to laser photons and X-ray photons is that they .....

(A) are coherent

(B) are monochromatic

(C) have the same speed in vacuum

(D) have the same energy

18 A surface is illuminated by different light sources of the same light power from the same distance. The illumination intensity on the surface is greatest when using .....

(A) light from a tungsten lamp
(B) light from a fluorescent lamp
(C) light from a neon lamp
(D) laser light

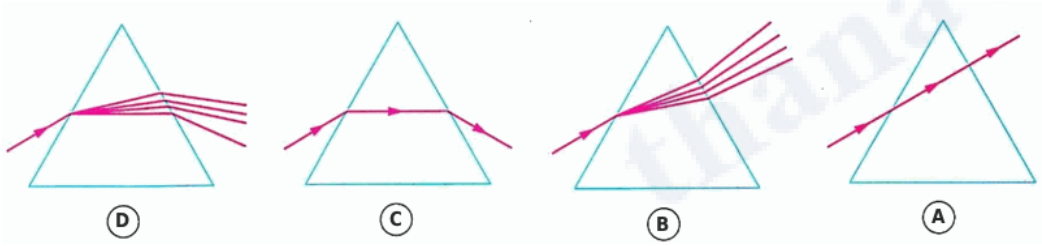
19 Laser rays do not obey the inverse square law of light because their photons .....

(A) are coherent
(B) scatter on air particles
(C) have a single wavelength
(D) have a large divergence angle

20 A laser light beam is parallel, which means that its photons have the same .....

(A) direction
(B) frequency
(C) intensity
(D) wavelength

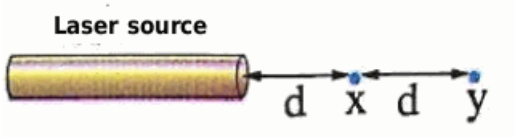
21 Which of the following figures represents a (helium-neon) laser beam passing through an equilateral triangular prism in the position of minimum deviation?



22 If the intensity of a laser beam 10 cm from its source is I, its intensity 20 cm from the source is .....

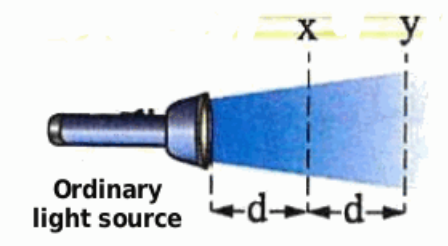
(A) 2 I
(B) I
(C) $I/2$
(D) $I/4$

23 In the figure shown, if the laser source is switched on, the ratio between the intensity of the laser beam at points x and y (I_x/I_y) is .....



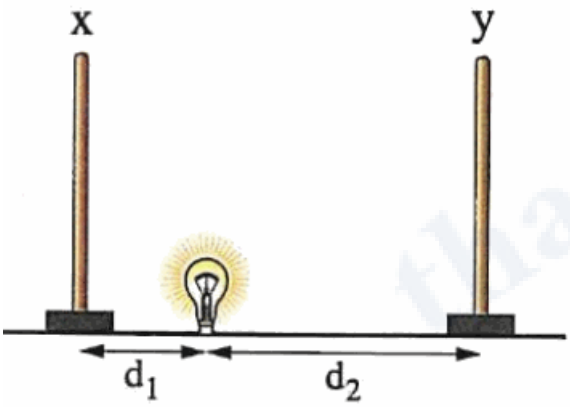
(A) $1/1$
(B) $4/1$
(C) $1/4$
(D) $2/1$

24 The opposite figure shows the path of ordinary light rays. The ratio between the amplitude of the light wave at point y and its amplitude at point x (A_y/A_x) equals .....



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

25 The opposite figure shows two identical flat surfaces (x, y) placed at different distances (d_1, d_2) on both sides of a light source. If the illumination intensity on surface (x) is 2.25 times that on surface (y), the ratio (d_1/d_2) equals .....



(A) 1/2 (B) 4/9 (C) 2/3 (D) 3/4

26 Laser rays are monochromatic because .....

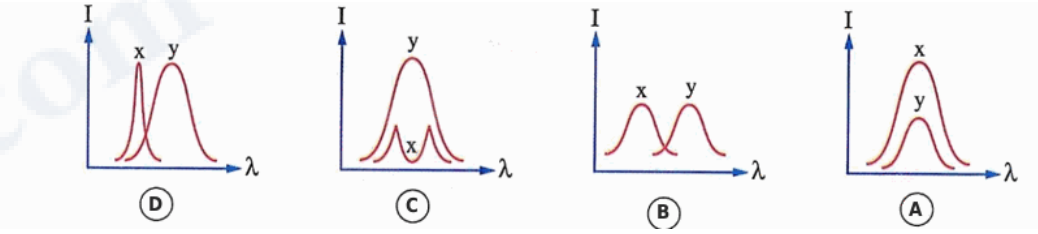
(A) all atoms of the active medium are excited to a single unstable energy level

(B) all atoms of the active medium are in the ground energy level

(C) all photons emitted by stimulated emission have the same energy

(D) all photons emitted by stimulated emission are amplified as they pass between the two reflecting mirrors

27 Two spectra (x) and (y): spectrum (x) is of a laser and spectrum (y) is of ordinary light. Each was analysed separately by a spectrometer. Which of the following graphs can express the relation between intensity (I) and wavelength (λ) for the two spectra?



28 All of the following are true about producing a laser except that .....

(A) spontaneous emission takes place in some atoms during production

(B) the intensity of the laser beam changes with the reflection coefficient of the partially transparent mirror

(C) producing a laser does not need an external energy source

(D) the atoms of the laser's active medium have a metastable energy level

29 Optical pumping in a laser aims to achieve .....

(A) a stable state

(B) population inversion

(C) a state of equilibrium

(D) amplification of the laser beam

30 In the laser action, the step that follows pumping is .....

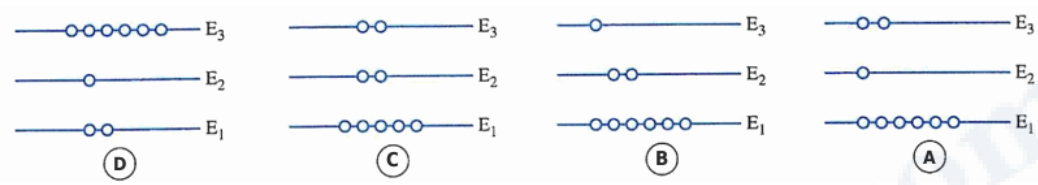
(A) a stable state of the atoms

(B) population inversion

(C) equilibrium between the atoms

(D) amplification of the laser beam

31 The following figures show how the atoms of an active medium are distributed among their energy levels. Which of them can represent the atoms reaching population inversion? (Note: level E_1 is the ground level.)



32 Optical pumping is used in the ..... laser.

(A) carbon dioxide

(B) helium-neon

(C) fluorine-hydrogen

(D) ruby

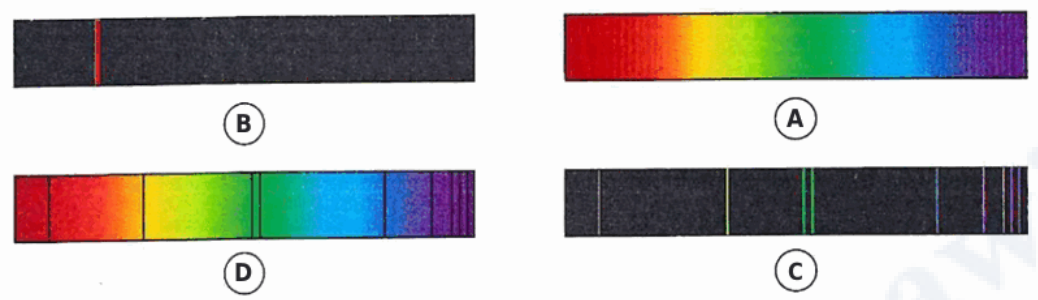
33 Optical pumping by a laser beam is used to produce a laser whose active medium is .....

(A) gas molecules (B) a solid crystal (C) a semiconductor (D) a liquid dye

34 The (helium-neon) laser lies in the region of .....

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

35 A spectrometer was used to analyse the light emitted from several light sources. Which of the following pictures represents the image formed in the spectrometer for (helium-neon) laser light?



36 In the (helium-neon) laser, the laser photons are emitted from the atoms of .....

(A) helium (B) neon

(C) both helium and neon (D) quartz

37 To produce a laser in the (helium-neon) laser, it is necessary to .....

(A) raise the pressure inside the tube above atmospheric pressure

(B) decrease the potential difference of the source

(C) make the proportion of helium atoms greater than that of neon atoms

(D) illuminate the tube with neon light

38 In the (helium-neon) laser, the element whose atoms reach population inversion as one of the steps of producing laser photons is .....

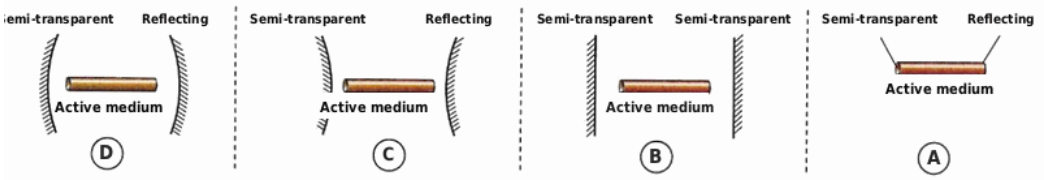
(A) helium only (B) neon only

(C) both helium and neon (D) sometimes helium and sometimes neon

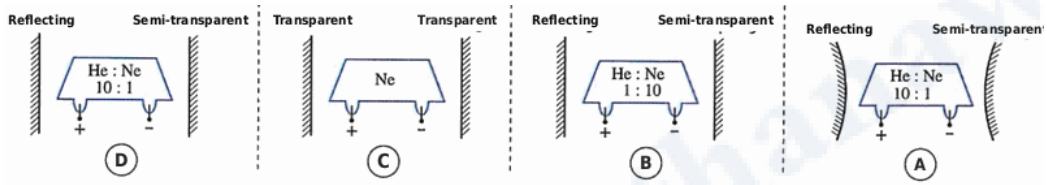
39 In the (helium-neon) laser, one of the steps of producing the laser is that an excited helium atom loses its excitation energy by colliding with .....

(A) another stable helium atom
(B) the walls of the electric discharge tube
(C) an unexcited neon atom
(D) an excited helium atom

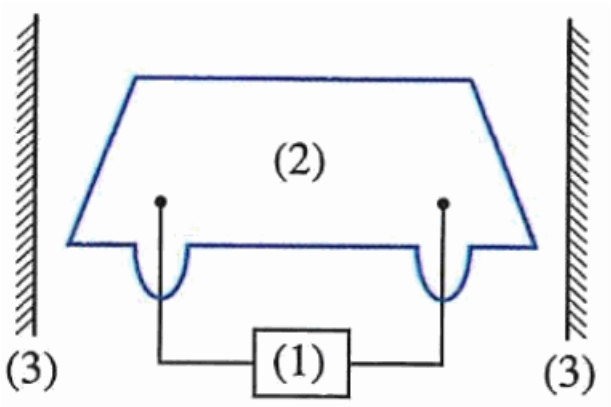
40 Which of the following figures correctly shows the external resonant cavity in a (helium-neon) laser?



41 Which of the following correctly represents the properties of the components of a (helium-neon) laser?

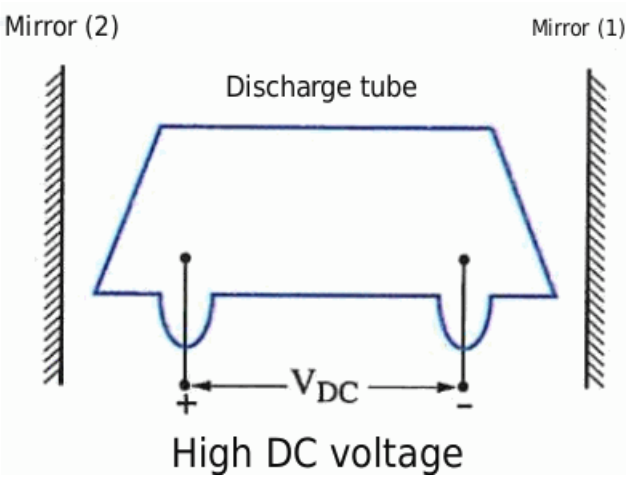


42 The opposite figure represents a (helium-neon) laser. Which of the components shown is the main cause of amplification?



