SECTION A [40 MARKS]

ANSWER **ALL** QUESTION

Question 1 **[25]**

a) For each question, there are four alternatives A, B, C and D. Choose the correct alternative and circle it. Do not circle more than ONE alternative. If there is more than one choice circled, NO score will be awarded.

i. Which fundamental force holds the nucleus of an atom together?

A strong force

B gravitational force

C weak nuclear force

D electromagnetic force

ii. Which of the following is a disadvantage of nuclear energy?

A scarcity of uranium as a fuel source

B consistent in production of electricity

C cheaper in building nuclear power plant

D emission of greenhouse gas during operation

iii. What is the time taken by a planet to sweep an area of 2 million square km if the time taken by the same planet to cover an area of 1 million square km is 36 hours?

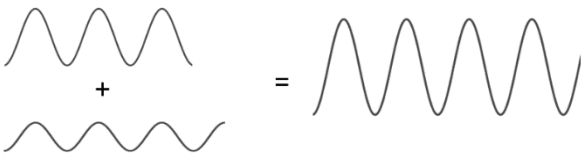
A 18 hours

B 36 hours

C 72 hours

D 144 hours

iv. The diagram below shows the phenomenon of interference. Which type of interference is shown in the diagram?



A diffraction

B refraction

C destructive interference

D constructive interference

v. During a photoelectric effect experiment, numerous observations were made. Which of the following are the main observations?

I. Emission of electrons is a non-instantaneous process.

II. Light of all frequencies ejects electrons from the metal plate.

III. The value of saturation current is independent of frequency of light.

IV. The greater the intensity of light, the greater is the number of photons emitted per second.

A I and II

B I and III

C II and IV

D III and IV

vi. When a student observed an object placed in front of a concave mirror, the image formed was virtual, upright, and larger than the object. Which statement provides the correct explanation for this observation?

A The object is placed at the center of curvature.

B The object is placed beyond the center of curvature.

C The object is placed between the focus and the pole of the mirror.

D The object is placed between the focal point and the center of curvature.

vii. In every household in Bhutan, the Bhutan Power Corporation Limited supplies power at 220V, 50Hz using step-down transformers. Considering the overall power supply to each household, how many times will the current become "zero"?

A 50 times

B 100 times

C 150 times

D 200 times

viii. A conducting loop is placed inside a changing magnetic field. What will happen to the induced electromotive force (emf) in the loop if the rate of change of magnetic field increases?

A The induced emf decreases.

B The induced emf increases.

C The induced emf becomes zero.

D The induced emf remains constant.

ix. From the two figures given below, which of the following conditions are correct.

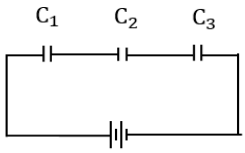


Figure – I

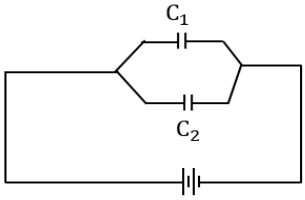


Figure – II

I. In figure I voltage will remain constant and current will change.

II. In figure I current will remain constant and voltage will change.

III. In figure II voltage will remain constant and current will change.

IV. In figure II current will remain constant and voltage will change.

A I and III

B I and IV

C II and III

D II and IV

x. When Sonam rubbed a ruler on Lemo's hair and brought it close to bits of paper, the papers were attracted to the ruler. This demonstrates that,

A gravitational force is charge dependent.

B electric force and gravitational force are equal.

C electric force is stronger than gravitational force.

D gravitational force is stronger than electric force.

xi. Which of the following quantity connected with S.H.M. does not vary periodically?

A velocity

B acceleration

C total energy

D displacement

xii. The V_{rms} of gas molecules is 250 m/s. If its absolute temperature is halved and molar mass is doubled, the V_{rms} value will become

A 125m/s.

B 25m/s.

C 65m/s.

D 500m/s.

xiii. What is the effect on fluid pressure as the water flows through the narrow sections of a pipe?

A The fluid pressure will increase.

B The fluid pressure will decrease.

C The fluid pressure will fluctuate.

