SECTION A [40 MARKS]
ANSWER **ALL** QUESTIONS

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. The magnetic flux linked with a coil is given by the equation $\phi = 6t^2 + 3t + 2$. The magnitude of induced emf in the coil at t = 3 seconds will be

    A   39 V.

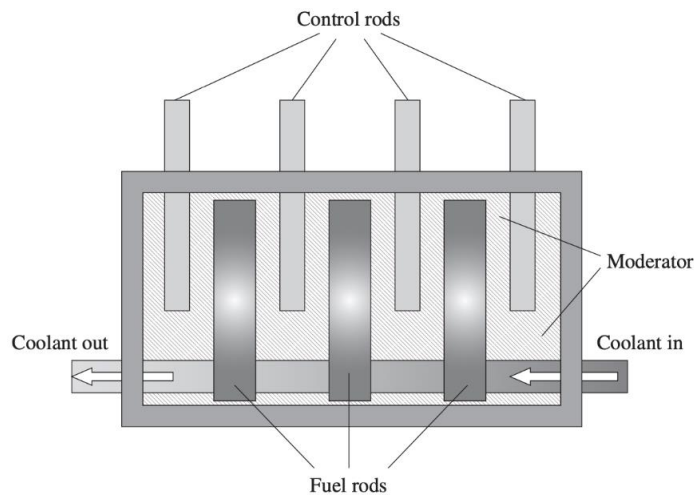   B   41 V

    C   54 V.

    D   65 V.

ii. If the speed of light were half of its present value, what effect would it have on the binding energy of the nucleus?

    A   increased to half

    B   decreased to half

    C   increased to one-fourth

    D   decreased to one-fourth

iii. A rocket engine produces thrust through action and reaction. The engine produces hot exhaust gasses which flow out from the back of the engine. In reaction, a thrusting force is produced in the opposite direction. However, we cannot successfully launch the rocket without the principle of conservation of

    A   mass.

    B   energy.

    C   momentum.

    D   internal energy.

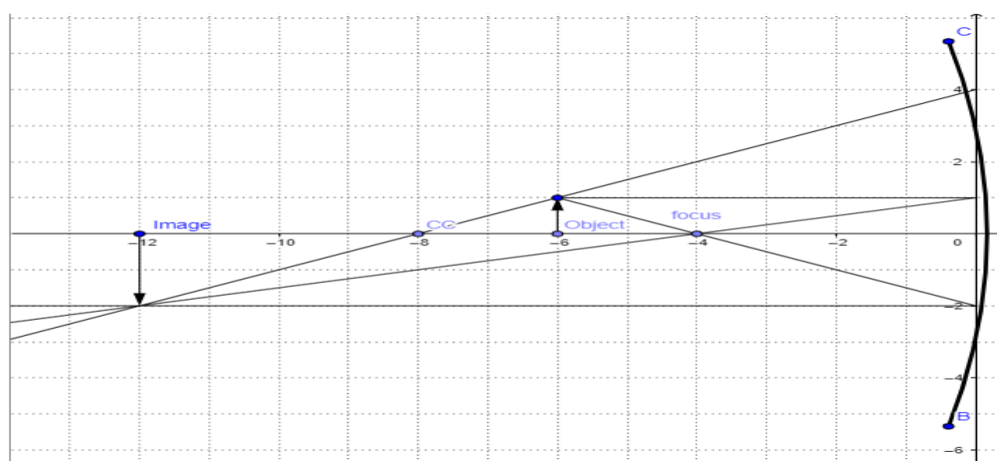iv.   A model of the core of a nuclear fission reactor is shown in the figure given below.

A fault causes some of the moderators to leak out of the core. Which action would compensate this?

A   withdraw the control rods from the core

B   lower the control rods further into the core

C   pump the coolant through the core at a faster rate

D   reduce the temperature of the coolant before pumping it into the core

v.   "A bird flapping its wings circles around a clock tower". Which part of the motion is periodic and oscillatory?