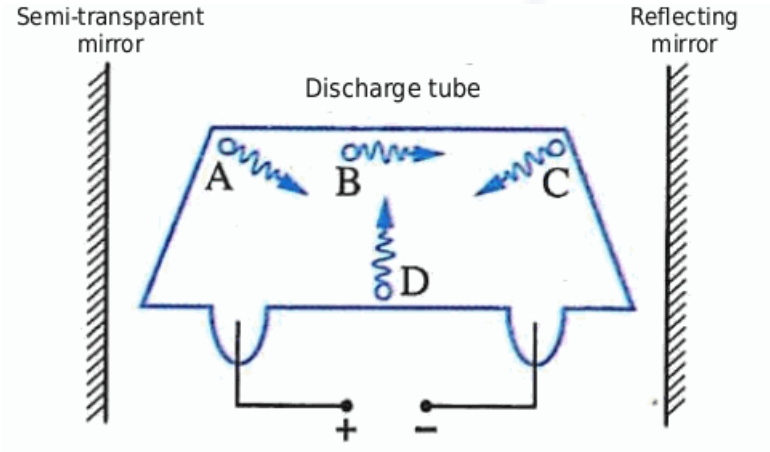
(A) Component (1)
(B) Component (2)
(C) Component (3)
(D) Components (1) and (2)

43 The opposite figure shows the structure of a (helium-neon) laser. If the laser beam comes out of mirror (1), then the reflection coefficient of mirror (1) compared to that of mirror (2) is .....



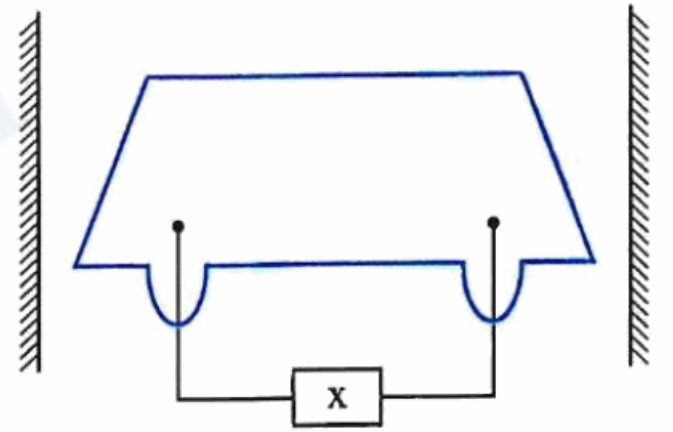
(A) greater
(B) smaller
(C) equal
(D) cannot be determined

44 The opposite diagram shows a (helium-neon) laser and four photons (A, B, C, D) emitted in different directions inside the tube. Which of these photons can stay moving inside the tube for the longest time before it comes out?



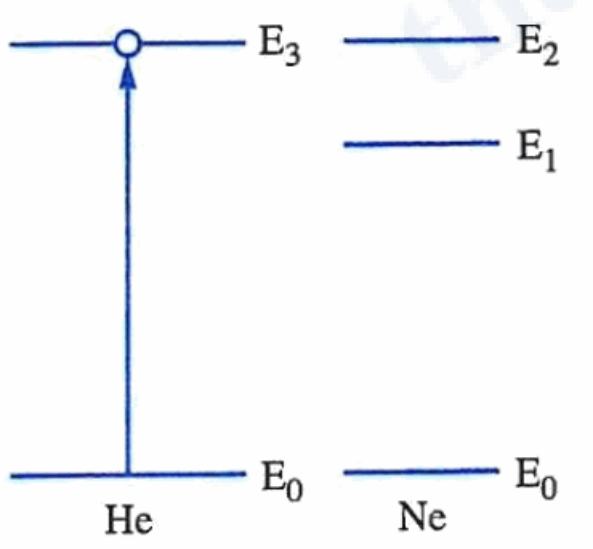
(A) Photon A
(B) Photon B
(C) Photon C
(D) Photon D

45 The opposite figure represents a (helium-neon) laser. If component (x) stops working .....



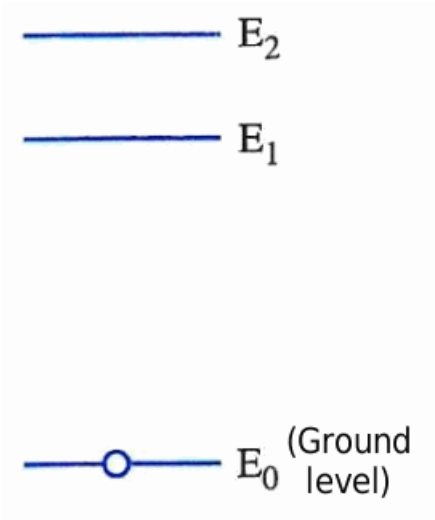
(A) the radiation intensity decreases
(B) the radiation frequency decreases
(C) the speed of the beam decreases
(D) no laser beam is produced

46 The opposite figure shows the energy levels of the atoms of the active medium in a (helium-neon) laser. When helium atoms in energy level E_3 (a metastable level) collide with unexcited neon atoms, the neon atoms are excited to level ..... so that population inversion is reached.



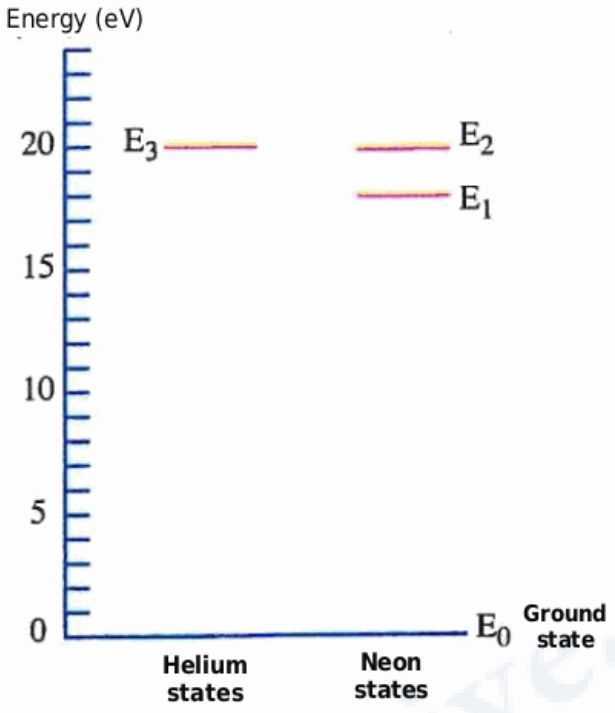
(A) E_0 only
(B) E_1 only
(C) E_2 only
(D) E_1 and E_2 together

47 The opposite figure represents the energy levels of a neon atom. When the atom gained energy (E_x) it was excited to a certain level, and before its lifetime in this level ended another photon of energy (E_y) passed by it, so the atom emitted a photon by stimulated emission whose energy equals that of a (helium-neon) laser photon. The energies of the two photons E_x and E_y are .....



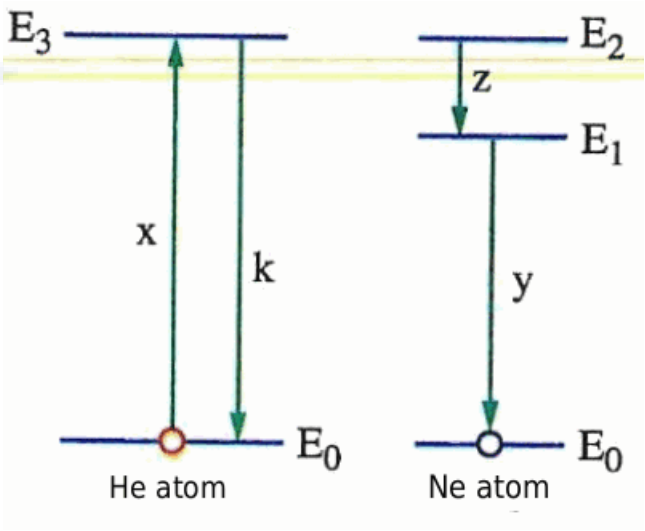
(A) E_x: E_1 - E_0, E_y: E_1 - E_0
(B) E_x: E_1 - E_0, E_y: E_2 - E_1
(C) E_x: E_2 - E_0, E_y: E_2 - E_0
(D) E_x: E_2 - E_0, E_y: E_2 - E_1

48 The opposite diagram represents the energy levels of helium and neon atoms. The largest energy difference between these levels is for a transition between the two levels .....



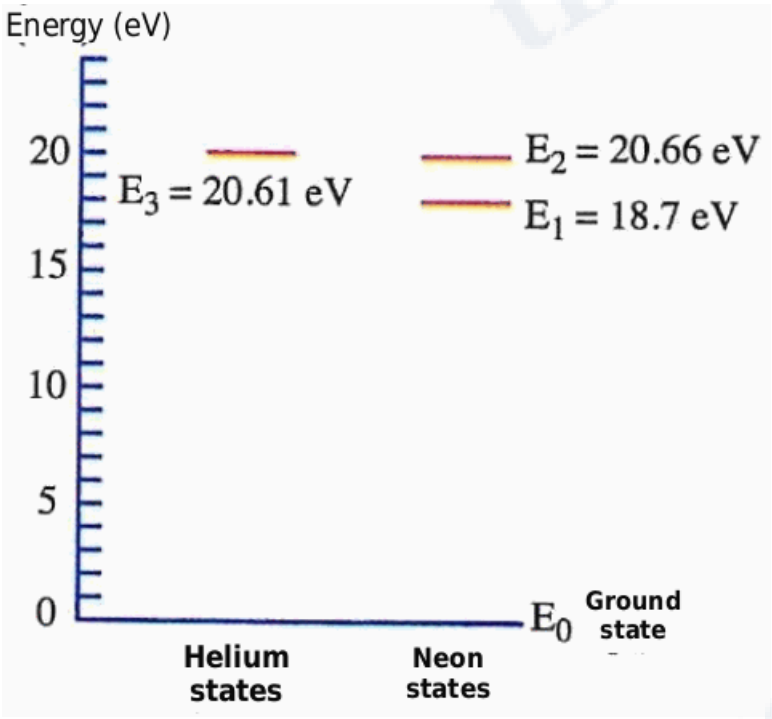
(A) E_3, E_1
(B) E_2, E_1
(C) E_1, E_0
(D) E_0, E_2

49 The opposite figure shows some transitions x, y, z, k in a (helium-neon) laser. The correct time order in which these transitions happen is .....