D The fluid pressure will remain the same.

xiv. Identify the correct statement regarding intrinsic semiconductor from the following options.

A Impurities are incorporated to improve conductivity.

B The conduction band and valence band overlap each other.

C The conduction band is completely filled at room temperature.

D The conduction band is completely empty at room temperature.

xv. A mass-spring system has a period of 2 seconds. If the mass is doubled while keeping the spring constant unchanged, what will be the new time period?

A 1 second

B 2 seconds

C 4 seconds

D 3 seconds

xvi. A teacher instructed students to design a pendulum clock with a weight suspended by a string or rod to show SHM. Which condition is necessary for exhibiting SHM?

A It should vibrate in all directions.

B It should rotate in a circular path.

C It should move in a parabolic path.

D It should swing back and forth.

xvii. Though the gravitational force pulls everything towards the center of the Earth, the transportation of water from the ground to various parts of the tree works against the gravitational pull. What specific phenomenon is responsible for this process?

A capillary action

B cohesive force is equal to adhesive force

C cohesive force is greater than adhesive force

D adhesive force is greater than cohesive force

xviii. Which of the following best describes the concept of wave-particle duality?

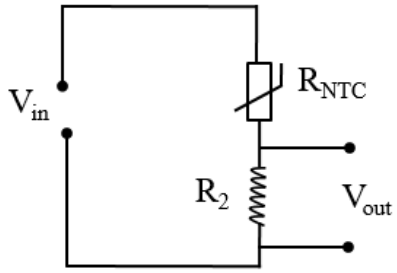
A particles can only exist in discrete energy states

B particles can be accelerated to speeds faster than light

C particles exhibit dual characteristics of waves and particles

D particles have the ability to occupy multiple locations simultaneously

xix. Based on the diagram provided below, select the answer that best describes it.



A $R_{NTC} < R_2$, high output and detects low temperature

B $R_{NTC} < R_2$, high output and detects high temperature

C $R_{NTC} > R_2$, high output and detects low temperature

D $R_{NTC} > R_2$, low output and detects low temperature

xx. A boy standing in front of a convex mirror was surprised to see his image behind the mirror at f/2, which was diminished. Where do you think he was standing?

A $0.5\,f$

B f

C $2\,f$

D Infinity

xxi. A Road Roller causes vibrations, unlike cars. As a physics student, which of the following phenomena best explains this speculating that the weight of the road roller might be a contributing factor?

A free oscillation

B forced oscillation

C periodic Motion

D simple Harmonic Motion

xxii. Which of the following process releases the maximum amount of energy?

A β^+ decay

B β^- decay

C Annihilation

D Pair production

xxiii. When a magnet is moved into a coil of wire, the direction of the induced current is determined by the

A speed of the motion.

B resistance of the wire.

C strength of the magnetic field.

D direction of the changing magnetic field.

xxiv. Thomas Young used a coherent light source in his double-slit experiment to observe the interference pattern on the screen. Which of the following source of light produces a coherent beam of light?

A laser

B candle flame

C fluorescent tube

D incandescent bulb

xxv. A space engineer intends to launch a weather forecasting satellite to measure temperature and humidity, and track storms and other weather events. Which orbit around the Earth should he choose for the launch?

A High Earth orbit (HEO)

B Low earth Orbit (LEO)

C Geostationary Orbit(GEO)

D Middle Earth Orbit(MEO)

b) Match each item in column I against the most appropriate item in column II. [5]
Write the letter against the number in Column III.

Column I	Column II	Column III	
i. Path difference	a) water		
ii. Photon energy	b) position and movement of spacecraft		
iii. Neutron absorption	c) Cadmium		
iv. Lepton	d) $k_{max} = hf - \Phi_0$		
v. Decrease in the speed of Neutron	e) radioactive decay		
vi. Weak force	f) hf		
vii. Telemetry, Tracking and Command System	g) Neutrino		
viii. Propulsion system	h $\frac{\lambda D}{d}$		
ix. Einstein photoelectric equation	i) orbit adjustments		
x. Fringe width	j) neutron		
	k $(2n+1)\frac{\lambda}{2}$		
	l) regulates temperature in a satellite		

c) Fill in the blanks with the most appropriate word(s). [5]

i.	Bernoulli's principle is based on the law of conservation of _____ whereas the equation of continuity is based on the conservation of _____.	
ii.	Attraction between two charges leads the electric field to contract _____ and repulsion between two unlike charges leads the electric field to expand _____.	