A   both the bird's motion and wings flapping are non-oscillatory

B   both the bird's motion and wings flapping are oscillatory

C   bird's motion is oscillatory while wings flapping is periodic

D   bird's motion is periodic while wings flapping is oscillatory

vi.   The simplest way to find the value of acceleration due to gravity on the Earth is by using a simple pendulum. If you conduct a similar experiment in space, the value of time period (T) will be

A   T.

B   2T.

C   zero.

D   infinity.

vii. Kumar started an electronic repair shop in Gasa. One of his customers brought a power bank to repair. He opened the power bank and at the core, he found two plates made of metal separated by a dielectric. To check the defect, he connected the power bank to a dc source. When the battery is disconnected and the dielectric is removed, the

A   voltage will decrease.

B   capacitance will increase.

C   electric field will increase.

D   energy stored will decrease.

viii. Pema and his friends are on a day hike to Jomolhari at an altitude approximately 7326 m above sea level. When they started to climb from the base, breathing became difficult and some started suffering from altitude sickness. Which of the following best describes this situation?

A   Boyle's law

B   Charles' law

C   Dalton's law

D   Ideal gas law

ix. In an optical experiment, a researcher observes a mirror giving a distortion or the spreading of an image. The error observed in the experiment is due to

A   reflected rays are focused on a single point on the principal axis.

B   reflected rays are focused on a single point on the principal axis.

C   refracted rays are focused on multiple points on the principal axis.

D   refracted rays are focused on multiple points on the principal axis.

x. The power supplied to our homes, schools and offices are 220 V and 50 Hz. This voltage varies like a sine function and it completes 50 oscillations in a second. While making 50 oscillations, how many times does the power become zero?

A   25 times

B   50 times

C   75 times

D   100 times

xi.   The earthquake with a magnitude of 6.1 on the Richter scale occurred in 2009 in Bhutan destroying many houses in the Eastern part of the country. Which of the following concepts can best explain the movement of tectonic plates?
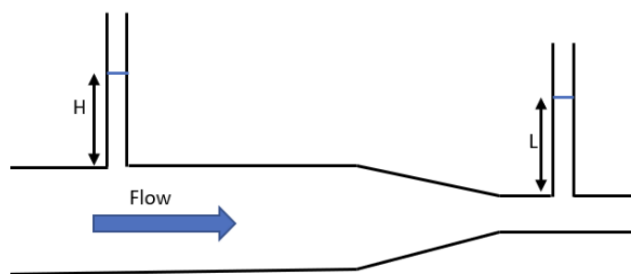
      A   resonance

      B   periodic motion

      C   oscillatory motion

      D   simple harmonic motion

xii.   The PhET simulation of the formation of an image by a concave mirror is given below. If an object's distance and image distance are reversed with the same height of an object, what are the size and the nature of the image?

      A   The size and nature of the image remain the same.

      B   The size of the image increases and the nature of the image changes.

      C   The size of the image increases and the nature of the image remains the same.

      D   The size of the image decreases and the nature of the image remains the same.

xiii.   Which of the following relationships are found between the acceleration 'β'' and the displacement 'y' of a particle involved in simple harmonic motion?

      A $\beta = 3x$

      B $\beta = -5y$

      C $\beta = -50y^2$

      D $\beta = 0.6y^3$

xiv. Which one of the following is similar between electrostatic force and gravitational force?

    A   both forces are strong forces

    B   force can be attractive or repulsive

    C   force depends on the medium between the bodies

    D   force is inversely proportional to the distance between the bodies

xv. Two identical coaxial circular loops carry a current 'i' each circulating in the same direction. If the loops approach each other, the current in

    A   each increases.

    B   each decreases.

    C   each remains the same.

    D   one increases whereas the other decreases.

xvi. In nanotechnology, Richard Feynman used nanoscale material because it is sensitive to

    A   size.

    B   temperature.

    C   composition.

    D   composition and size.

xvii. What will be the relation between H & L?

    A $H > L$
    B $H < L$
    C $H = L$
    D $H \leq L$

xviii. A 100 W sodium lamp radiates energy uniformly in all directions. The lamp is located at the centre of a large sphere that absorbs all the sodium light which is incident on it. The wavelength of the sodium light is 589 nm. The energy per photon associated with sodium light is

A   2.00 eV.

B   2.11 eV.

C   2.22 eV.