(A) k then y then z then x
(B) x then y then z then k
(C) x then k then z then y
(D) z then y then x then k

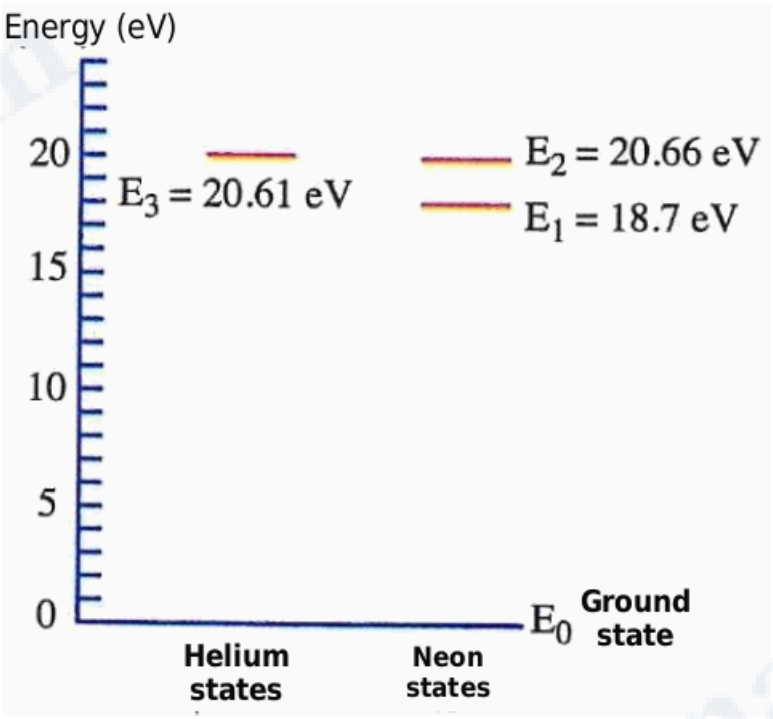
50 The opposite figure represents the energy level diagram of a (helium-neon) laser:
(1) The energy needed to excite helium atoms equals .....



(A) 18.7 eV
(B) 20.61 eV
(C) 20.66 eV
(D) 21 eV

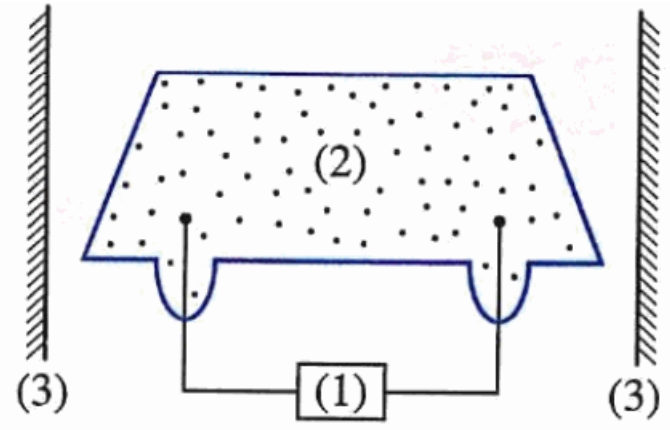
51 The opposite figure represents the energy level diagram of a (helium-neon) laser:

(2) The energy of the emitted laser photons equals .....



(A) 0.68 eV (B) 1.96 eV (C) 3.12 eV (D) 4.05 eV

52 The opposite diagram represents a (helium-neon) laser. Which of the parts shown is the component in which population inversion takes place?



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

53 The property that allows laser rays to be used in holography is that .....

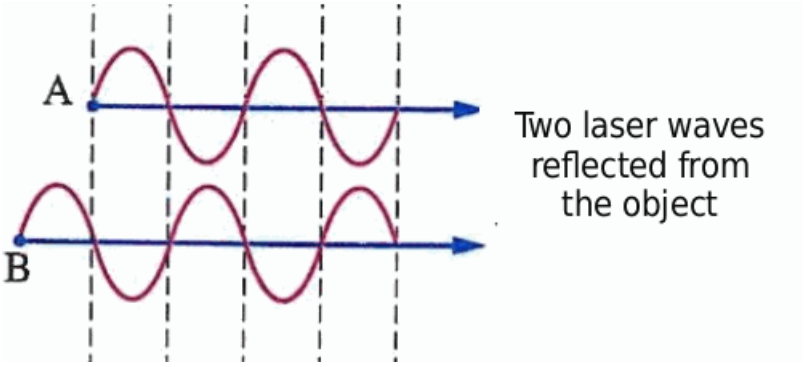
(A) its photons are coherent (B) its rays are parallel

(C) it keeps a constant intensity (D) it has a high intensity

54 A laser beam of wavelength λ was used in holography, and the phase difference between two of the rays reflected from the object was $(\pi)/2$. The path difference between them is .....

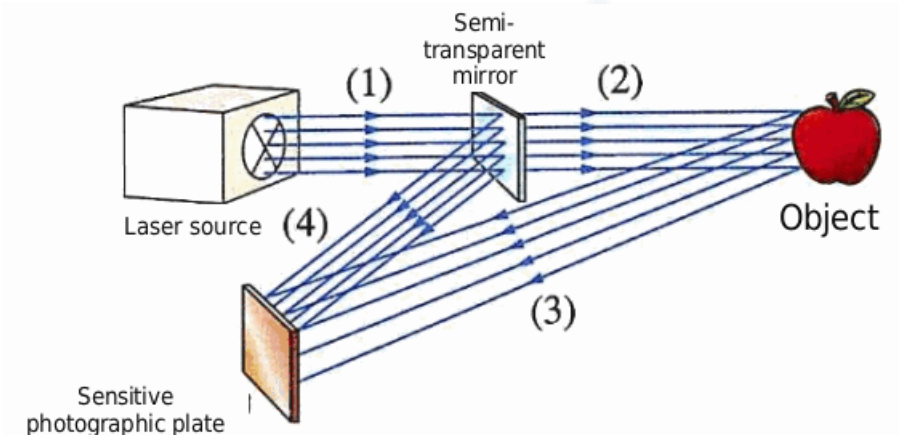
(A) $(\lambda)/4$ (B) $(\lambda)/2$ (C) 2 λ (D) 4 λ

55 The opposite figure represents two laser waves reflected from two points A and B on an object in holography. If the path difference between them is 3164 Å, the wavelength of the laser equals .....



(A) 1582 Å (B) 3164 Å (C) 4746 Å (D) 6328 Å

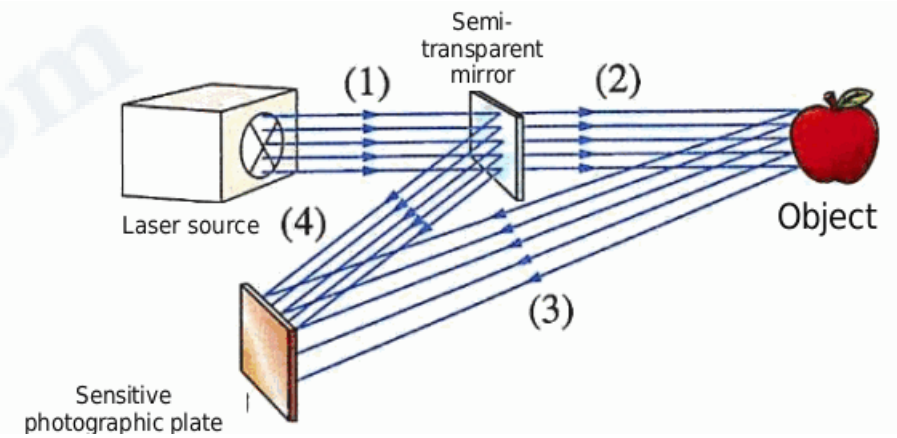
56 The opposite figure shows how an image of an object is formed on a photographic plate:
(1) The group of rays that differ from each other in intensity is group .....



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

57 The opposite figure shows how an image of an object is formed on a photographic plate:

(2) The group of rays that differ from each other in phase is group .....

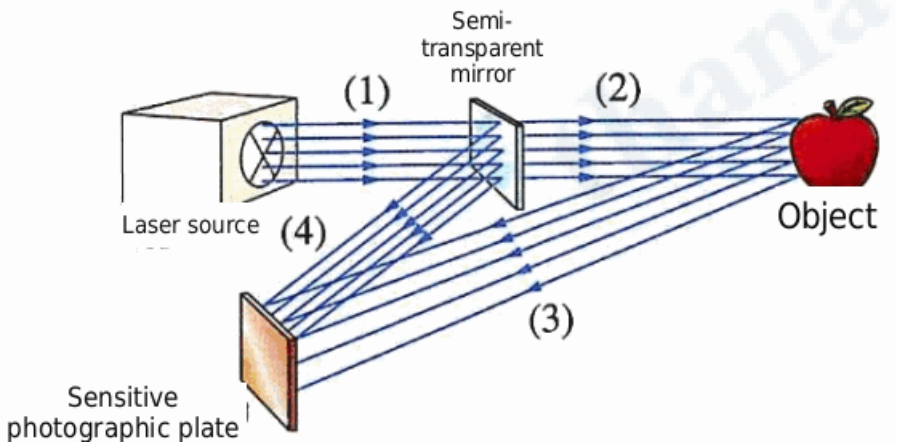


(A) (1) (B) (2) (C) (3) (D) (4)

---

58 The opposite figure shows how an image of an object is formed on a photographic plate:

(3) The image formed on the photographic plate is .....



(A) similar to the object and two-dimensional

(B) similar to the object and three-dimensional

(C) coded as interference fringes

(D) similar to the object and magnified

---

59 Measuring long distances using laser rays depends on the property of .....

(A) the spectral purity of the laser (B) the parallelism of laser rays

(C) the heating effect of laser rays (D) the high speed of the laser

---

60 The laser is used to reattach a detached retina depending on .....

(A) the coherence of its photons
(B) its heating effect
(C) its spectral purity
(D) its high speed

Essay questions — 16 questions

1 The following diagrams show an atom moving between two of its energy levels. Show, with explanation, which of these diagrams represents:

(1) absorption.

(2) stimulated emission.

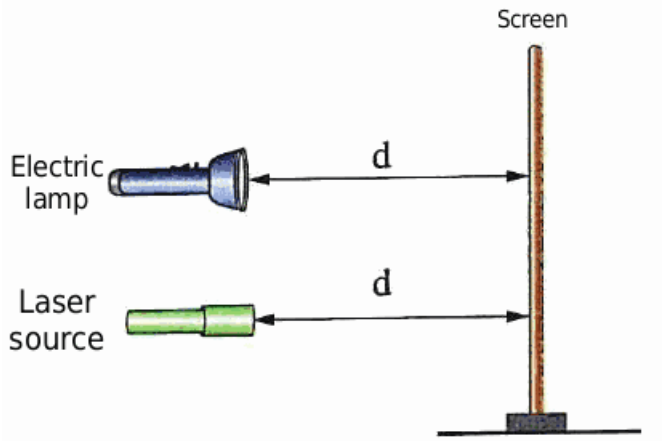
(3) spontaneous emission.



2 Stimulated emission involves producing another photon identical to the incident photon. Show whether getting these two photons breaks the law of conservation of energy.

3 Explain: laser rays do not obey the inverse square law.

4 In the opposite figure, a laser source and an electric lamp of the same light power are placed at the same large distance from a screen. Compare the intensity of the laser light and the intensity of the lamp light on the screen, and explain your answer.



5 If the intensity of light from a tungsten lamp 1 m from the source is $16\ mW/m^2$, what is the intensity of this light 2 m from the source?

6 In the (helium-neon) laser, what is the function of each of:

(1) the neon atoms?

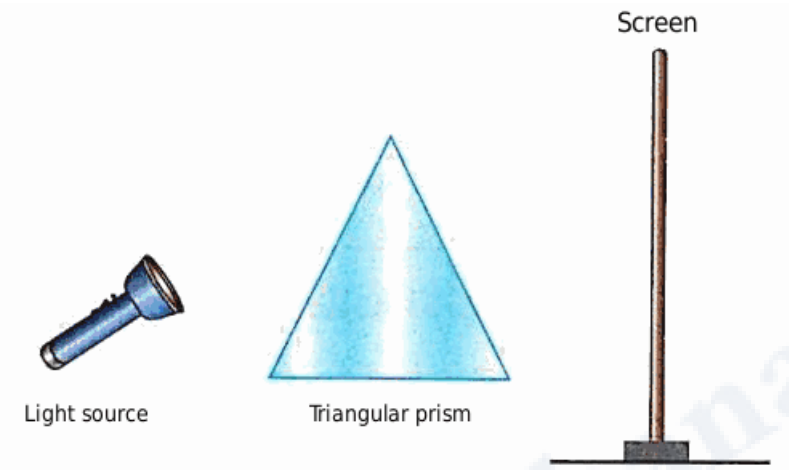
(2) the electric voltage source?

