

**PHY · PHYSICS**

14. Dawn of Modern Physics

Official PMDC Solved Past Paper Topical Booklet · High-Yield Examination Series

© 51 Solved Questions

👤 2014 to 2024 Archive

🛡 Boards: BUMHS, DUHS, KMU, KU, MDCAT, PMDC

📄 Weightage: 27% of MDCAT (54 MCQs)

Curated by Ibrahim for fellow bees. Every question in this chapter has been verified against official UHS, NUMS, SZABMU, DUHS, and KMU answer keys. Propolis cognitive autopsies are provided at the end of this booklet to explain core concepts and break down common distractor traps.

OFFICIAL SOLVED EDITION**Q1.**

SZABMU 2024

At what angle made by scattered photon with x-axis, we can get maximum value of Compton's shift?

[SZABMU 2024]

- (A) 180°
- (B) 0°
- (C) 45°
- (D) 90°

Q2.

SZABMU 2024

The kinetic energy of emitted electrons in photoelectric effect can be increased by increasing _____ **[SZABMU 2024]**

- (A) Frequency of electromagnetic wave
- (B) Applied potential of electrodes
- (C) Intensity of incident light
- (D) Momentum of incident photon

Q3.

KU 2024

The momentum of moving photon is: **[KU 2024]**

- (A) mc^2
- (B) $\frac{\lambda}{h}$
- (C) $\frac{h}{\lambda}$
- (D) Zero

Q4.

KU 2024

In every instant of time, wavelength associated with a freely falling body: **[KU 2024]**

- (A) Decreases
- (B) Increases two times
- (C) Increases four times
- (D) Remains constant

Q5.

KU 2024

As per 2nd photoelectric experiment, photoelectric effect does not occur if the frequency of the incident light is: **[KU 2024]**

- (A) Below the threshold frequency
- (B) Equals the threshold frequency
- (C) Three times the threshold frequency
- (D) Twice the threshold frequency

Q6.

UHS 2024

The value of Plank constant is **[UHS 2024]**

- (A) $6.63 \times 10^{-34} \text{ Js}$
- (B) $6.63 \times 10^{34} \text{ Js}$
- (C) $6.63 \times 10^{-34} \text{ Js}^{-1}$
- (D) $6.63 \times 10^{34} \text{ Js}^{-1}$

Q7.

UHS 2024

The de-Broglie wavelength associated with a particle moving at 10^6 m/s and having mass 10^{-30} kg [UHS 2024]

- (A) 6.6×10^{-10} m
- (B) 1.5×10^9 m
- (C) 1.9×10^{-5} m
- (D) 7.2×10^{-8} m

Q8.

UHS 2024

Light propagates through space as a wave is evident by all of the following EXCEPT [UHS 2024]

- (A) Interference
- (B) Photoelectric effect
- (C) Diffraction
- (D) Polarization

Q9.

BUMHS 2024

When placed in light which of the following can generate an output voltage across its electrodes? [BUMHS 2024]

- (A) p-n diode
- (B) Light emitting diode
- (C) Photo diode
- (D) All of the given options

Q10.

BUMHS 2024

Photoelectron emission depends upon the: [BUMHS 2024]

- (A) Intensity of incident light
- (B) Color of the body
- (C) Frequency of incident light
- (D) Shape of the body

Q11.

BUMHS 2024

In photo-electric effect electrons are emitted on incidence of light upon certain material surfaces: [BUMHS 2024]

- (A) Below a certain frequency
- (B) Beyond a certain wavelength
- (C) Above a certain frequency
- (D) None of the given options

Q12.

BUMHS 2024

Let an electron beam is accelerated by adjustable potential V . If we decrease potential V , wavelength of matter wave associated with electron will: [BUMHS 2024]

- (A) Increase
- (B) Decrease
- (C) Remain same
- (D) Sometime increase sometime decrease

Q13.

UHS 2023

In Compton effect, the incident photon when compared to the scattered photon is of: [UHS 2023]

- (A) Greater frequency
- (B) Greater energy and momentum
- (C) Equal energy
- (D) Greater wavelength

Q14.

UHS 2023

The process of ejection of loosely bound electrons from a certain photo sensitive surface by absorption of photon is called: [UHS 2023]

- (A) Photoelectric effect
- (B) Compton effect
- (C) Pair production
- (D) Black body radiation

Q15.

UHS 2023

In Compton effect, a photon of a certain wavelength collides with a stationary electron. The wavelength of the emitted photon is: [UHS 2023]

- (A) Shorter
- (B) Longer
- (C) Same
- (D) Infinite

Q16.

SZABMU 2023

Which is the correct 'ascending order' in which the following photons are arrange according to their energy? [SZABMU 2023]

- (A) Gamma rays, ultraviolet rays, microwaves
- (B) Microwaves, ultraviolet rays, gamma rays
- (C) Gamma rays, microwaves, ultraviolet rays
- (D) Ultraviolet rays, gamma rays, microwaves

Q17.

SZABMU 2023

The wavelength associated with an electron is of the order of: [SZABMU 2023]

- (A) Visible light
- (B) X-rays
- (C) Radio waves
- (D) Infrared

Q18.

SZABMU 2023

Red light is used in photographic dark room because of: [SZABMU 2023]

- (A) Low frequency, long wavelength
- (B) High frequency, short wavelength
- (C) Low frequency, short wavelength
- (D) High frequency, long wavelength

Q19.

SZABMU 2023

Which photons carries the most energy? [SZABMU 2023]

- (A) Violet
- (B) Blue
- (C) Red
- (D) Green

Q20.

DUHS 2023

Which of the following corresponds to the momentum of a photon? [SINDH 2023]

- (A) $\frac{h}{\lambda}$
- (B) $h\lambda$
- (C) $\frac{\lambda}{h}$
- (D) $h^2\lambda^{-1}$

Q21.

DUHS 2023

If the wavelength of a light is 3×10^{-7} m, then what is its frequency? [SINDH 2023]

- (A) 1×10^{15} Hz
- (B) 1×10^{13} Hz
- (C) 1×10^{14} Hz
- (D) 1×10^{16} Hz

Q22.

DUHS 2023

The energy of light is determined by its: [SINDH 2023]

- (A) Intensity
- (B) Frequency
- (C) Amplitude
- (D) Speed

Q23.

UHS 2022

If electron, proton, neutron, and alpha particle have same velocity, which of them has the shortest wavelength? [UHS 2022]

- (A) Electron
- (B) Proton
- (C) Neutron
- (D) Alpha particle

Q24.

UHS 2022

The process of ejection of loosely bound electrons from a certain photo sensitive surface by absorption of photon is called: [UHS 2022]

- (A) Photoelectric effect
- (B) Compton effect
- (C) Pair production
- (D) Black body radiation

Q25.

UHS 2022

In a photoelectric effect experiment, the stopping potential is: [UHS 2022]

- (A) The kinetic energy of the most energies electron ejected
- (B) The potential energy of the most energetic electron ejected
- (C) The photon energy
- (D) The electric potential that causes the electron current to vanish

Q26.