D   2.33 eV.

xix. Dechen was studying about a certain phenomenon of light. To validate his findings, he poured oil on an irregular surface and waited until the sun's rays fell vertically on it. He observed that the oil on the surface looked like a combination of vibrant colours. What would be the cause of this phenomenon?

A   diffraction of light

B   interference of reflected light waves

C   interference of refracted light waves

D   interference of both reflected and refracted light waves

xx. Firefighters use a firehose to adjust water pressure. If the firefighters have to reach the sixth floor of a building to extinguish a fire, what should be the flow of water in the pipe?

A   streamlined

B   laminar flow
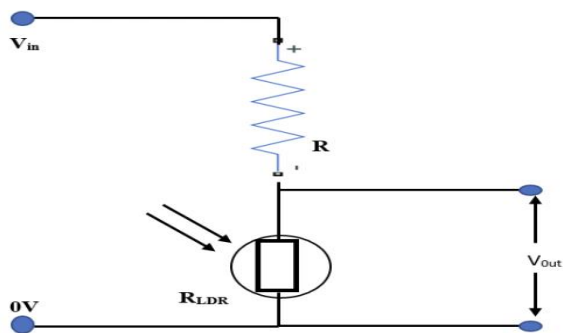
C   turbulent flow

D   turbulent and streamlined

xxi.	In a photoelectric experiment, Sonam recorded metals and their work function as given in the table below. She was unable to predict which metal will give photoelectric emission for a radiation of wavelength 3300 Å. Which metal will eject the electrons from the metal surface?

Metal	Work function
K	2.30 eV
Ni	5.15 eV
Mo	4.17 eV
Na	2.75eV

A	K and Na

B	Na and Ni

C	Na and Mo

D	Ni and Mo

xxii.	Karma met with an Ophthalmologist and was asked to wear spectacles to enable him to see clearly up to 90 meters. Which of the following lenses would best suit his eyesight?

A	convex

B	concave

C	plano-convex

D	convexo concave

xxiii. The figure given below is a circuit diagram of a light sensor. The light sensors are used to automatically switch on and switch off the power. If you were to use the light sensor in Thimphu city, what would be the function of this circuit if the light dependent resistor (R_{LDR}) is higher?

A   Switch on when the intensity of light is high

B   Switch on when the intensity of light is low

C   Switch off when the intensity of light is high

D   Switch off when the intensity of light is low

xxiv. In the LCR circuit, inductance, capacitance and resistance are connected in series. Which of the following conditions would lead it to undergo resonance?

A $X_L = X_c$

B $X_L = R$

C $X_c = R$

D $Z = R$

xxv. In a surface tension experiment with a capillary tube, the water rises up to 0.1m. If the same experiment is repeated on an artificial satellite revolving around the Earth, the rise of water in the capillary tube will

A   be 0.

B   remain the same.

C   be half-length of the capillary tube.

D   be full length of the capillary tube.

b) **Match each item under column A with the most appropriate item in column B.** **[5]**
Write the correct alphabet under the 'answer' column in the space provided.

Answer		Column A		Column B
	i.	Magnetic permeability	a)	H
	ii.	N-type	b)	trivalent
	iii.	Constructive interference	c)	Δx and ϕ are different
	iv.	Critical design review	d)	neutrino
	v.	Quarks	e)	functional checkpoint
	vi.	Safety review	f)	diatomic
	vii.	Destructive interference	g)	relative permeability
	viii.	Leptons	h)	technical checkpoint
	ix.	P-type	i)	neutrons
	x.	Magnetic intensity	j)	Δx and ϕ are same
			k)	pentavalent
			l)	μ