7 While researching laser production, scientists found that the efficiency of producing a laser is very high when helium atoms are added to neon atoms in a certain ratio, instead of using neon atoms alone in the tube. Explain the role of the helium atoms.

8 In the opposite figure, describe, with explanation, the spectrum formed on the screen if the light source is:

(1) a (helium-neon) laser.

(2) a tungsten lamp.



9 How does amplification take place in a (helium-neon) laser?

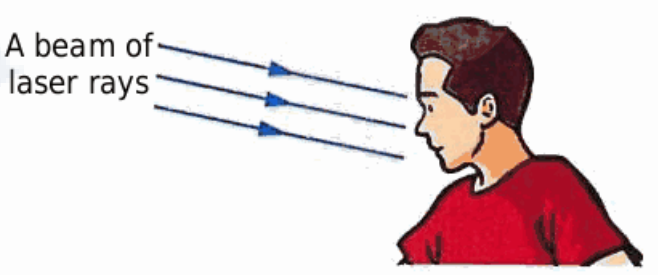
10 Give a reason: an X-ray photon has more energy than a (helium-neon) laser photon, yet (helium-neon) laser rays can reach farther distances than X-rays.

11 State one similarity and one difference between: (helium-neon) laser photons and X-ray photons.

12 Explain why, when a (helium-neon) laser beam falls on a metal surface, no photoelectrons are emitted despite the high concentration of the beam, while when white light falls on the same surface, photoelectrons are emitted.

13 What happens when a hologram is illuminated by a laser beam of the same wavelength as the reference rays, and you look through it with the naked eye?

14 In the opposite figure, how do the properties of the beam reflected from the object differ from those of the beam falling on it?



15 What is the condition for recording the surface shape of an object on a photographic plate?

16 Why are laser rays used in each of:

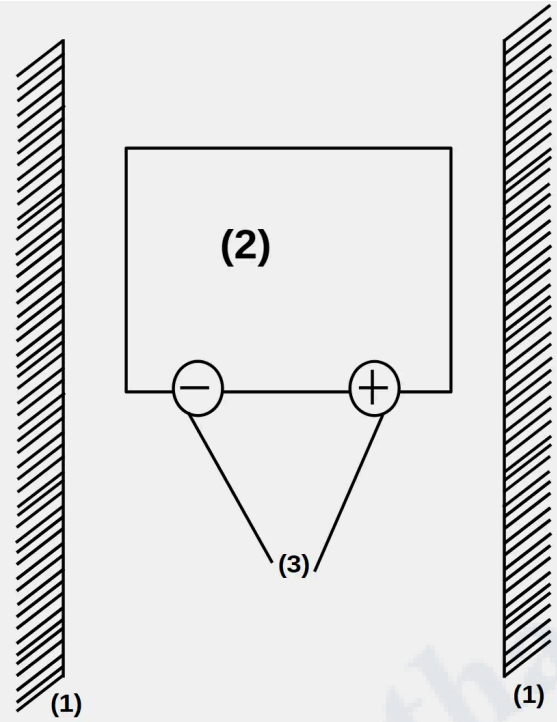
(1) guiding missiles in military applications?

(2) holography?

(3) treating a detached retina?

Past exam questions — 42 questions

1 The diagram shows a (helium-neon) laser device. (Trial exam / June 2021)
What is the role of the components shown in the figure?



(A) 1- producing photons 2- making a high potential difference 3- reflecting photons

(B) 1- reflecting photons 2- containing the active medium 3- making a high potential difference

(C) 1- pumping excitation energy to the atoms 2- exciting neon atoms 3- amplifying photons

(D) 1- producing laser photons 2- the energy source used 3- exciting neon atoms

---

2 In the chromium-doped ruby laser, powerful xenon lamps are used to excite the atoms of the active medium. (Trial exam / June 2021)
So *(speed of the laser beam)/(speed of xenon lamp light in air)* ...

(A) is greater than one

(B) equals zero

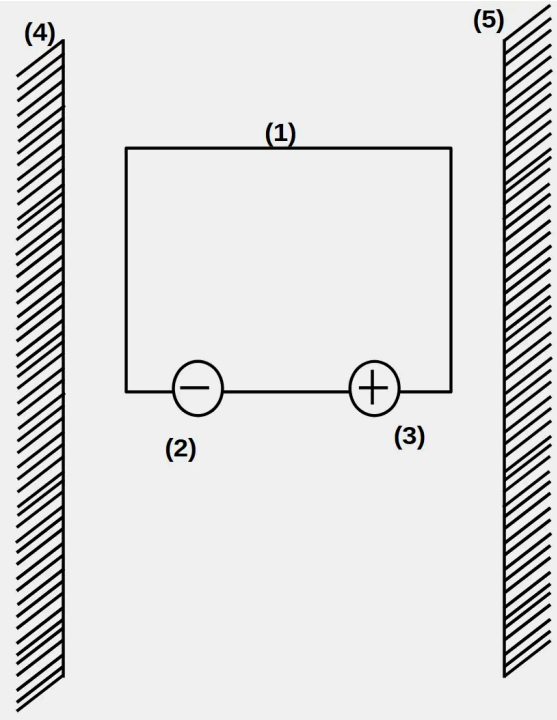
(C) is less than one

(D) equals one

---

3 The figure shows a diagram of a helium-neon laser device. (1st session 2021)

Which choice correctly gives the parts with an important role in amplifying the laser photons?



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

---

4 A laser beam has radius (r) and intensity (I) at its source. (1st session 2021)

Its intensity and its diameter 15 m from the source ...

(A) intensity: does not change, diameter: does not change

(B) intensity: increases, diameter: increases

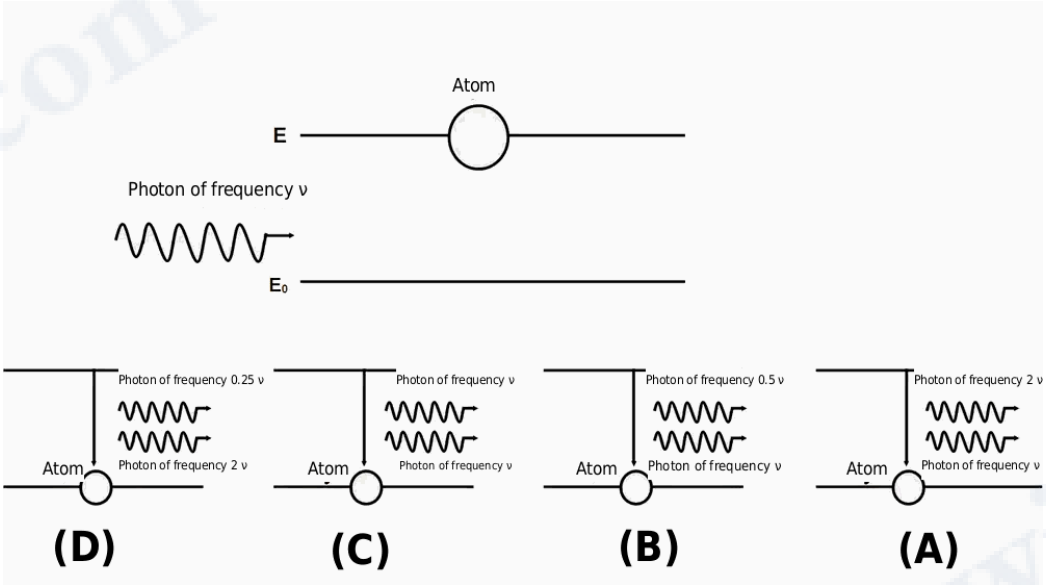
(C) intensity: decreases, diameter: decreases

(D) intensity: decreases, diameter: increases

---

5 A photon of frequency ν fell on an excited atom as in the opposite figure. (Trial exam / June 2021)

Which of the following figures shows the properties of stimulated emission?



6 The spectral purity of laser rays means that their photons … (Sample exam 2025)

(A) have one direction
(B) have almost a single wavelength
(C) do not obey the inverse square law
(D) are in phase

7 The form of energy used to excite the atoms of the active medium in the liquid dye laser is … (Sample exam 2025)

(A) light
(B) heat
(C) electric
(D) chemical

8 Helium and neon are chosen as the active medium for producing the (He-Ne) laser because of … (Sample exam 2025)

(A) the equal number of energy levels in them
(B) the close values of the energies of their stable excited levels
(C) the close values of the energies of their metastable excited levels
(D) all of the above

9 In the (helium-neon) laser, when the partially transparent mirror (reflection coefficient 95%) is replaced by another one (reflection coefficient 98%), (Sample exam 2025)
the intensity of the resulting laser beam ... and the energy of a single photon of the resulting laser beam ... respectively

(A) changes , stays constant
(B) changes , changes
(C) stays constant , changes
(D) stays constant , stays constant

10 In the helium-neon laser, when the partially transparent mirror is replaced by a transparent glass plate, which of the following choices is correct? (2nd session 2024)

(A) The intensity of the resulting laser beam rises to a maximum
(B) Population inversion never takes place
(C) No laser beam is produced at all
(D) Stimulated emission never takes place

11 The laser is used in holography because laser rays are characterised by ... (2nd session 2024)

(A) their high intensity
(B) their effect on photographic plates
(C) the coherence of their photons
(D) having a single wavelength

12 If the phase difference between two waves reflected from the object in holography equals $(\pi)/4$, which of the following choices gives the path difference between them? (1st session 2024)

(A) $(\lambda)/2$ (B) $(\lambda)/4$ (C) $(\lambda)/8$ (D) $(\lambda)/16$

13 In three-dimensional imaging using the laser, (1st session 2024)
which of the following rays differ from each other in phase?

(A) The rays falling from the light source on the plane mirror
(B) The rays falling from the light source on the object
(C) The rays reflected from the plane mirror to the photographic plate
(D) The rays reflected from the object to the photographic plate

14 The laser beam starts to come out of the partially transparent mirror in the helium-neon laser depending on ... (2nd session 2023)

(A) the radiation intensity inside the resonant cavity

(B) the proportion of atoms of the active medium in population inversion

(C) the electric potential difference inside the laser tube

(D) the lifetime of the atoms in the metastable level

---

15 Using the laser in the military field to destroy missiles depends on ... (2nd session 2023)

(A) the energy of the laser beam

(B) the spectral purity of the laser beam

(C) the coherence of the laser beam photons

(D) the wave nature of laser light

---

16 The number of photons is amplified by stimulated emission in the helium-neon laser as a result of the collision of ... (2nd session 2023)

(A) excited neon atoms in the metastable level with each other

(B) excited helium atoms with excited neon atoms in the metastable level

(C) photons reflected from the resonant cavity mirrors with excited neon atoms in the metastable level

(D) excited helium atoms with unexcited neon atoms

---

17 If the phase difference between two laser waves after reflection from an object is 2π, (1st session 2023)
the path difference between them is ...

(A) λ (B) 2λ (C) π (D) 2π

---

18 Two light sources: one emits ordinary monochromatic (blue) light and the other emits a laser in the red region of the spectrum. (Trial exam 2023)
Which of the following statements is correct?