SZABMU 2022

Red light is used in photographic dark room because of: [SZABMU 2022]

- (A) More frequency, less wavelength
- (B) Less frequency, less wavelength
- (C) Less frequency, more wavelength
- (D) More frequency, more wavelength

Q27.

SZABMU 2022

Which photons carriers the most energy? [SZABMU 2022]

- (A) Violet
- (B) Blue
- (C) Red
- (D) Green

Q28.

KMU 2022

An electron will have maximum kinetic energy when it has: [ETEA 2022]

- (A) Short wavelength
- (B) Long wavelength
- (C) Low frequency
- (D) Circular motion

Q29.

KMU 2022

In pair annihilation two gamma ray's photons created, travel in opposite direction not in the same direction, because: [ETEA 2022]

- (A) This proves law of conservation of momentum
- (B) This proves law of conservation of energy
- (C) This proves law of conservation of charge
- (D) This proves law of conservation of mass-energy

Q30.

KMU 2022

Which photon is travelling with largest speed in vacuum? [ETEA 2022]

- (A) Gamma photon
- (B) Visible light photon
- (C) All photons move with the speed of light
- (D) Infrared

Q31.

KMU 2022

In physics it is observed that when matter and anti-matter combine, they form: [ETEA 2022]

- (A) Particles with zero charge
- (B) Particles with positive charge
- (C) Particles with negative charge
- (D) Particles with dual mass

Q32.

BUMHS 2022

Positron and electron annihilate into: [BMU 2022]

- (A) α -rays
- (B) One γ ray photon
- (C) Two γ ray photons
- (D) X-rays

Q33.

BUMHS 2022

The units of the equation of Compton scattering

$\Delta\lambda = \frac{h}{m_0c}(1 - \cos\theta)$ are of: [BMU 2022]

- (A) Length
- (B) Time
- (C) Mass
- (D) Frequency

Q34.

DUHS 2022

The minimum energy of photon for pair production is [DUHS 2022]

- (A) 1.02 J
- (B) 1.02 MeV
- (C) 1.02 eV
- (D) 1.02 GeV

Q35.

DUHS 2022

The experimental proof of particle nature of light is: [DUHS 2022]

- (A) Photoelectric effect
- (B) Pair-production
- (C) Davison-Germer experiment
- (D) de-Broglie concept

Q36.

PMDC 2021

Photon is made up _ quarks [NMDCAT 2021]

- (A) Basons
- (B) No quark
- (C) Quarks in hadrons
- (D) Masons

Q37.

PMDC 2021

If wavelength = 500 nm of a photon, then its frequency is: [NMDCAT 2021]

- (A) 6×10^{14} Hz
- (B) 5×10^{14} Hz
- (C) 7×10^{14} Hz
- (D) 8×10^{14} Hz

Q38.

PMDC 2021

Find the energy in eV of a photon having a wavelength of 1440 nm.? [NMDCAT 2021]

- (A) 0.867 eV
- (B) 18.67 eV
- (C) 9.32 eV
- (D) 0.932 eV

Q39.

PMDC 2021

If velocity Becomes 5 times, what happened to De Broglie Wavelength [NMDCAT 2021]

- (A) Increase by 5 times
- (B) Decrease by 5 times
- (C) Both
- (D) None

Q40.

PMDC 2020

The wavelength associated with an electron is of the order of: [NMDCAT 2020]

- (A) Visible light
- (B) X-Rays
- (C) Radio waves
- (D) Infrared

Q41.

PMDC 2020

Which photon carries the most energy? [NMDCAT 2020]

- (A) Blue
- (B) Red
- (C) Violet
- (D) Green

Q42.

MDCAT 2019

The value and units of the Plank constant 'h' can be expressed as: [MDCAT 2019]

- (A) $6.63 \times 10^{-34} \text{ Js}^{-1}$
- (B) $6.63 \times 10^{34} \text{ Js}$
- (C) $6.63 \times 10^{-34} \text{ Js}$
- (D) $3.63 \times 10^{14} \text{ Js}$

Q43.

MDCAT 2019

Calculate the energy of a photon of frequency $3.0 \times 10^{18} \text{ Hz}$. ($h = 6.63 \times 10^{-34} \text{ Js}$) [MDCAT 2019]

- (A) $19.89 \times 10^{-18} \text{ J}$
- (B) $11.89 \times 10^{-16} \text{ J}$
- (C) $1.89 \times 10^{-16} \text{ J}$
- (D) $19.89 \times 10^{-16} \text{ J}$

Q44.

MDCAT 2018

The de Broglie wave length of an electron travelling with a speed of $1.0 \times 10^7 \text{ m/s}$ equal to, ($h = 6.6 \times 10^{-34} \text{ Js}$ and $m_e = 9.1 \times 10^{-31} \text{ kg}$): [MDCAT 2018]

- (A) $7.3 \times 10^{11} \text{ m}$
- (B) $7.3 \times 10^{-11} \text{ m}$
- (C) $7.3 \times 10^{10} \text{ m}$
- (D) $7.3 \times 10^{-10} \text{ m}$

Q45.

MDCAT 2018

A 5-watt LED bulb converts 80% of the power into light photons of wavelength 660 nm. What is the number of photons emitted from the bulb in one second? [MDCAT 2018]

- (A) 5.8×10^{14}
- (B) 7.5×10^{18}
- (C) 1.3×10^{19}
- (D) 6.6×10^7

Q46.

MDCAT 2017

The momentum of wave of wavelength $1.32 \times 10^{-9} \text{ m}$ is: [MDCAT 2017]

- (A) $5 \times 10^{-26} \text{ Ns}$
- (B) $5 \times 10^{-25} \text{ Ns}$
- (C) $5 \times 10^{-43} \text{ Ns}$
- (D) $5 \times 10^{-44} \text{ Ns}$

Q47.

MDCAT 2017

Calculate the frequency of a photon having a momentum of $4.42 \times 10^{-26} \text{ Ns}$: [MDCAT 2017]

- (A) $2 \times 10^{14} \text{ Hz}$
- (B) $5 \times 10^{16} \text{ Hz}$
- (C) $2 \times 10^{16} \text{ Hz}$
- (D) $2 \times 10^{18} \text{ Hz}$

Q48.

MDCAT 2015

Which one of the following has the largest energy content? [MDCAT 2015]

- (A) Infrared rays
- (B) Ultra violet radiations
- (C) γ -rays
- (D) X-rays

Q49.

KMU 2015

Choose the correct relationship, when E = energy, h = plank's constant, c = velocity of light, f = frequency, λ = wavelength: [ETEA 2015]

- (A) $E = hfc$
- (B) $E = \frac{c}{\lambda}$
- (C) $E = \frac{h\lambda}{c}$
- (D) $E = hf$

Q50.

KMU 2015

Which of the following is the best evidence for the wave nature of matter? [ETEA 2015]

- (A) The reflection of electrons by crystal
- (B) The photoelectric effect
- (C) The Compton effect
- (D) The spectral radiation from cavity radiation

Q51.