iii.	The current in a capacitor _____ exponentially while voltage in capacitor _____exponentially during the charging process.	
iv.	The dentists uses a _____ mirror to fill cavities and a _____mirror is used in the car as a rear view mirror.	
v.	At resonance in series LCR circuit _____ of the circuit is minimum and _____ in the circuit is maximum.	

d) Write TRUE or FALSE against each statement in the space provided. [5]

i.	Phuntsho observed his son cycling around a basketball court and completing one lap in 2 minutes repeatedly which led him to conclude that this is a periodic motion.		
ii.	When a current entering a coil increases, both the magnetic flux and the induced current in the opposite direction also increases.		
iii.	N-type semiconductors achieve efficient conduction by positioning the donor level closer to the conduction band, facilitating the transition to the valence band.		
iv.	Sonam examined two mirrors and made the following observations: the first mirror reflected his image with the same size, indicating it was a plane mirror, while the second mirror showed an enlarged image, indicating it was a concave mirror.		
v.	When the turbines of an AC generator are in motion, the rotating armature coil generates the maximum magnetic flux when the angle between the area vector and magnetic fields is 90 degree.		

SECTION B [60 MARKS]

ATTEMPT **ANY SIX** QUESTIONS

Question 2

a) Calculate the amplitude, angular frequency, frequency, time period and initial phase for the simple harmonic motion from the equation $y = 3\sin(2\pi t - 1.5)$ **[2]**

b) Mention and explain **TWO** real-life scenarios which demonstrate actions that fulfills the conditions necessary to understand Lenz's law. **[3]**

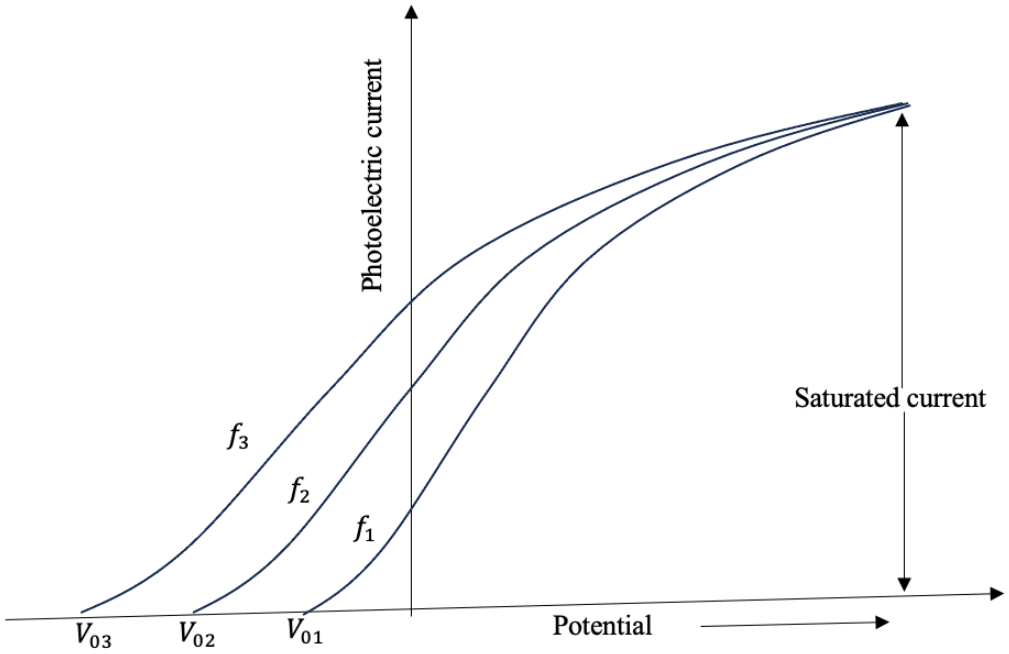
c) The current-voltage relationship in a pure capacitor can be expressed as: **[2]**

$$i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

Draw and explain a phasor diagram to visualize this relationship.