(A) Laser photons are coherent and have higher energy

(B) Ordinary light photons are coherent and have lower energy

(C) Laser photons are not coherent and have higher energy

(D) Ordinary light photons are not coherent and have higher energy

19 The intensity of a helium-neon laser beam increases ... (Trial exam 2023)

(A) by decreasing the electric potential difference used

(B) by decreasing the proportion of helium atoms to neon

(C) by increasing the rate of repeated reflections inside the resonant cavity

(D) by increasing the pressure of the gas mixture inside the tube

20 When one of the two resonant cavity mirrors of a laser device is replaced by a piece of transparent glass and the device is switched on again ... (Trial exam 2023)

(A) the laser beam comes out from the side of the transparent plate

(B) no laser beam comes out of the device

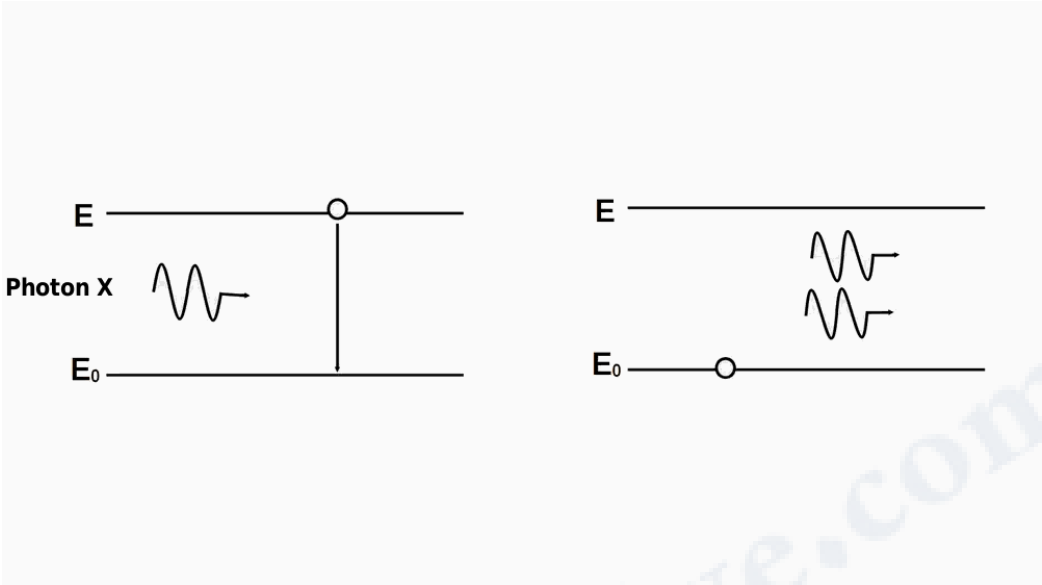
(C) the laser beam comes out from the side with the mirror

(D) the laser beam comes out from both sides

21 In three-dimensional imaging of an object using the laser, the path difference between two laser waves (2nd session 2021)
reflected from the object was $2/3\lambda$,
so the phase difference between these two waves equals ...

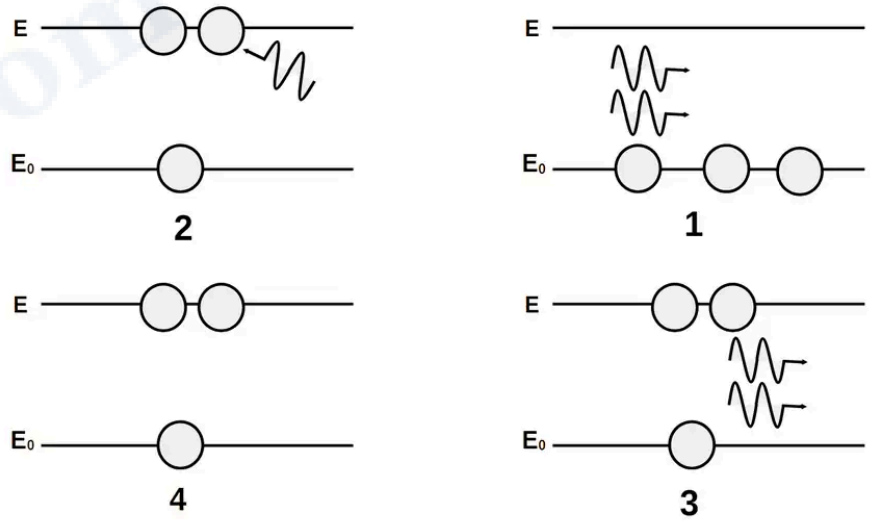
(A) $(3\pi)/4$ (B) $(4\pi)/3$ (C) π (D) $(3\pi)/2$

22 In the following figure, for stimulated emission to take place, the energy of photon (X) must be ... (1st session 2022)



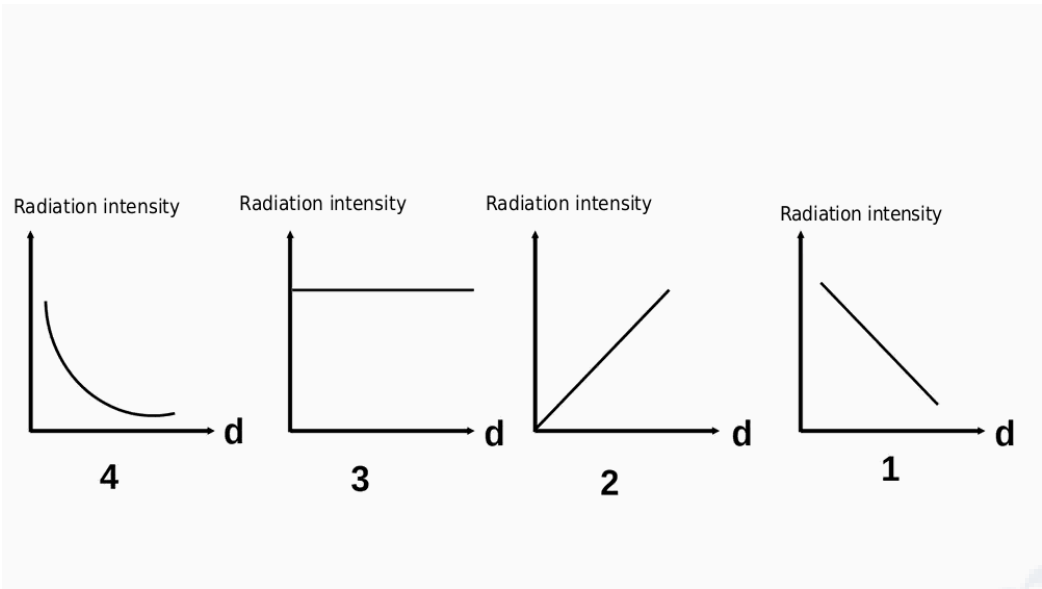
(A) $E + E_0$ (B) $E - E_0$ (C) $2(E - E_0)$ (D) $2(E + E_0)$

23 Diagrams 1, 2, 3 and 4 show the steps of getting laser photons. (2nd session 2022)
The correct order of the steps of getting the laser beam is ...



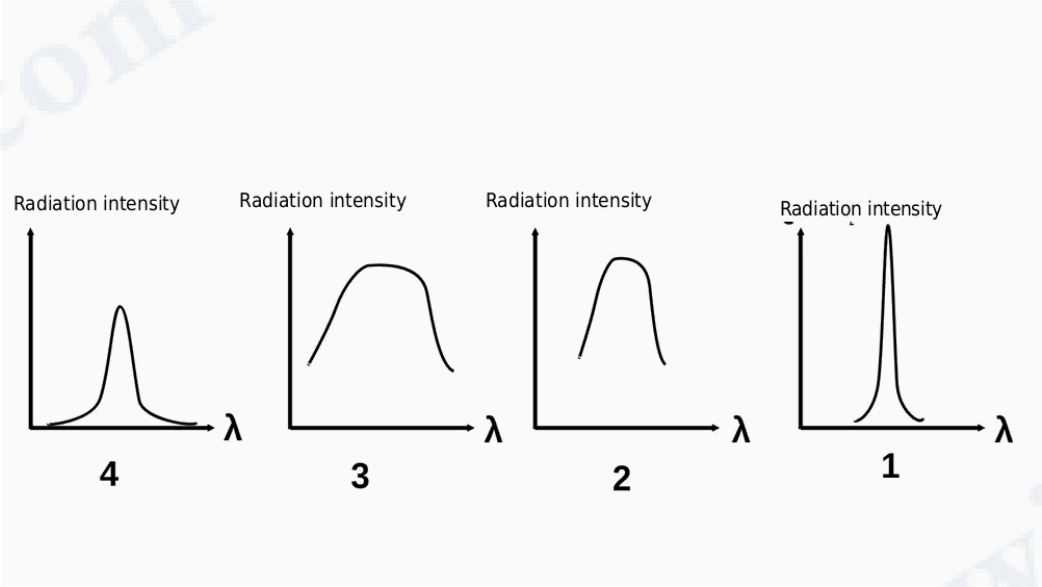
(A) 1 → 2 → 4 → 3 (B) 4 → 1 → 2 → 3 (C) 2 → 1 → 4 → 3 (D) 1 → 4 → 2 → 3

24 The following graphs show the relation between radiation intensity and the distance from the source d. (1st session 2022)
The graph that represents a laser beam is ...



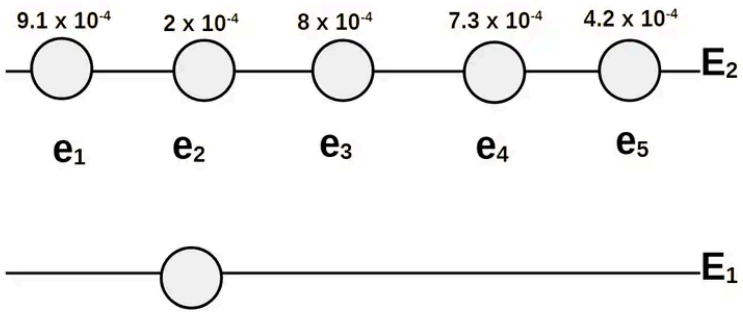
(A) 1 (B) 2 (C) 3 (D) 4

25 The following graphs show the relation between radiation intensity and wavelength (λ) for several light sources, drawn to the same scale. (2nd session 2022)
Which graph represents radiation that can be used in holography?



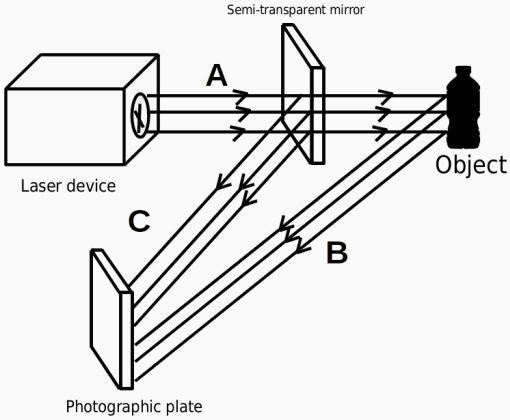
(A) 1 (B) 2 (C) 3 (D) 4

26 The figure shows population inversion in neon gas and the time each of the five atoms excited to the metastable level E_2 has spent there until a certain moment. Assuming that 5×10^{-4} s after that moment, photons each of energy E_2 - E_1 reach the five atoms shown in level E_2, which of the five atoms will be stimulated before their lifetime ends? (2nd session 2022)
(Assume that the lifetime of the metastable level $E_2 = 10^{-3}s$)



(A) e_1, e_3 (B) e_2, e_4 (C) e_2, e_5 (D) e_1, e_2, e_5

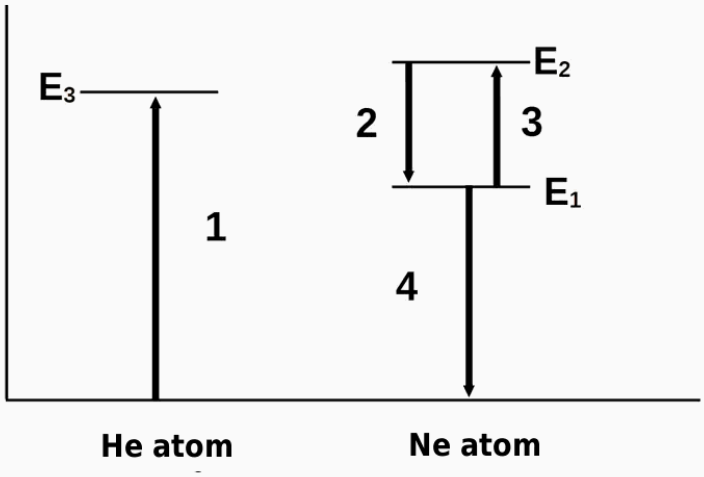
27 The opposite figure shows how a hologram is formed. Which of the following choices represents the reference rays that take part in forming the interference fringes? (1st session 2023)



(A) B , C (B) A , B (C) C only (D) B only

28 The opposite figure shows the process of producing helium-neon laser photons, given that E_2 and E_3 are metastable energy levels. (1st session 2023)