KMU 2014

Select the correct relation between wave and particle nature of radiation? [ETEA 2014]

- (A) $E = \frac{\lambda c}{h}$
- (B) $E = \frac{hc}{\lambda}$
- (C) $E = \frac{hc}{c}$
- (D) $E = h\lambda c$

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 14. Dawn of Modern Physics.

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Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	A	SZABMU 2024	12	A	BUMHS 2024	23	D	UHS 2022	34	B	DUHS 2022	45	C	MDCAT 2018
2	A	SZABMU 2024	13	B	UHS 2023	24	A	UHS 2022	35	A	DUHS 2022	46	B	MDCAT 2017
3	C	KU 2024	14	A	UHS 2023	25	D	UHS 2022	36	B	PMDC 2021	47	C	MDCAT 2017
4	A	KU 2024	15	B	UHS 2023	26	C	SZABMU 2022	37	A	PMDC 2021	48	C	MDCAT 2015
5	A	KU 2024	16	B	SZABMU 2023	27	A	SZABMU 2022	38	A	PMDC 2021	49	D	KMU 2015
6	A	UHS 2024	17	B	SZABMU 2023	28	A	KMU 2022	39	B	PMDC 2021	50	A	KMU 2015
7	A	UHS 2024	18	A	SZABMU 2023	29	A	KMU 2022	40	B	PMDC 2020	51	B	KMU 2014
8	B	UHS 2024	19	A	SZABMU 2023	30	C	KMU 2022	41	C	PMDC 2020			
9	C	BUMHS 2024	20	A	DUHS 2023	31	A	KMU 2022	42	C	MDCAT 2019			
10	C	BUMHS 2024	21	A	DUHS 2023	32	C	BUMHS 2022	43	D	MDCAT 2019			
11	C	BUMHS 2024	22	B	DUHS 2023	33	A	BUMHS 2022	44	B	MDCAT 2018			

TOTAL
MCQS

51

CORRECT

INCORRECT

BLANK

ACCURACY

%

Scan the booklet QR code to enter answers in
BeambePrep Grind Mode for automated error
autopsies.

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (A)

SZABMU 2024

At what angle made by scattered photon with x-axis, we can get maximum value of Compton's shift? [SZABMU 2024]

CORE CONCEPT AND DERIVATION

The Compton shift calculates the change in a photon's wavelength after colliding with an electron, heavily dependent on the scattering angle θ .

Formula:

$$\Delta\lambda = \frac{h}{m_0c}(1 - \cos\theta)$$

Solution:

- To maximize the shift $\Delta\lambda$, the expression $(1 - \cos\theta)$ must be maximized.
- The cosine function reaches its minimum mathematical value of -1 at an angle of 180° .
- Substitute this in: $1 - (-1) = 2$.
- This represents a direct head-on collision where the photon bounces straight back, yielding the maximum possible energy transfer to the electron and maximum wavelength shift.

Why other options are incorrect:

At 0° , $\cos(0) = 1$ yielding zero shift. At 90° , $\cos(90) = 0$ yielding a standard shift of exactly one Compton wavelength, which is half of the maximum possible shift.

Question #2 Key: (A)

SZABMU 2024

The kinetic energy of emitted electrons in photoelectric effect can be increased by increasing ____ [SZABMU 20...]

CORE CONCEPT AND DERIVATION

Einstein's photoelectric equation maps out exactly what governs the speed (kinetic energy) of electrons ejected from a metal plate.

Formula:

$$K.E_{max} = hf - \Phi$$

Solution:

- The work function Φ is a constant material property.
- Therefore, the only variable that directly increases the maximum kinetic energy ($K.E_{max}$) of the freed electron is an increase in the incident light's frequency f .

Why other options are incorrect:

Increasing light intensity only increases the *number* of electrons emitted per second, not their individual speeds. Applied potential helps collect electrons but does not alter their initial ejection kinetic energy.

Question #3 Key: (C)

KU 2024

The momentum of moving photon is: [KU 2024]

CORE CONCEPT AND DERIVATION

Despite having no resting mass, a moving photon carries momentum as a consequence of relativistic energy-momentum dynamics.

Formula:

$$p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

Solution:

- Using de Broglie's foundational wave-particle relation, momentum is definitively given as Planck's constant divided by the particle's wavelength.
- Thus, $p = \frac{h}{\lambda}$ perfectly describes photon momentum.

Why other options are incorrect:

mc^2 represents rest-mass energy, not momentum (and photons have no rest mass anyway). "Zero" momentum would mean the photon carries no energy and exerts no radiation pressure, which is false.

Question #4 Key: (A)

KU 2024

In every instant of time, wavelength associated with a freely falling body: [KU 2024]

CORE CONCEPT AND DERIVATION

A body in free fall accelerates constantly downward due to gravity, meaning its velocity continuously increases over time.

Formula:

$$\lambda = \frac{h}{mv}$$

Solution:

- As the falling object accelerates (velocity v increases every instant), the denominator in the de Broglie equation grows larger.
- Because wavelength λ is inversely proportional to velocity v , a continuously increasing velocity yields a continuously shrinking wavelength.
- Therefore, the wavelength continuously decreases.

Why other options are incorrect:

Increasing wavelength would require the object to be slowing down. Remaining constant would require the object to fall at a terminal (constant) velocity, which contradicts "freely falling".

Question #5 Key: (A)

KU 2024

As per 2nd photoelectric experiment, photoelectric effect does not occur if the frequency of the incident light...

CORE CONCEPT AND DERIVATION

Electrons are bound to their host metal by attractive atomic forces. A rigid energy barrier must be broken to free them.

Formula:

$$E = hf$$

$$K.E_{max} = hf - hf_0$$

Solution:

- The term f_0 represents the critical "threshold frequency" specific to that metal.
- If the incoming light's frequency f is strictly less than f_0 , a single photon will lack the required binding energy to rip an electron out.
- Because quantum interactions are strictly one-to-one (one photon to one electron), no emission can occur, regardless of how intensely the light shines.

Why other options are incorrect:

At exactly the threshold frequency, emission does occur (though electrons emerge with zero kinetic energy). Above the threshold, the effect easily occurs.

Question #6 Key: (A)

UHS 2024

The value of Planck constant is [UHS 2024]

CORE CONCEPT AND DERIVATION

Planck's constant is the fundamental proportionality factor in quantum mechanics, anchoring the energy of photons to their respective wave frequencies.

Formula:

$$h = \frac{E}{f}$$

Solution:

- The scientifically established universal constant value is $6.626 \times 10^{-34} \text{ J} \cdot \text{s}$.
- It quantifies the "action" in the quantum realm, dictating the step-sizes of energy quantization.

Why other options are incorrect:

Positive exponents represent numbers larger than the observable universe, completely violating the microscopic nature of quantum mechanics. Js^{-1} represents a unit of Power (Watts), not Action.

Question #7 Key: (A)

UHS 2024

The de-Broglie wavelength associated with a particle moving at [Formula] and having mass [Formula] [UHS 2024]

CORE CONCEPT AND DERIVATION

Matter possesses wave-like behavior depending directly on its physical momentum.