d) How does kinetic theory explain the pressure exerted by a gas? **[1]**

e) The graph below shows the variation of photoelectric current with potential for various frequencies. Write **TWO** conclusions based on it. **[2]**



Question 3

a) Prove that the total energy of a body in SHM is always conserved. **[2]**

b) Kinley conducted an experiment by pouring equal volumes of water and mercury into two identical glass tubes. He observed that the water level rises while the mercury level falls in their respective glass tubes. What could be the reason for this? **[2]**

c) Calculate the separation distance between two small charged spheres having charge $8\mu C$ and $5\mu C$ with a magnitude of force 4×10^{-9}N. **[2]**

d) Karma plans to select a capacitor to build an electronic device which can hold the highest capacitance. From the following capacitor specifications, which would be the most suitable choice? Show your work. **[2]**

Capacitor 1	**Capacitor 2**	**Capacitor 3**
$d = 1\ mm$	$d = 2\ mm$	$d = 3\ mm$
$A = 0.4\ mm^2$	$A = 0.3\ mm^2$	$A = 0.2\ mm^2$

e) Is it wise for people to engage in recreational space travel? Justify. **[2]**

Question 4

a) Currently the street lights are manually switched on and off. Design and illustrate a circuit diagram that can recognize light and darkness, enabling their automatic operation? Explain how it works. **[3]**

b) Draw a ray diagram of a convex lens to show the formation of image, when the object is placed at center of curvature (2F). Describe the nature of the image formed. **[2]**

c) Is it possible for nanotechnology to bring about a revolutionary transformation in the field of electronics by the development of smaller, faster, and more efficient devices? Give a justification for your answer. **[2]**

d) What is kinetic theory of gas? **[1]**

e) The mass of nitrogen $[N_7^{14}]$ nucleus is 14.00307 a.m.u. If the masses of proton and neutron are 1.007275 a.m.u and 1.008665 a.m.u respectively, calculate the mass defect. **[2]**

Question 5

a) A straight metal wire crosses a magnetic field of flux 4 mWb in time 0.4 s. Calculate the magnitude of the emf induced in the wire. **[2]**

b) Is it possible for an object to undergo oscillation in the absence of a restoring force? Provide a justification for your answer. **[2]**

c) What is the purpose of a capacitor in an electronic circuit? **[1]**

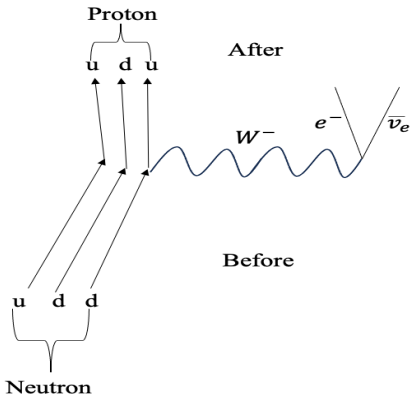
d) Namdrel can clearly see an object at a distance but cannot read the text in a book. On the other hand, Losel cannot see objects at a distance but can read the text in a book. This indicates they both have eyesight problem. Based on this context, complete the table. **[3]**

	Namdrel	**Losel**	
Name of the problem			
Type of Lens to be used			
Power of lens			

e) Derive the formula for calculating the resonant frequency (f_0) of a LCR series circuit using the condition of resonance. **[2]**

Question 6

a) Examine the diagram provided. State the equation, identify the type of beta decay and explain the process involved. **[2]**



b) According to Union of Concerned Scientists (UCS), there are approximately 3000 inactive satellites in space, which pose risk to active satellites. Provide at least **TWO** suggestions for disposing such satellites. **[2]**

c) The equation for SHM is $y(t) = 10\ \sin(5t)$. Calculate the maximum velocity and maximum acceleration. **[2]**

d) Narrate a practical real-life scenario in which we can accurately predict both the position and speed of a particle, thereby challenging Werner Heisenberg's uncertainty principle, which states that we cannot simultaneously predict the position and speed of a particle with certainty. **[2]**

e) According to a report by BBS on March 16, 2023, roofs of 18 households in one of the Dzongkhags were blown away by a strong windstorm. Which scientific principle is related to the cause of this disaster? Explain the cause based on the principle mentioned. **[2]**