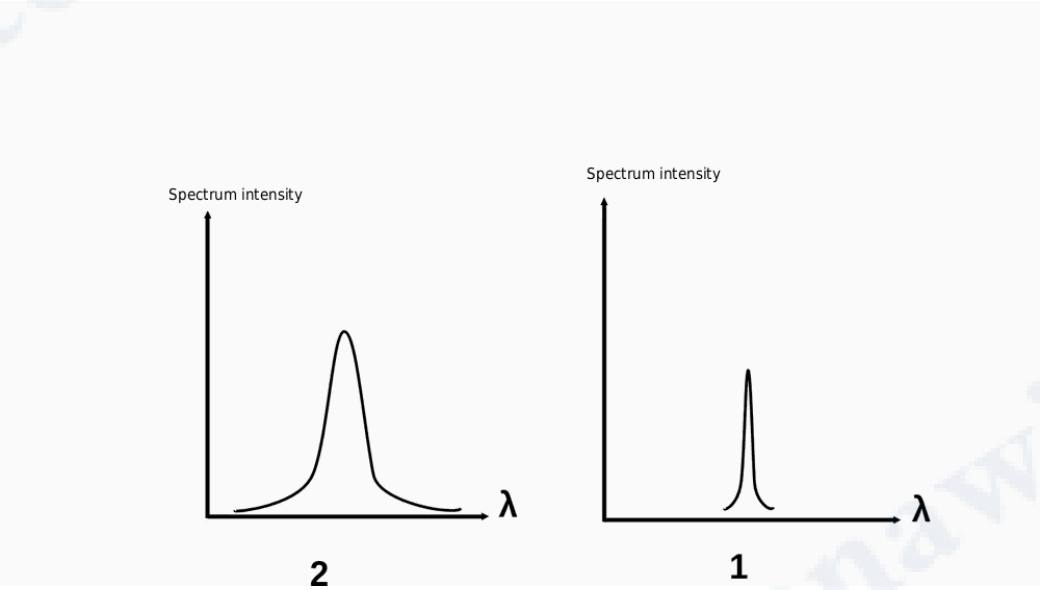
Which transition releases a helium-neon laser photon?



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

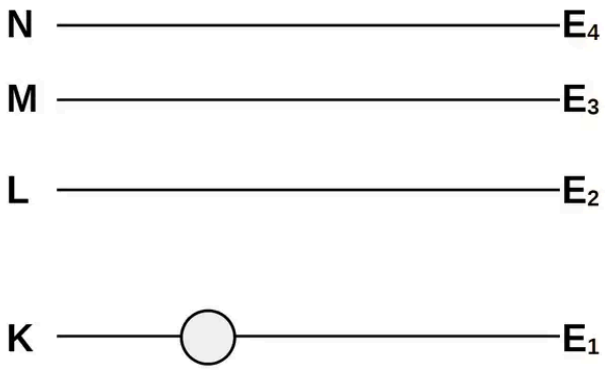
29 The two graphs show the range of two spectra 1 and 2 emitted from two light sources. (1st session 2024)

When the spectrum from each source had travelled a distance d, the intensity of spectrum 2 was 2I and that of spectrum 1 was 2I. If the distance each spectrum travels from the source becomes 2d, the intensities of spectra 1 and 2 respectively are ...



(A) *2I,I/4* (B) *I,I/2* (C) *I/4,2I* (D) *I,I/4*

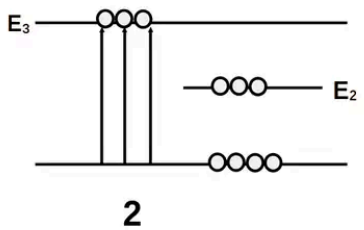
30 The opposite figure shows an electron in the first level of an atom. (2nd session 2024)
A photon of energy $E = E_4 - E_1$ fell on it, so the electron was excited to a higher level, and before the lifetime of the electron in that level ended, another photon of energy $E = E_4 - E_3$ fell on the excited electron. Which of the following choices is correct?

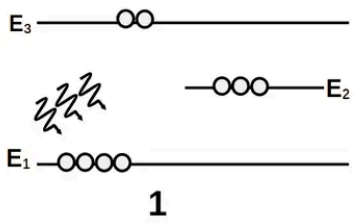


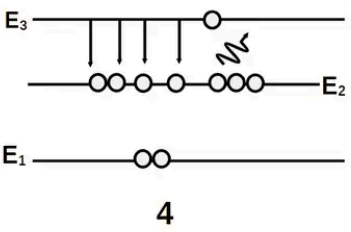
(A) The electron returns from N to K and stimulated emission takes place
(B) The electron returns from N to M and spontaneous emission takes place
(C) The electron returns from N to M and stimulated emission takes place
(D) The electron returns from N to K and spontaneous emission takes place

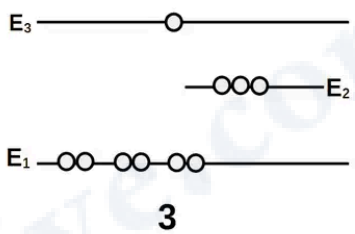
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31 You have four figures showing the stages of producing a laser. Which figure represents population inversion? (1st session 2021)



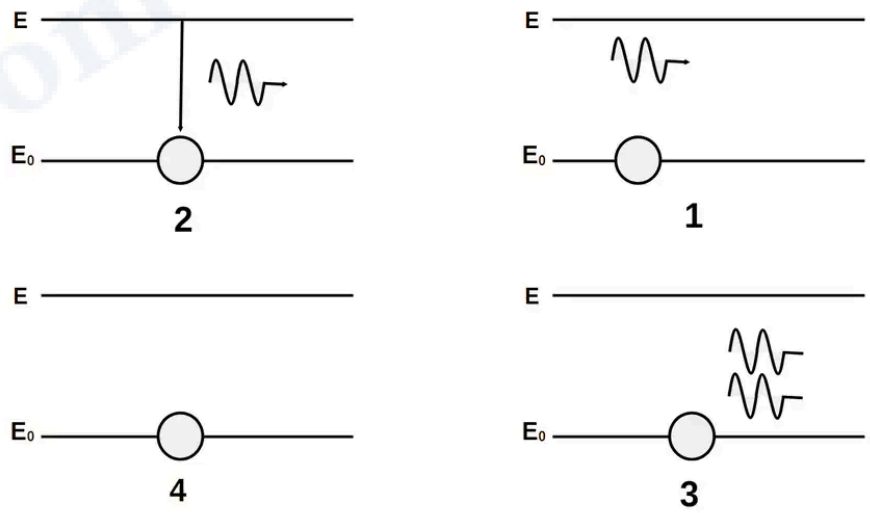






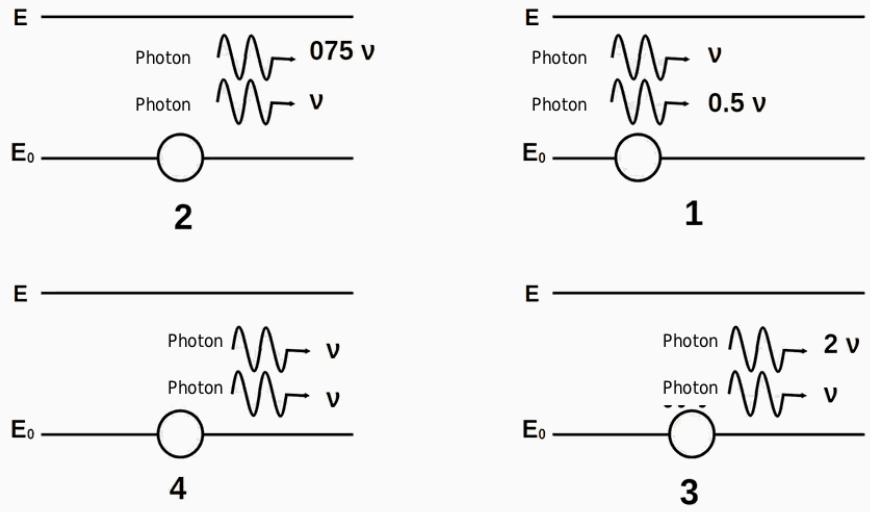
(A) 1 (B) 2 (C) 3 (D) 4

32 You have four figures showing the stages of producing a laser. Which figure shows an emission spectrum? (1st session 2021)



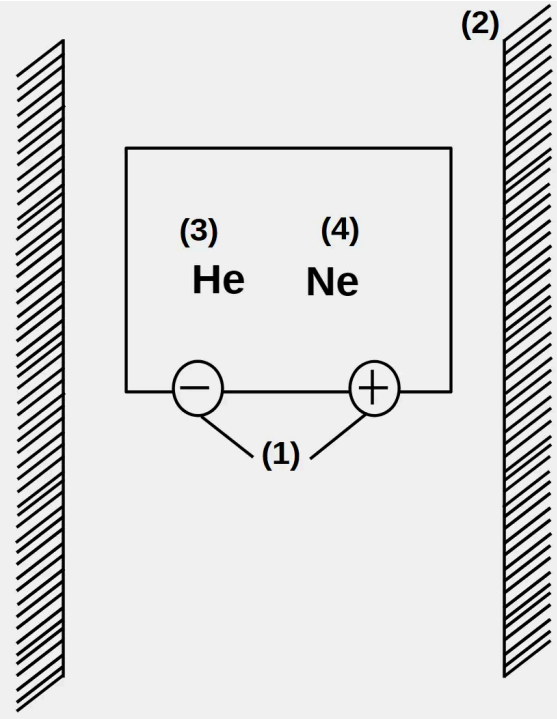
(A) 1 (B) 2 (C) 3 (D) 4

33 You have four figures showing the stages of producing a laser. Which figure shows the idea of atomic spectral purity? (2nd session 2021)



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

34 The figure shows the structure of a helium-neon laser. The neon atoms are excited because of ... (2nd session 2021)



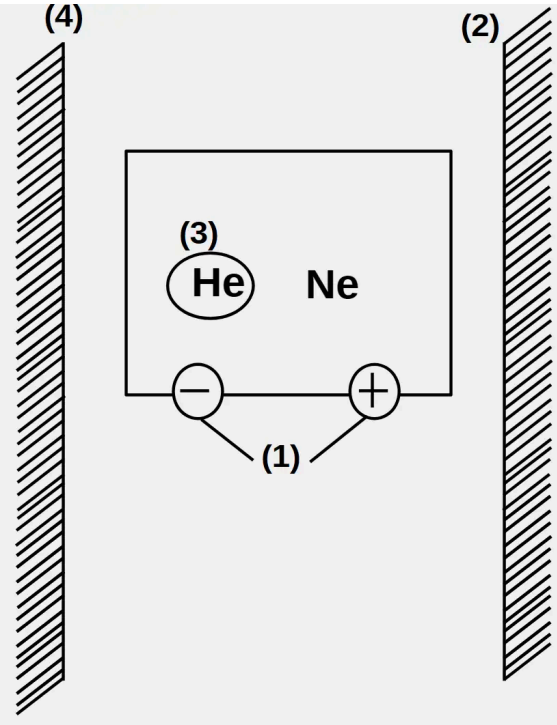
(A) their collision with component 2

(B) their collision with excited atoms of component 3

(C) their collision with unexcited atoms of component 3

(D) gaining energy from component 1

35 The opposite figure shows the structure of a helium-neon device. Which component is responsible for exciting the neon atoms? (1st session 2022)