Formula:

$$\lambda = \frac{h}{mv}$$

Solution:

- Given mass $m = 10^{-30}$ kg and velocity $v = 10^6$ m/s.
- Using $h \approx 6.6 \times 10^{-34}$ J · s.
- Calculate momentum: $p = (10^{-30}) \times (10^6) = 10^{-24}$ kg m/s.
- Substitute into equation: $\lambda = \frac{6.6 \times 10^{-34}}{10^{-24}}$.
- Result: $\lambda = 6.6 \times 10^{-10}$ m.

Why other options are incorrect:

The other options are the result of arithmetic mistakes, specifically mishandling the subtraction of negative exponents during the final division step.

Question #8 Key: (B)

UHS 2024

Light propagates through space as a wave is evident by all of the following EXCEPT [UHS 2024]

CORE CONCEPT AND DERIVATION

Historical experiments strictly categorize light phenomena into those proving wave theory (continuous oscillation) and those proving particle theory (discrete quantization).

Formula:

N/A

Solution:

- Interference (Young's double slit), diffraction (bending around obstacles), and polarization (transverse oscillation orientation) can ONLY be explained by modeling light as a wave.
- However, the Photoelectric effect utterly defies wave logic; classical wave theory predicted delayed electron emission at low intensities, which never happens.
- Einstein solved this by proving light acts as a discrete particle (photon) during the photoelectric effect.

Why other options are incorrect:

The question asks for the EXCEPTION to wave evidence. Interference, Diffraction, and Polarization are explicitly wave evidence, leaving only the Photoelectric effect as the particle exception.

Question #9 **Key: (C)**

BUMHS 2024

When placed in light which of the following can generate an output voltage across its electrodes? [BUMHS 2024]

CORE CONCEPT AND DERIVATION

Semiconductor devices can manipulate photons. Some emit photons when given electricity, while others create electricity when struck by photons.

Formula:

N/A

Solution:

- A photodiode (or a photovoltaic cell) is specifically engineered with an active depletion region.
- When photons strike it, they generate electron-hole pairs, which the internal electric field pushes to opposite ends.
- This charge separation acts as a battery, generating a measurable output voltage/current purely from light exposure.

Why other options are incorrect:

A standard p-n diode is an electrical one-way valve, not designed for optical interactions. A Light Emitting Diode (LED) does the exact opposite—it consumes voltage to produce light.

Question #10 **Key: (C)**

BUMHS 2024

Photoelectron emission depends upon the: [BUMHS 2024]

CORE CONCEPT AND DERIVATION

The fundamental trigger for the photoelectric effect hinges entirely on quantum energy levels, not macroscopic quantities or shapes.

Formula:

$$E = hf$$

Solution:

- An electron will strictly refuse to leave the metal surface unless it is hit by a single photon carrying energy equal to or greater than the metal's work function.
- Because photon energy is dictated exclusively by frequency (f), the mere occurrence of emission relies entirely on reaching this specific threshold frequency.

Why other options are incorrect:

Intense low-frequency light will never cause emission. Shape and color of the macroscopic body have absolutely no bearing on atomic-level quantum binding energies.

Question #11 Key: (C)

BUMHS 2024

In photo-electric effect electrons are emitted on incidence of light upon certain material surfaces: [BUMHS 20...

CORE CONCEPT AND DERIVATION

A binding energy barrier (work function) exists for electrons in a metal, requiring a minimum packet of incident energy to overcome.

Formula:

$$hf \geq \Phi$$

Solution:

- Since energy scales directly with frequency, a threshold frequency (f_0) exists.
- Light must possess a frequency strictly above this f_0 limit to provide enough individual photon energy to eject an electron.

Why other options are incorrect:

"Below a certain frequency" provides insufficient energy.
 "Beyond a certain wavelength" implies longer wavelengths, which means lower frequencies and lower energy, defeating emission.

Question #12 Key: (A)

BUMHS 2024

Let an electron beam is accelerated by adjustable potential V . If we decrease potential V , wavelength of matte...

CORE CONCEPT AND DERIVATION

An accelerating voltage imparts electrical potential energy into an electron, converting it completely into kinetic energy, which in turn defines its momentum and wavelength.

Formula:

$$K.E = eV$$

$$\lambda = \frac{h}{\sqrt{2m(eV)}}$$

Solution:

- The formula explicitly places the voltage V inside the denominator.
- This establishes an inverse-square-root relationship between the associated matter wavelength and the applied voltage.
- Therefore, if you actively decrease the voltage V , the denominator shrinks, causing the resulting wavelength λ to increase.

Why other options are incorrect:

Decreasing the voltage removes kinetic energy, making the electron slower. A slower electron has less momentum, leading to a larger, not smaller, wavelength.

Question #13 **Key: (B)**

UHS 2023

In Compton effect, the incident photon when compared to the scattered photon is of: [UHS 2023]

CORE CONCEPT AND DERIVATION

The Compton effect involves an inelastic collision between a high-energy photon and a resting electron, adhering to conservation of energy.

Formula:

$$E_{\text{incident}} = E_{\text{scattered}} + K.E_{\text{electron}}$$

Solution:

- Because the incident photon transfers a portion of its initial energy to the target electron to knock it away, the scattered photon must have less energy.
- Since energy E and momentum p for a photon are proportional ($E = pc$), the incident photon inherently possesses greater energy and greater momentum than the scattered photon.

Why other options are incorrect:

Option A (Greater frequency) is also technically true, but Option B provides a much more complete and physically rigorous description of the initial vs final state. 's source key marked the answer as "Greater energy and momentum". Actually, incident has shorter wavelength, greater frequency, greater energy, greater momentum. The exact historical correct option per the key is "Greater energy and momentum".

Question #14 **Key: (A)**

UHS 2023

The process of ejection of loosely bound electrons from a certain photo sensitive surface by absorption of photo...

CORE CONCEPT AND DERIVATION

The emission of electrons when electromagnetic radiation hits a material is a core quantum phenomenon.

Formula:

N/A

Solution:

- This is the exact definition of the photoelectric effect.
- An incoming photon is completely absorbed by an atomic electron. If the photon's energy exceeds the work function of the metal, the electron is violently ejected.

Why other options are incorrect:

The Compton effect involves photon scattering (not complete absorption). Pair production is energy becoming mass. Black body radiation is a thermal emission process.

Question #15 **Key: (B)**

UHS 2023

In Compton effect, a photon of a certain wavelength collides with a stationary electron. The wavelength of the...

CORE CONCEPT AND DERIVATION

Compton scattering dictates that an incident photon loses energy when it collides with a stationary electron.

Formula:

$$\lambda_{\text{scattered}} - \lambda_{\text{incident}} = \frac{h}{m_e c} (1 - \cos \theta)$$

Solution:

- Because the photon transfers kinetic energy to the electron, its own final energy decreases.
- Energy and wavelength are inversely proportional ($E = \frac{hc}{\lambda}$).
- A decrease in energy guarantees an increase in wavelength. Thus, the emitted (scattered) photon has a strictly longer wavelength.

Why other options are incorrect:

A shorter wavelength would imply the photon magically gained energy from nowhere. "Same" implies a perfectly elastic collision with no energy transfer, which does not happen.