Question 7

a) Phurpa noticed two dew droplets on a leaf: flat large droplet and spherical small droplet. How can this be scientifically explained? **[2]**

b) In a transformer, the number of turns in the primary coil and the secondary coil are 410 and 1230 respectively. If the current in primary coil is 6A, what is the current in secondary coil? **[2]**

c) The binding energy of $^{16}_{8}O$ is 127.52 MeV, whereas the binding energy of $^{238}_{92}O$ is 1802 MeV. Which of these nuclei is more stable? Show your work. **[2]**

d) Write **TWO** differences between interference and diffraction. **[2]**

Sl No	INTERFERENCE	DIFFRACTION
1		
2		

e) Does De-Broglie's hypothesis apply to all particles, including macroscopic objects? Explain. **[2]**

Question 8

a) Consider a pendulum oscillating back and forth. How does the period and frequency of the pendulum change with variations in the length of the string and the acceleration due to gravity? Provide the corresponding mathematical relationships. **[2]**

b) How does the direction of the force between two charged objects change based on the type of charge? **[1]**

c) Write any **TWO** advantages of combined lenses. **[2]**

d) For the two statements below, choose one and provide a justification for your choice to describe p-type semiconductor. **[3]**

Statement 1: In a p-type semiconductor, the majority charge carriers are holes created by doping the pure semiconductor material with impurity atoms that have fewer valence electrons.

Statement 2: In a p-type semiconductor, the majority charge carriers are electrons that are added to the crystal lattice through the doping process.

e) Two coherent sources of intensity ratio 25:16 are used in an interference experiment. Find the ratio of intensities of maxima and minima in the interference pattern. **[2]**

Question 9

a) Write the applications of satellites in the fields of agriculture and environment. **[2]**

b) Is nuclear fusion a feasible source of energy for power generation? Justify. **[2]**

c) For the reaction given below, calculate conservation of charge and conservation of Baryon number: $n \rightarrow p + e^{-} + v$ **[2]**

d) The shape of the wavefront depends upon the characteristics of the light source, thus giving rise to the formation of the wavefronts. **[3]**

Wave A: A wavefront that is flat and propagates in a straight line, with wave energy spreading uniformly in all directions.

Wave B: A point source of light which creates a wavefront that expands outward, spreading in a 3D object.

Wave C: A linear source of light which creates a wavefront that extends in a 3D object, with wave energy propagating along the axis of the object and spreading uniformly in the perpendicular direction.

Fill in the table given below.

	Wave A	**Wave B**	**Wave C**
Name of the wavefront			
Diagram of the wavefront			

e) Which lens is used in a CCTV camera? **[1]**

[PHYSICAL CONSTANTS]

Acceleration due to gravity	$g = 9.8\ m/s^2$
Gravitational Constant	$G = 6.67408 \times 10\text{-}11\ Nm^2\ kg^{-2}$
Avogadro's number	$NA = 6.022 \times 10^{23}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\ J/K$
Density of water at 4˚C	$\rho = 1000\ kg/m3$
Electron charge	$e = 1.6 \times 10^{-19}\ C$
Energy equivalent	1 u = 931.5 MeV
Mass of an electron	$m_e = 9.1 \times 10^{-31}\ kg$
Mass of a neutron	$m_n = 1.008665\ u$
Mass of a proton	$m_p = 1.007276\ u$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ TmA^{-1}$
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} C\ 2N^{-1} m^{-2}$
Planck's constant	$h = 6.63 \times 10^{-34} J.S$
Speed of electromagnetic wave	$c = 3 \times 108\ ms^{-1}$
Standard atmospheric pressure	1 atm=101325 Pa
Universal gas constant	R = 8.31 J/mol. K
1 electron volt	$1eV = 1.6 \times 10^{-19}\ J$
	$\pi = 3.14$