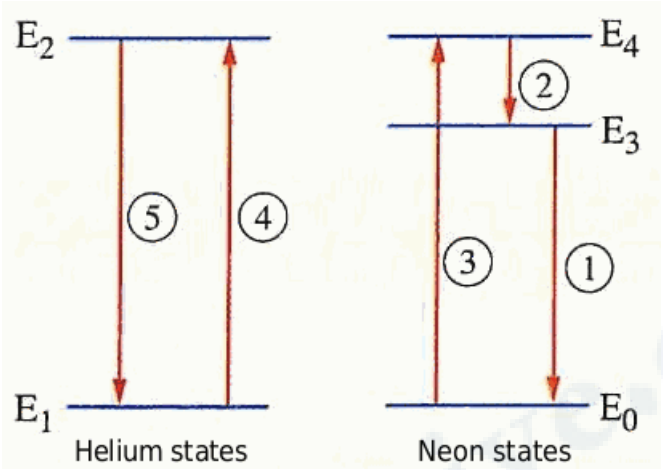


(A) 1 (B) 2 (C) 3 (D) 4

36 The energy of a photon of monochromatic green light emitted from an ordinary light source is ..... the energy of a (helium-neon) laser photon. (1st session 2025)

(A) less than (B) greater than (C) half (D) equal to

37 The diagram shows the transitions of helium and neon atoms between energy levels during laser production. Which two transitions happen when an excited helium atom collides with an unexcited neon atom? (1st session 2025)

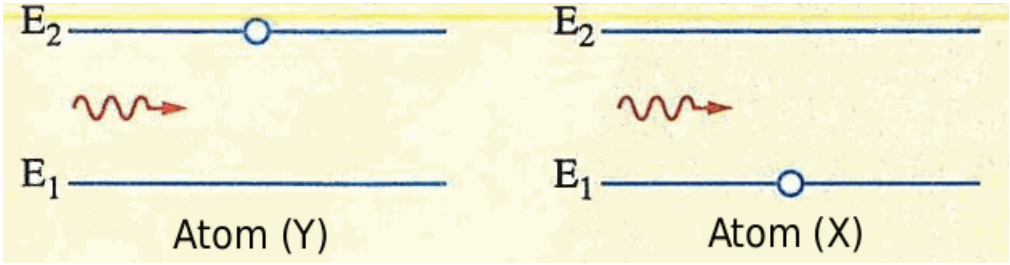


(A) transitions 1 , 4 (B) transitions 5 , 3 (C) transitions 3 , 4 (D) transitions 5 , 2

38 In three-dimensional imaging, a coherent beam of laser rays of wavelength (λ) fell on an object. If the path difference between two laser waves reflected from the object equals (2λ), the phase difference between them equals ..... (1st session 2025)

(A) 3π (B) 2π (C) 4π (D) 6π

39 A photon of energy $(E_2 - E_1)$ falls on each of the two atoms (X) and (Y) of an active medium as in the opposite figure. What process takes place in each atom? (2nd session 2025)



(A) atom (X): stimulated emission, atom (Y): spontaneous emission

(B) atom (X): spontaneous emission, atom (Y): stimulated emission

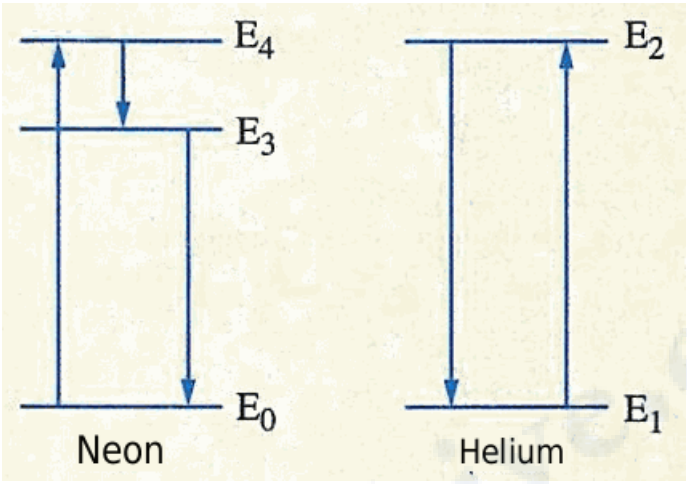
(C) atom (X): spontaneous emission, atom (Y): optical pumping

(D) atom (X): optical pumping, atom (Y): stimulated emission

40 The type of energy used to excite the atoms of the active medium in the ruby laser is ..... (2nd session 2025)

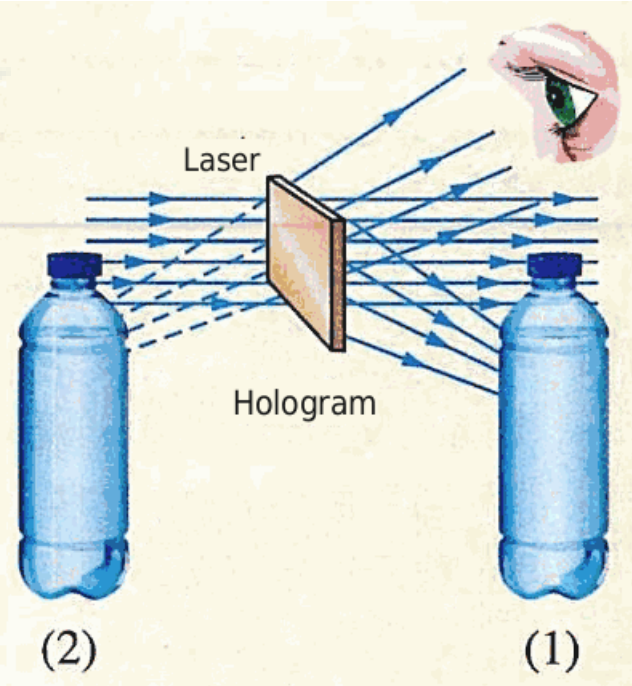
(A) electric energy (B) light energy (C) chemical energy (D) heat energy

41 A mixture of helium and neon atoms is used to produce a laser of wavelength 632.8 nm. The figure shows a simplified diagram of the energy levels of helium and neon. Between which two energy levels is there an energy difference of 3.141×10^{-19} J? (2nd session 2025)



(A) $(E_4 - E_3)$ (B) $(E_4 - E_0)$ (C) $(E_3 - E_0)$ (D) $(E_2 - E_1)$

42 The figure shows two images (1) and (2) appearing when laser rays fall on a hologram. Which of the following choices gives the properties of each image? (Sample exam 2026)



(A) image (1): real, image (2): real
(B) image (1): virtual, image (2): real
(C) image (1): real, image (2): virtual
(D) image (1): virtual, image (2): virtual

Answer key and solutions

Multiple choice questions

1 A	2 C	3 B	4 B	5 B	6 C	7 C	8 C	9 C	10 B
11 C	12 B	13 B	14 A	15 D	16 C	17 C	18 D	19 A	20 A
21 C	22 B	23 A	24 A	25 C	26 C	27 D	28 C	29 B	30 B
31 D	32 D	33 D	34 C	35 B	36 B	37 C	38 B	39 C	40 D
41 D	42 C	43 B	44 B	45 D	46 C	47 D	48 D	49 C	50 B
51 B	52 B	53 A	54 A	55 D	56 C	57 C	58 C	59 B	60 B

1 **Answer (A)**

An ordinary lamp emits light spontaneously, without any external effect.

2 **Answer (C)**

Lifetime in an ordinary excited level is 10^-8 s, in a metastable level 10^-3 s

$(10^{-8})/(10^{-3}) = 10^{-5} < 1$

3 **Answer (B)**

In a neon lamp, spontaneous emission is dominant.

4 **Answer (B)**

X is in the lower level, so it absorbs the photon.

Y is in the upper level, so stimulated emission takes place.

5 **Answer (B)**

The atom is excited and its lifetime has not ended: a photon whose energy equals the difference between the two levels causes stimulated emission.

$E = -3.4-(-13.6) = 10.2\ eV$

6 **Answer (C)**

Coherent photons have the same frequency, the same direction and the same phase.

7 **Answer (C)**

One photon goes in and two identical photons come out: stimulated emission.

8 **Answer (C)**

The atom in the lower level absorbed the photon and moved up to the higher level: absorption.

9 **Answer (C)**

A photon whose energy equals the difference between the two levels must fall on it.

$E = E_1 - E_0$

10 **Answer (B)**

The atom is excited to E1, and the incident photon has the energy

$E = E_1 - E_0$

11 **Answer (C)**

Spontaneous emission takes place without any external effect.

12 **Answer (B)**

x returns spontaneously, and y returns by the effect of a photon before its lifetime ends.

The two photons have the same energy and speed; what differs is the time each atom spent in E1.

13 **Answer (B)**

The lifetime of the level is 10^-3 s.

Atom (1) returned after 10^-5 s, before its lifetime ended: by a photon.

Atom (2) returned after 10^-3 s, when its lifetime ended: without an external effect.

14 **Answer (A)**

The intensity of an ordinary lamp is inversely proportional to the square of the distance.

$I \propto 1/(d^2)$

15 **Answer (D)**

Laser intensity does not change as the beam travels away from the source.

16 **Answer (C)**

The speed of light in vacuum is the same for all sources.

17 **Answer (C)**

All light and X-ray photons travel at the speed of light in vacuum.

18 **Answer (D)**

A laser beam does not spread out, so its intensity stays greater at the same distance.

19 **Answer (A)**

Laser photons are coherent and parallel, so they do not spread out or weaken with distance.

20 **Answer (A)**

Parallel means they have the same direction.

21 **Answer (C)**

A laser has a single wavelength, so the prism does not disperse it.

At minimum deviation the ray inside the prism travels parallel to the base.

22 **Answer (B)**

Laser intensity does not change with distance, so it stays I.

23 **Answer (A)**

The laser intensity is the same at both points.

$I_x/I_y = 1$

24 **Answer (A)**

The wave amplitude is inversely proportional to the distance.

$A \propto 1/d$

$A_y/A_x = d/2d = 1/2$

25 **Answer (C)**

$I_x/I_y = (d_2^2)/(d_1^2) = 2.25$

$d_2/d_1 = 1.5$

$d_1/d_2 = 2/3$

26 **Answer (C)**

All photons emitted by stimulated emission have the same energy.

27 **Answer (D)**

The laser spectrum is a narrow line of high intensity,

and the spectrum of ordinary light is wide.

28 **Answer (C)**

A laser needs an external energy source for pumping, so the false statement is (does not need).

29 **Answer (B)**

Pumping aims at population inversion.

30 **Answer (B)**

After pumping, population inversion takes place.

31 **Answer (D)**

Population inversion: the higher level has more atoms than the lower one.

In figure D: six atoms in E3 and only two in E1.

32 **Answer (D)**

Optical pumping is used in the ruby laser.

33 **Answer (D)**

Pumping with a laser beam is used in the liquid dye laser.

34 **Answer (C)**

The helium-neon laser is visible red light.

$\lambda = 632.8\ nm$

35 **Answer (B)**

The helium-neon laser spectrum is a single red line.

36 **Answer (B)**

The photons are emitted from neon atoms,

and the job of helium is only to transfer energy.

37 **Answer (C)**

Helium is more than neon so that there are many excited helium atoms.

$He:Ne = 10:1$

38 **Answer (B)**

Only neon reaches population inversion,

and helium transfers energy to it by collisions.

39 **Answer (C)**

The excited helium atom collides with an unexcited neon atom and transfers its energy to it.

40 **Answer (D)**

The active medium is between two facing mirrors: a reflecting mirror and a partially transparent one.

41 **Answer (D)**

The ratio of helium to neon is 10:1,
with a reflecting mirror and a partially transparent mirror at the two ends of the tube.

42 **Answer (C)**

The mirrors (3) reflect the photons back and forth, so the beam is amplified.

43 **Answer (B)**

The laser comes out of mirror (1), so it is the partially transparent one,
and its reflection coefficient is less than that of mirror (2).

44 **Answer (B)**

The photon moving parallel to the axis of the tube (B) bounces between the two mirrors,
so it stays the longest before coming out.

45 **Answer (D)**

Component x is the voltage source responsible for pumping.
If it stops, no population inversion takes place and no laser is produced.

46 **Answer (C)**

Helium atoms in E3 collide with unexcited neon and excite it to E2,
because E3 and E2 have almost the same energy.

47 **Answer (D)**

The atom gained the excitation energy
$E_x = E_2 - E_0$
and the stimulating photon that passed by it
$E_y = E_2 - E_1$

48 **Answer (D)**

The largest energy difference is between the ground level E0 and level E2.