Question #16 Key: (B)

SZABMU 2023

Which is the correct 'ascending order' in which the following photons are arranged according to their energy? [...]

CORE CONCEPT AND DERIVATION

The electromagnetic spectrum classifies waves. Energy per photon directly scales with frequency.

Formula:

$$E \propto f$$

Solution:

- "Ascending order" means starting with the lowest energy and moving to the highest energy.
- Microwaves have long wavelengths and very low energy.
- Ultraviolet rays sit above visible light and have intermediate energy.
- Gamma rays have incredibly short wavelengths and the highest energy in the universe.
- The sequence is: Microwaves → Ultraviolet → Gamma rays.

Why other options are incorrect:

Any order starting with Gamma rays is a descending order. Placing ultraviolet below microwaves is factually incorrect regarding the EM spectrum.

Question #17 Key: (B)

SZABMU 2023

The wavelength associated with an electron is of the order of: [SZABMU 2023]

CORE CONCEPT AND DERIVATION

This addresses the fundamental scale of quantum mechanical matter waves for particles accelerated to practical laboratory energies.

Formula:

$$\lambda = \frac{h}{\sqrt{2meV}}$$

Solution:

- An electron accelerated through typically encountered potentials (tens to thousands of volts) achieves a de Broglie wavelength in the realm of 0.01 nm to 1 nm.
- This exact spatial dimension matches the wavelength of X-rays, making crystalline atomic structures excellent diffraction gratings for both X-rays and electrons.

Why other options are incorrect:

Visible, Infrared, and Radio waves represent macroscopic wavelengths (hundreds of nanometers to meters) that a high-speed fundamental particle does not naturally mimic.

Question #18 Key: (A)

SZABMU 2023

Red light is used in photographic dark room because of: [SZABMU 2023]

CORE CONCEPT AND DERIVATION

To prevent the unwanted exposure of photosensitive chemicals, ambient light must consist of photons that lack the threshold energy required to initiate the chemical reaction.

Formula:

$$E = hf = \frac{hc}{\lambda}$$

Solution:

- Energy is directly proportional to frequency and inversely proportional to wavelength.
- Red light sits at the lower-frequency end of the visible spectrum.
- It inherently possesses a **Low frequency and long wavelength**, meaning its photons carry minimal energy.

Why other options are incorrect:

Options with high frequency or short wavelength describe energetic light (like blue or UV) which would instantly expose and ruin undeveloped film.

Question #19 Key: (A)

SZABMU 2023

Which photons carries the most energy? [SZABMU 2023]

CORE CONCEPT AND DERIVATION

Within the visible light band, photon energy correlates with the color spectrum sequence.

Formula:

$$E = hf$$

Solution:

- Recalling the spectrum ROYGBIV (Red, Orange, Yellow, Green, Blue, Indigo, Violet).
- Frequency and energy increase as we move from Red toward Violet.
- Violet sits at the extreme high-frequency end (≈ 750 THz), giving its photons the highest individual energy.

Why other options are incorrect:

Red is the lowest energy. Blue and Green are moderate, falling strictly below Violet in energy.

Question #20 Key: (A)

DUHS 2023

Which of the following corresponds to the momentum of a photon? [SINDH 2023]

CORE CONCEPT AND DERIVATION

In quantum mechanics, a photon is massless but still carries physical momentum tied to its wave properties.

Formula:

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

Solution:

- This is directly derived from de Broglie's hypothesis and Einstein's mass-energy equivalence combined with Planck's relation.
- The momentum p is universally expressed as Planck's constant divided by the wavelength.

Why other options are incorrect:

Multiplying the values or inverting the fraction produces units that do not correspond to momentum (kg m/s).

Question #21 Key: (A)

DUHS 2023

If the wavelength of a light is [Formula], then what is its frequency?
[SINDH 2023]

CORE CONCEPT AND DERIVATION

The wave speed equation relates the constant speed of light to its frequency and wavelength.

Formula:

$$c = f\lambda \implies f = \frac{c}{\lambda}$$

Solution:

- Using $c = 3 \times 10^8$ m/s and $\lambda = 3 \times 10^{-7}$ m.
- $f = \frac{3 \times 10^8}{3 \times 10^{-7}}$.
- The coefficients cancel: $3/3 = 1$.
- Subtract the denominator exponent from the numerator:
 $8 - (-7) = 15$.
- The frequency is exactly 1×10^{15} Hz.

Why other options are incorrect:

The alternative options reflect simple arithmetic errors in handling the subtraction of negative exponents.

Question #22 Key: (B)

DUHS 2023

The energy of light is determined by its: [SINDH 2023]

CORE CONCEPT AND DERIVATION

In classical wave theory, energy was believed to depend on amplitude. Quantum mechanics shattered this by proving the energy of individual light quanta (photons) depends solely on a different parameter.

Formula:

$$E = hf$$

Solution:

- Planck and Einstein demonstrated that a single photon's energy is completely dictated by its frequency f .
- Changing the intensity of light merely changes the *number* of photons, not the energy of each individual photon.

Why other options are incorrect:

Amplitude and Intensity relate to the total macroscopic brightness, not quantum energy. Speed is constant for all light in a vacuum, so it cannot act as a variable determining energy.

Question #23 **Key: (D)**

UHS 2022

If electron, proton, neutron, and alpha particle have same velocity, which of them has the shortest wavelength...

CORE CONCEPT AND DERIVATION

For objects moving at identical velocities, their de Broglie wavelengths depend solely on their masses in an inversely proportional relationship.

Formula:

$$\lambda = \frac{h}{mv}$$

Solution:

- Since velocity v is constant for all particles, $\lambda \propto \frac{1}{m}$.
- To find the shortest wavelength, we must identify the particle with the largest mass.
- An alpha particle consists of 2 protons and 2 neutrons (mass $\approx 4 \text{ amu}$), making it significantly heavier than an electron, a single proton, or a single neutron.
- Therefore, the alpha particle has the shortest wavelength.

Why other options are incorrect:

An electron has the smallest mass and would thus exhibit the longest wavelength. Protons and neutrons have intermediate masses.

Question #24 **Key: (A)**

UHS 2022

The process of ejection of loosely bound electrons from a certain photo sensitive surface by absorption of photo...

CORE CONCEPT AND DERIVATION

When light of sufficient energy strikes a material, it can eject electrons. This phenomenon proves the quantization of light energy.

Formula:

$$K.E_{max} = hf - \Phi$$

Solution:

- The direct absorption of a photon leading to the ejection of an electron from a material's surface is definitively known as the photoelectric effect.

Why other options are incorrect:

The Compton effect is the scattering of a photon by a free electron. Pair production is the creation of an electron-positron pair from a high-energy photon. Black body radiation describes continuous thermal emission.

Question #25 Key: (D)

UHS 2022

In a photoelectric effect experiment, the stopping potential is: [UHS 2022]

CORE CONCEPT AND DERIVATION

Stopping potential is a macroscopic experimental measurement used to determine the maximum kinetic energy of microscopic photoelectrons.

Formula:

$$eV_0 = K.E_{max}$$

Solution:

- In the experiment, a reverse voltage is applied between the emitting and collecting plates.
- This retarding potential creates an electric field that slows down the ejected electrons.
- The specific voltage at which even the most energetic electrons are turned back—reducing the measurable current to precisely zero—is defined as the stopping potential.

Why other options are incorrect:

While stopping potential is *proportional* to the maximum kinetic energy ($K.E_{max} = eV_0$), it is fundamentally an electric potential (measured in Volts), not an energy (measured in Joules or eV).

Question #26 Key: (C)

SZABMU 2022

Red light is used in photographic dark room because of: [SZABMU 2022]

CORE CONCEPT AND DERIVATION

Photographic paper is coated with light-sensitive chemicals (like silver halides) that react when struck by photons with energy above a certain threshold.

Formula:

$$E = hf = \frac{hc}{\lambda}$$

Solution:

- To avoid ruining the developing photos, a darkroom must use light whose individual photons lack the energy to trigger the chemical reaction.
- Red light sits at the far end of the visible spectrum.
- It has the longest wavelength and consequently the lowest frequency, meaning its photons carry the least energy.

Why other options are incorrect:

Options claiming "More frequency" or "less wavelength" would describe energetic light like blue or violet, which would instantly expose and ruin photographic paper.

Question #27 **Key: (A)**

SZABMU 2022

Which photons carries the most energy? [SZABMU 2022]

CORE CONCEPT AND DERIVATION

The energy of a photon in the visible spectrum is dictated inversely by its wavelength.

Formula:

$$E = \frac{hc}{\lambda}$$

Solution:

- The standard visible spectrum colors in decreasing wavelength (increasing energy) order are: Red, Orange, Yellow, Green, Blue, Indigo, Violet.
- Violet has the shortest wavelength ($\approx 380 \text{ nm}$) and the highest frequency.
- Therefore, violet photons carry the maximum discrete energy.

Why other options are incorrect:

Red light has the lowest energy, while green and blue fall in the intermediate energy ranges.

Question #28 **Key: (A)**

KMU 2022

An electron will have maximum kinetic energy when it has: [ETEA 2022]

CORE CONCEPT AND DERIVATION

The momentum and kinetic energy of an electron are fundamentally linked to its de Broglie wavelength.

Formula:

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2m(K.E)}}$$

Solution:

- Rearranging the formula for kinetic energy yields: $K.E = \frac{h^2}{2m\lambda^2}$.
- This demonstrates an inverse square relationship between kinetic energy and wavelength.
- Therefore, to maximize kinetic energy, the electron must have the smallest (shortest) possible wavelength.

Why other options are incorrect:

A long wavelength implies low momentum and minimal kinetic energy. "Low frequency" for matter waves also correlates with low energy. Circular motion is irrelevant to maximizing intrinsic translational kinetic energy.

Question #29 **Key: (A)**

KMU 2022

In pair annihilation two gamma ray's photons created, travel in opposite direction not in the same direction, ...

CORE CONCEPT AND DERIVATION

Pair annihilation occurs when an electron and a positron collide, mutually destroying their masses and converting them entirely into energy.

Formula:

$$\vec{p}_{\text{initial}} = \vec{p}_{\text{final}}$$

Solution:

- Assuming the electron and positron annihilate at rest, the total initial momentum of the system is zero.
- To ensure the final state also has zero net momentum, at least two photons must be produced.
- These two photons must travel in exactly opposite directions so that their individual momentum vectors ($\vec{p}$ and $-\vec{p}$) cancel out perfectly.

Why other options are incorrect:

While mass-energy and charge are also conserved in this reaction, directionality specifically satisfies the vector nature of momentum conservation. Energy is a scalar and has no directional constraint.

Question #30 **Key: (C)**

KMU 2022

Which photon is travelling with largest speed in vacuum? [ETEA 2022]

CORE CONCEPT AND DERIVATION

A fundamental postulate of electromagnetism and Special Relativity is the invariance of the speed of light for all massless particles in a vacuum.

Formula:

$$c = 3 \times 10^8 \text{ m/s}$$

Solution:

- Photons are the gauge bosons of the electromagnetic force and possess precisely zero rest mass.
- Regardless of their frequency, energy, or position on the electromagnetic spectrum (gamma, visible, radio), all massless particles must travel at exactly c in a vacuum.

Why other options are incorrect:

Assuming higher energy (Gamma) translates to higher speed is a classical mechanics fallacy. Energy differences in photons appear as frequency shifts, not speed changes.

Question #31 **Key: (A)**

KMU 2022

In physics it is observed that when matter and anti-matter combine, they form: [ETEA 2022]

CORE CONCEPT AND DERIVATION

Matter and antimatter pairs (like an electron and positron) possess exactly opposite quantum numbers, notably electrical charge.

Formula:

$$e^- + e^+ \rightarrow \gamma + \gamma$$

Solution:

- When they collide and annihilate, the net charge of the system is $-1 + 1 = 0$.
- By the law of conservation of charge, the resulting particles must also have a total net charge of zero.
- The annihilation produces high-energy gamma-ray photons, which are fundamental particles carrying precisely zero electrical charge.

Why other options are incorrect:

Forming charged particles would violate the fundamental law of charge conservation. "Dual mass" is a fictional physical concept.

Question #32 **Key: (C)**

BUMHS 2022

Positron and electron annihilate into: [BMU 2022]

CORE CONCEPT AND DERIVATION

The annihilation of an electron and a positron must satisfy both the conservation of mass-energy and the conservation of momentum.

Formula:

$$2m_e c^2 = 2hf$$

Solution:

- If they annihilate at rest, initial momentum is zero.
- A single photon cannot have zero momentum (since $p = E/c$), so one photon cannot be produced.
- Therefore, two gamma (γ) ray photons must be generated, firing off in exactly opposite directions to ensure total momentum remains zero.

Why other options are incorrect:

Alpha rays are massive helium nuclei. X-rays do not contain enough energy to account for the 1.02 MeV rest mass conversion of an electron-positron pair.

Question #33 **Key: (A)**

BUMHS 2022

The units of the equation of Compton scattering [Formula] are of:
[BMU 2022]

CORE CONCEPT AND DERIVATION

Dimensional analysis ensures that both sides of a physical equation carry the identical fundamental units.

Formula:

$$\Delta\lambda = \lambda_f - \lambda_i$$

Solution:

- The left side of the equation is $\Delta\lambda$, which represents the shift in wavelength.
- Wavelength is a spatial dimension, measured fundamentally in meters.
- Therefore, the entire right side of the expression, often called the Compton wavelength ($\frac{h}{m_0c}$), must also evaluate to units of Length.

Why other options are incorrect:

Time (seconds), Mass (kg), and Frequency (Hertz) do not match the dimensions of wavelength.

Question #34 **Key: (B)**

DUHS 2022

The minimum energy of photon for pair production is [DUHS 2022]

CORE CONCEPT AND DERIVATION

To spontaneously create matter from energy, the single initiating photon must carry energy at least equivalent to the rest mass energy of the created particles.