49 **Answer (C)**

The order: pumping helium x, then energy transfer by collision k,
then stimulated emission z, then return to the ground level y.

50 **Answer (B)**

The excitation energy of helium
$E = E_3 - E_0 = 20.61\ eV$

51 **Answer (B)**

The laser photon comes from the neon transition from E2 to E1.
$E = 20.66 - 18.7 = 1.96\ eV$

52 **Answer (B)**

Population inversion takes place in the active medium (2).

53 **Answer (A)**

Holography depends on the interference of photons, so they must be coherent.

54 **Answer (A)**

$\Delta x = (\lambda)/(2\pi)\Delta\varphi$
$\Delta x = (\lambda)/(2\pi) \times (\pi)/2 = (\lambda)/4$

55 **Answer (D)**

The two waves are opposite in phase: the phase difference is π.
$\Delta x = (\lambda)/2$
$\lambda = 2 \times 3164 = 6328\ mathringA$

56 **Answer (C)**

The rays (3) reflected from different parts of the object differ in intensity.

57 **Answer (C)**

The same rays (3) differ in phase because their distances are different.

58 **Answer (C)**

The plate records interference fringes between the object beam and the reference beam.

59 **Answer (B)**

Measuring distances depends on the laser beam being parallel.

60 **Answer (B)**

Reattachment depends on the heating effect of the laser beam.

Essay questions

1 **Model answer**

(1) Diagram (2), because it shows a photon whose energy equals the energy difference between the two levels E_1 and E_2 falling on the atom, which made the atom move from the lower energy level to the higher one.

(2) Diagram (1), because it shows the atom moving from the higher energy level to the lower one, emitting two coherent photons, caused by a photon whose energy equals the energy difference between the two levels.

(3) Diagram (3), because it shows the atom moving from the higher energy level to the lower one without any external effect, emitting a single photon.

2 **Model answer**

No, because one of the two photons is the photon that fell on the excited atom, and the other one comes from the atom returning from the excited level to the lower energy level.

3 **Model answer**

Because the photons of laser rays are coherent, highly parallel and spread out very little, so the intensity of the rays stays almost constant as they travel away from the light source.

4 **Model answer**

The intensity of the laser light on the screen is greater than that of the lamp light, because laser photons are coherent, parallel and spread out very little, so the light intensity stays constant as it travels away from the source.

Unlike the photons of the electric lamp, which are not coherent, so their intensity decreases as they travel away from the source because they obey the inverse square law.

5 **Model answer**

$I \propto 1/(d^2)$

$I_1/I_2 = (d_2{}^2)/(d_1{}^2)$, $16/I_2 = ((2)^2)/((1)^2)$

$I_2 = 4\ mW/m^2$

6 **Model answer**

(1) They are responsible for producing the laser photons.

(2) It continuously supplies the atoms of the active medium with the energy needed to excite them, so that they reach population inversion.

7 **Model answer**

Excited helium atoms transfer their excitation energy to unexcited neon atoms when they collide with them, so the neon atoms become excited. This helps the neon atoms reach population inversion.

8 **Model answer**

(1) A single red spectral line, because the (helium-neon) laser emits light of a single wavelength.

(2) A continuous spectrum (a continuous region of the spectrum colours), because a tungsten lamp emits a continuous spectrum.

9 **Model answer**

Photons moving along the axis of the tube, or parallel to it, are reflected again and again between the two mirrors of the resonant cavity. As they move between the mirrors they cause more stimulated emissions from excited neon atoms whose lifetime has not ended, so their number doubles again. This repeats until the radiation is amplified.

10 **Model answer**

Because the ability of rays to reach far distances does not depend on the energy of a single photon, but on the coherence of the photons and the parallelism of the rays, which laser rays have and X-rays do not.

11 **Model answer**

Similarity: the photons of both move in vacuum at the same speed $(c = 3 \times 10^8\ m/s)$.

Difference: (helium-neon) laser photons have a single wavelength in the visible region, are coherent and do not obey the inverse square law.

X-ray photons have a continuous range of wavelengths from $10^{-13}\ m$ to $10^{-8}\ m$ (not visible), are not coherent and obey the inverse square law.

12 **Model answer**

Because in this case the work function of the metal surface is greater than the energy of the red light photons of the (helium-neon) laser.

White light contains a range of rays with photons of higher energy than the (helium-neon) laser photons, so they free photoelectrons from the surface.

13 **Model answer**

A three-dimensional virtual image identical to the object appears.

14 **Model answer**

The beam falling on the object: parallel and in phase.

The beam reflected from the object: not parallel, with differences in intensity and phase between its rays, because it carries the properties of the surface it was reflected from (its colour differences and its surface shape).

15 **Model answer**

Using reference rays of the same wavelength as the rays reflected from the object, so that they interfere on the photographic plate.

16 **Model answer**

(1) Because laser rays are parallel and their intensity does not change as the distance travelled increases, so they reach the missiles with a suitable intensity.

(2) Because laser rays are coherent, so when used in holography they record the differences in both the light intensity and the phase difference of the resulting interference fringes, which is the condition for forming a three-dimensional image.

(3) Because laser rays have a high intensity, so they carry a large thermal energy that welds the detached parts together.

Past exam questions

1	2	3	4	5	6	7	8	9	10
B	D	C	A	C	B	A	C	A	C
11	12	13	14	15	16	17	18	19	20
C	C	D	A	A	C	A	D	C	B
21	22	23	24	25	26	27	28	29	30
B	B	D	C	A	C	C	C	B	C
31	32	33	34	35	36	37	38	39	40
D	B	D	B	C	B	B	C	D	B
41	42								
A	C								

1 **Answer (B)**

(1) The resonant cavity mirrors: they reflect the photons back and forth.

(2) The tube: it contains the active medium (a mixture of helium and neon).

(3) The voltage source: it makes a high potential difference that excites the atoms.

2 **Answer (D)**

The laser beam and the xenon lamp light are both electromagnetic waves whose speed in air is c, so the ratio equals one.

3 **Answer (C)**

Amplification takes place by the repeated reflections of the photons between the two resonant cavity mirrors (4) and (5).

4 **Answer (A)**

Laser rays are parallel and coherent and do not obey the inverse square law,
so neither their intensity nor their diameter changes noticeably.

5 **Answer (C)**

In stimulated emission a photon of frequency ν falls on the excited atom, so the atom returns to its level and two photons are released, each of frequency ν (identical).

6 **Answer (B)**

Spectral purity means that laser photons have almost a single wavelength.

7 **Answer (A)**

The atoms of the active medium in the liquid dye laser are excited by light energy.

8 **Answer (C)**

The metastable excited levels of helium and neon are close in energy, so the energy of excited helium is transferred to neon by collisions.

9 **Answer (A)**

Changing the reflection ratio changes the intensity of the beam that comes out.
The photon energy $E = h\nu$ depends on the difference between the energy levels, so it stays constant.

10 **Answer (C)**

The transparent plate does not reflect the photons, so the repeated reflections do not happen and there is no amplification,
so no laser beam is produced at all.

11 **Answer (C)**

Holography depends on the interference of rays, which needs the laser photons to be coherent.

12 **Answer (C)**

$\Delta\varphi = (2\pi)/(\lambda)\ \Delta x$
$(\pi)/4 = (2\pi)/(\lambda)\ \Delta x$
$\Delta x = (\lambda)/8$

13 **Answer (D)**

The rays reflected from the object differ in phase because they travel different distances from the different parts of the object's surface.

14 **Answer (A)**

The beam comes out of the partially transparent mirror when the radiation intensity inside the resonant cavity reaches a certain value.

15 **Answer (A)**

Destroying missiles needs high energy, so it depends on the energy of the laser beam.

16 **Answer (C)**

The photons reflected from the resonant cavity mirrors collide with the excited neon atoms in the metastable level, causing new stimulated emissions.

17 **Answer (A)**

$\Delta x = (\lambda)/(2\pi)\ \Delta\varphi = (\lambda)/(2\pi) \times 2\pi = \lambda$

18 **Answer (D)**

The photons of ordinary light are not coherent.
Blue light has a higher frequency than red, so its photon energy $E = h\nu$ is higher.

19 **Answer (C)**

More repeated reflections inside the resonant cavity cause more stimulated emissions, so the beam intensity increases.

20 **Answer (B)**

Without the mirror the repeated reflections do not happen, so there is no amplification and no laser beam comes out.

21 **Answer (B)**

$\Delta\varphi = (2\pi)/(\lambda)\ \Delta x = (2\pi)/(\lambda) \times 2/3\lambda = (4\pi)/3$

22 **Answer (B)**

For stimulated emission, the energy of the incident photon must equal the energy difference between the two levels.

$X = E - E_0$

23 **Answer (D)**

(1) atoms in the ground level, then (4) excitation and population inversion, then (2) spontaneous emission starts the process, then (3) stimulated emission with two coherent photons.

24 **Answer (C)**

The intensity of a laser beam hardly changes with distance from the source, so the line is horizontal (graph 3).

25 **Answer (A)**

Holography needs light of almost a single wavelength (spectral purity), so the narrowest curve (1).

26 **Answer (C)**

The lifetime is 10^{-3} s; after 5×10^{-4} s the atom will have spent (the earlier time + 5×10^{-4}) s.

$e_2 : 2 \times 10^{-4} + 5 \times 10^{-4} = 7 \times 10^{-4} < 10^{-3}$

$e_5 : 4.2 \times 10^{-4} + 5 \times 10^{-4} = 9.2 \times 10^{-4} < 10^{-3}$

The rest go over 10^{-3} s, so they return spontaneously before the photons arrive.

27 **Answer (C)**

The reference rays are the ones reflected from the partially transparent mirror to the plate without falling on the object: (C).

28 **Answer (C)**

The laser photon is released when the neon atom moves from the metastable level E_2 to E_1, which is transition (2).

29 **Answer (B)**

Spectrum (1) is wide (ordinary light) and obeys the inverse square law: doubling the distance makes its intensity a quarter.

$2I \times 1/4 = I/2$

Spectrum (2) is narrow (laser), so its intensity stays I

30 **Answer (C)**

The second photon of energy E_4 - E_3 causes stimulated emission, so the electron returns from N to M and two coherent photons are released.

31 **Answer (D)**

Population inversion: the number of atoms in the metastable level E_2 is greater than the number in the lower level E_1 (figure 4).

32 **Answer (B)**

An emission spectrum is produced when the atom moves from a higher level to a lower one, releasing a photon (figure 2).

33 **Answer (D)**

Spectral purity: the two released photons have the same frequency ν (figure 4).

34 **Answer (B)**

Neon atoms are excited by colliding with excited helium atoms (component 3).

35 **Answer (C)**

Helium (component 3) is excited by the electric discharge and then excites the neon atoms by collisions.

36 **Answer (B)**

The frequency of green light is higher than that of the red (helium-neon) laser light.

$E = h\nu$, so the energy of the green light photon is greater.

37 **Answer (B)**

The excited helium atom returns from E_2 to E_1 (transition 5) and transfers its energy to the neon atom, which is excited from E_0 to E_4 (transition 3).

38 **Answer (C)**

$\Delta\varphi = (2\pi)/(\lambda)\ \Delta x = (2\pi)/(\lambda) \times 2\lambda = 4\pi$

39 **Answer (D)**

Atom (X) in level E_1 absorbs the photon and is excited (optical pumping).

Atom (Y) is excited in E_2, so stimulated emission takes place.

40 **Answer (B)**

The chromium atoms in the ruby laser are excited by light energy from the xenon lamp.

41 **Answer (A)**

$E = hc/(\lambda) = (6.625 \times 10^{-34} \times 3 \times 10^{8})/(632.8 \times 10^{-9}) = 3.141 \times 10^{-19}\ J$

which is the energy of the laser photon produced when neon moves from E_4 to E_3

42 **Answer (C)**

Image (1), on the viewer's side, is formed where the rays actually meet, so it is real.

Image (2), behind the hologram, is virtual.