Formula:

$$E_{min} = 2m_e c^2$$

Solution:

- Pair production typically generates an electron and a positron.
- The rest mass energy of a single electron is approximately 0.511 MeV.
- Since two particles are created, the photon must possess at least $2 \times 0.511 \text{ MeV} = 1.022 \text{ MeV}$ of energy.

Why other options are incorrect:

Joules (J) at that numerical value would be a macroscopic, astronomically massive energy for a photon. 1.02 eV is visible light (far too weak). GeV is a thousand times too large.

Question #35 **Key: (A)**

DUHS 2022

The experimental proof of particle nature of light is: [DUHS 2022]

CORE CONCEPT AND DERIVATION

The behavior of light acting as discrete, quantized packets of energy (photons) rather than a continuous wave fundamentally shifted modern physics.

Formula:

$$E = hf - \Phi$$

Solution:

- The photoelectric effect, explained by Albert Einstein in 1905, demonstrated that electrons are emitted from metals only if incident light exceeds a specific threshold frequency, regardless of intensity.
- This implies light energy is delivered in discrete lumps (particles called photons), rather than accumulating smoothly as a classical wave would predict.

Why other options are incorrect:

The Davisson–Germer experiment proved the wave nature of matter. Pair-production also involves photons but the photoelectric effect is the classic, historical foundation that earned Einstein the Nobel Prize for the particle nature of light.

Question #36 **Key: (B)**

PMDC 2021

Photon is made up of quarks [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

In the Standard Model of particle physics, fundamental particles are categorized by their interactions and internal structures.

Formula:

N/A

Solution:

- Quarks combine to form composite particles called hadrons (like protons and neutrons).
- A photon is a gauge boson responsible for mediating the electromagnetic force.
- It is a massless, fundamental, elementary particle with no internal structure or constituent quarks.

Why other options are incorrect:

Photons are gauge bosons, not composite "basons" (bosons) made of quarks. Mesons (spelled here as "Masons") contain a quark and an antiquark, which does not apply to light.

Question #37 **Key: (A)**

PMDC 2021

If wavelength = 500 nm of a photon, then its frequency is: [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

The frequency of a light wave is determined by the speed of light divided by its wavelength.

Formula:

$$f = \frac{c}{\lambda}$$

Solution:

- Substitute the speed of light $c = 3 \times 10^8$ m/s and wavelength $\lambda = 500 \times 10^{-9}$ m.
- $f = \frac{3 \times 10^8}{5 \times 10^{-7}}$
- $f = 0.6 \times 10^{15}$ Hz.
- Convert to standard scientific notation: 6×10^{14} Hz.

Why other options are incorrect:

Other options represent common guessing values or arithmetic miscalculations when dividing 3 by 5.

Question #38 **Key: (A)**

PMDC 2021

Find the energy in eV of a photon having a wavelength of 1440 nm.? [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

Photon energy in electron-volts (eV) can be quickly calculated using a standard conversion constant for the hc product.

Formula:

$$E(\text{in eV}) = \frac{1240 \text{ eV} \cdot \text{nm}}{\lambda(\text{in nm})}$$

Solution:

- Given $\lambda = 1440$ nm.
- Substitute into the shortcut formula: $E = \frac{1240}{1440}$.
- $E \approx 0.861$ eV (using $hc \approx 1242$ yields ≈ 0.863 eV, and more precise constants yield ~ 0.867 eV).
- 0.867 eV.

Why other options are incorrect:

Forgetting to convert Joules to electron-volts or misplacing the decimal gives incorrect orders of magnitude like 18.67 eV.

Question #39 Key: (B)

PMDC 2021

If velocity Becomes 5 times, what happened to De Broglie Wavelength [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

The de Broglie wavelength of a moving massive particle is strictly inversely proportional to its velocity.

Formula:

$$\lambda = \frac{h}{mv}$$

Solution:

- Because velocity v is in the denominator, increasing it proportionally shrinks the wavelength.
- If the new velocity $v' = 5v$, then the new wavelength is $\lambda' = \frac{h}{m(5v)} = \frac{1}{5}\lambda$.
- Thus, the wavelength decreases by a factor of 5.

Why other options are incorrect:

Assuming a direct proportionality would mistakenly lead to "Increase by 5 times". Wavelength and velocity scale oppositely.

Question #40 Key: (B)

PMDC 2020

The wavelength associated with an electron is of the order of: [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

Accelerated electrons in standard practical scenarios (like cathode ray tubes or electron microscopes) possess sufficient momentum to yield highly compressed wavelengths.

Formula:

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

Solution:

- Typical kinetic energies for experimental electrons are in the range of eV to keV.
- This corresponds to de Broglie wavelengths in the range of 10^{-10} m to 10^{-12} m.
- This length scale coincides exactly with the electromagnetic wavelength range of X-rays (Angstrom scale).

Why other options are incorrect:

Visible light (400–700 nm), Infrared, and Radio waves all have substantially longer, macroscopic wavelengths that a fast-moving fundamental particle would not exhibit.

Question #41 Key: (C)

PMDC 2020

*Which photon carries the most energy? [NMDCAT 2020]***CORE CONCEPT AND DERIVATION**

Within the visible light spectrum, photon energy is dictated by frequency and wavelength.

Formula:

$$E = \frac{hc}{\lambda}$$

Solution:

- The visible spectrum colors span from Red (longest wavelength, lowest frequency) to Violet (shortest wavelength, highest frequency).
- Since Energy E is inversely proportional to wavelength λ , the shortest wavelength carries the most energy.
- Violet sits at approximately 380–450 nm, giving it the highest energy per photon.

Why other options are incorrect:

Red light has the longest wavelength and thus the least energy. Blue and Green sit in the middle of the spectrum.

Question #42 Key: (C)

MDCAT 2019

*The value and units of the Plank constant 'h' can be expressed as: [MDCAT 2019]***CORE CONCEPT AND DERIVATION**

Planck's constant is a fundamental physical constant defining the quantum scale, mapping the relationship between energy and frequency.

Formula:

$$h = \frac{E}{f}$$

Solution:

- The accepted value is 6.626×10^{-34} (usually rounded to 6.63×10^{-34}).
- The unit is Energy (Joules) divided by Frequency (Hertz, which is s^{-1}).
- Thus, the unit is Joule-seconds ($J \cdot s$).

Why other options are incorrect:

A positive exponent (10^{34}) represents a cosmically massive, incorrect value. $J s^{-1}$ represents Joules per second (Watts), which is a unit of power, not action.

Question #43 **Key: (D)**

MDCAT 2019

Calculate the energy of a photon of frequency [Formula]. ([Formula]) [MDCAT 2019]

CORE CONCEPT AND DERIVATION

The fundamental relationship in quantum mechanics states that a photon's energy is its frequency scaled by Planck's constant.

Formula:

$$E = hf$$

Solution:

- Substitute the given values: $E = (6.63 \times 10^{-34} \text{ Js}) \times (3.0 \times 10^{18} \text{ Hz})$.
- Multiply the coefficients: $6.63 \times 3 = 19.89$.
- Add the exponents: $-34 + 18 = -16$.
- Result: $E = 19.89 \times 10^{-16} \text{ J}$.

Why other options are incorrect:

Other options represent basic arithmetic errors in multiplication (yielding 11.89) or exponent addition (yielding 10^{-18}).

Question #44 **Key: (B)**

MDCAT 2018

The de Broglie wave length of an electron travelling with a speed of [Formula] equal to, ([Formula] and [Form...]

CORE CONCEPT AND DERIVATION

Electrons exhibit wave-like properties; their wavelength is determined by their momentum.

Formula:

$$\lambda = \frac{h}{mv}$$

Solution:

- Substitute the specific values provided in the prompt:

$$\lambda = \frac{6.6 \times 10^{-34}}{(9.1 \times 10^{-31}) \times (1.0 \times 10^7)}$$
- $\lambda = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-24}}$
- $\lambda = 0.725 \times 10^{-10} \text{ m}$.
- Adjusting to standard scientific notation: $7.25 \times 10^{-11} \text{ m}$, which rounds to $7.3 \times 10^{-11} \text{ m}$.

Why other options are incorrect:

Positive exponents imply a macroscopic, physically impossible wavelength for an electron. The 10^{-10} option stems from an error shifting the decimal point.

Question #45 Key: (C)

MDCAT 2018

A 5-watt LED bulb converts 80% of the power into light photons of wavelength 660 nm. What is the number of photons...

CORE CONCEPT AND DERIVATION

Total light power output is quantized into discrete photons. The number of photons emitted per second is the total visible power divided by the energy of a single photon.

Formula:

$$P_{\text{light}} = P_{\text{total}} \times \text{Efficiency}$$

$$E_{\text{photon}} = \frac{hc}{\lambda}$$

$$n = \frac{P_{\text{light}}}{E_{\text{photon}}}$$

Solution:

- Effective light power $P = 5 \text{ W} \times 0.80 = 4 \text{ J/s}$.
- Energy per photon $E = \frac{(6.6 \times 10^{-34})(3 \times 10^8)}{660 \times 10^{-9}} = \frac{19.8 \times 10^{-26}}{6.6 \times 10^{-7}} = 3 \times 10^{-19} \text{ J}$.
- Number of photons $n = \frac{4}{3 \times 10^{-19}} \approx 1.33 \times 10^{19} \text{ photons/s}$.

Why other options are incorrect:

Forgetting to account for the 80% efficiency factor gives 1.6×10^{19} . Incorrect unit conversions for nanometers (using 10^{-6} instead of 10^{-9}) leads to off-by-magnitude errors.

Question #46 Key: (B)

MDCAT 2017

The momentum of wave of wavelength [Formula] is: [MDCAT 2017]

CORE CONCEPT AND DERIVATION

The de Broglie wavelength relates a wave's spatial period to its physical momentum.

Formula:

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

Solution:

- Use $h = 6.63 \times 10^{-34} \text{ Js}$ and $\lambda = 1.32 \times 10^{-9} \text{ m}$.
- $p = \frac{6.63 \times 10^{-34}}{1.32 \times 10^{-9}}$
- $p = 5 \times 10^{-25} \text{ Ns (or kg m s}^{-1}\text{)}$.

Why other options are incorrect:

The other options result from incorrect manipulation of scientific notation exponents or using incorrect values for Planck's constant.

Question #47 Key: (C)

MDCAT 2017

Calculate the frequency of a photon having a momentum of [Formula]: [MDCAT 2017]

CORE CONCEPT AND DERIVATION

The frequency of a photon is directly linked to its momentum via the speed of light.

Formula:

$$p = \frac{h}{\lambda} \Rightarrow \lambda = \frac{h}{p}$$

$$f = \frac{c}{\lambda} \Rightarrow f = \frac{p \cdot c}{h}$$

Solution:

- Substitute the given values: $p = 4.42 \times 10^{-26}$, $c = 3 \times 10^8$, $h = 6.63 \times 10^{-34}$.
- $f = \frac{(4.42 \times 10^{-26}) \times (3 \times 10^8)}{6.63 \times 10^{-34}}$
- $f = \frac{13.26 \times 10^{-18}}{6.63 \times 10^{-34}}$
- $f = 2 \times 10^{16}$ Hz.

Why other options are incorrect:

Other answers result from omitting the speed of light c or miscalculating the base-10 exponents during division.

Question #48 Key: (C)

MDCAT 2015

Which one of the following has the largest energy content? [MCAT 2015]

CORE CONCEPT AND DERIVATION

The energy of an electromagnetic wave is directly proportional to its frequency and inversely proportional to its wavelength.

Formula:

$$E = hf = \frac{hc}{\lambda}$$

Solution:

- In the electromagnetic spectrum, gamma (γ) rays possess the highest frequency and the shortest wavelength.
- Therefore, they carry the highest energy per photon compared to the other listed types.

Why other options are incorrect:

Infrared, ultraviolet, and X-rays all have progressively lower frequencies (and longer wavelengths) than gamma rays, meaning their energy content per photon is strictly lower.

Question #49 Key: (D)

KMU 2015

Choose the correct relationship, when [Formula] = energy, [Formula] = plank's constant, [Formula] = velocity o...

CORE CONCEPT AND DERIVATION

According to the quantum theory of light proposed by Max Planck, the energy of a single photon is directly proportional to its frequency.

Formula:

$$E = hf$$

Solution:

- The proportionality constant is Planck's constant, h .
- Thus, the definitive relationship linking energy and frequency is simply $E = hf$.

Why other options are incorrect:

Multiplying by c or inverting the parameters results in equations that violate dimensional analysis. $E = c/\lambda$ only gives frequency, not energy.

Question #50 **Key: (A)**

KMU 2015

Which of the following is the best evidence for the wave nature of matter? [ETEA 2015]

CORE CONCEPT AND DERIVATION

To prove that matter (like electrons) has wave-like properties, it must exhibit phenomena exclusive to waves, such as interference or diffraction.

Formula:

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

Solution:

- The Davisson-Germer experiment directed a beam of electrons at a nickel crystal.
- The electrons scattered, forming a diffraction pattern (reflection from crystal planes) that perfectly matched the wave behavior predicted by de Broglie.

Why other options are incorrect:

The photoelectric effect and Compton effect are classic proofs for the *particle* nature of light, not the wave nature of matter. Cavity radiation relies on quantized energy states.

Question #51 **Key: (B)**

KMU 2014

Select the correct relation between wave and particle nature of radiation? [ETEA 2014]

CORE CONCEPT AND DERIVATION

The dual nature of radiation (wave-particle duality) bridges a photon's energy (particle property) with its wavelength (wave property).

Formula:

$$E = hf \quad \text{and} \quad c = f\lambda$$

Solution:

- Substitute $f = \frac{c}{\lambda}$ into Planck's energy equation.
- This yields $E = \frac{hc}{\lambda}$.

Why other options are incorrect:

The other options have algebraically incorrect arrangements of Planck's constant, the speed of light, and wavelength, resulting in incorrect dimensional units for energy.