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

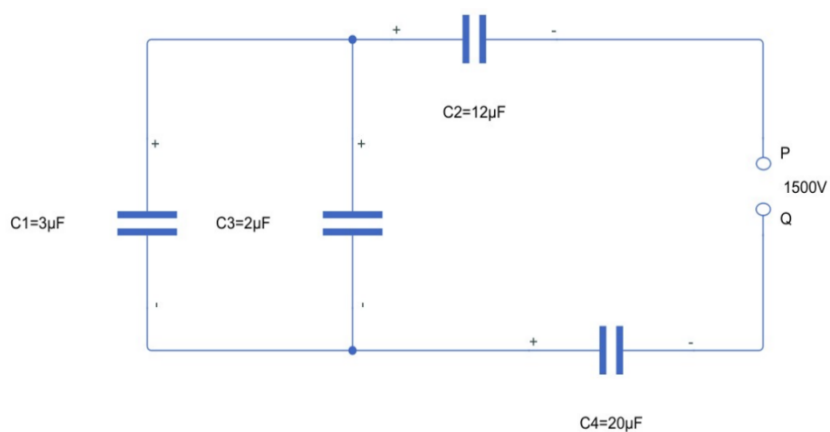|		
i.	When an object is at 2f, the relative displacement of both object and the image is _____.	
ii.	A plane wave passes through a convex lens. The geometrical shape of the wavefront that emerges is _____.	
iii.	In Heisenberg's uncertainty principle, the two variable characteristics are _____ and _____.	
iv.	After the up-linking process, a satellite _____and _____ the signal.	
v.	When a particle and its antiparticle collide with each other, they _____ and release energy in the form of radiation.	
vi.	The beta decay process provides clear evidence that _____ and _____are not elementary particles.	
vii.	When a spherical mirror is immersed in water, its focal length will be _____.	

d) **Circle the appropriate letter T for True and F for False against each statement.** **[5]**

i.	Nuclear fission is more common than nuclear fusion because fusion reactions require extremely high temperatures which is very difficult to attain. T / F	
ii.	In Young's double slit experiment, when the white-coloured light is passed through it, the fringes formed on the screen are black and white. T / F	
iii.	The conductivity of semiconductors increases with a decrease in temperature. T / F	
iv.	When the potential energy and kinetic energy are equal, the amplitude 'A' of motion of a particle in SHM is $\pm \frac{A}{2}$. T / F	
v.	If the current in one coil is steady, the mutual inductance becomes infinite. T / F	
vi.	The laboratory worksheet recorded timing of 20 oscillations of the spring instead of just one oscillation. This is because the period of oscillation is expected to vary. T / F	
vii.	Semiconductors are always neutral because the number of protons and neutrons are equal. T / F	
viii.	If the number of turns in primary and secondary coils is increased to two times each, the mutual inductance becomes four times. T / F	
ix.	When a film is illuminated by white light, its upper portion appears dark. The path difference between two reflected beams at the spot must be λ. T / F	
x.	Nuclear energy is used in creating nuclear technology which is used in the field of agriculture. Workers use radiation to prevent harmful insects from reproducing. T / F	

Question 2

a)   Dema and her friends could not find the resultant capacitance between points P and   **[2]**
        Q. Rearrange the diagram and compute the resultant capacitance between P and Q.

b) A group of students conducted an experiment with a convex lens. While conducting the experiment, they placed an object between focus and lens.

i. Construct a ray diagram to represent the image formed in the above experiment and label clearly. **[2]**

ii. If the same concept in part (i) is applied to the rear-view mirror of a car with a focal length of 20 cm and object distance of 4 cm, what is the image distance? **[2]**
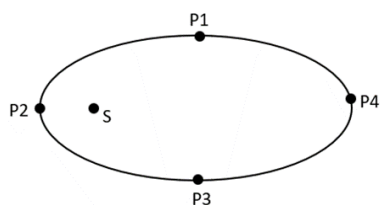
c) Explain how normal metals can be converted into superconductors. Draw a graph to represent this situation. **[2]**

d) We know that we cannot explain Heisenberg's Uncertainty Principle using any object that are visible to our naked eyes. Using an object which is familiar to you, draw a diagram to show why it cannot explain this principle. **[2]**

Question 3

a)   Mention any **TWO** applications of nanotechnology in the field of medicine.   **[1]**

b)   The figure given below shows a planet in an elliptical orbit around the Sun S. At   **[2]**
       what position will the kinetic energy of the planet be maximum? Justify your answer
       using the appropriate law.

c)   The velocities of five particles are: 3m/s, 7m/s, 12m/s, 17m/s, and 19m/s.   **[1]**
i.   What is the average velocity of the particles?

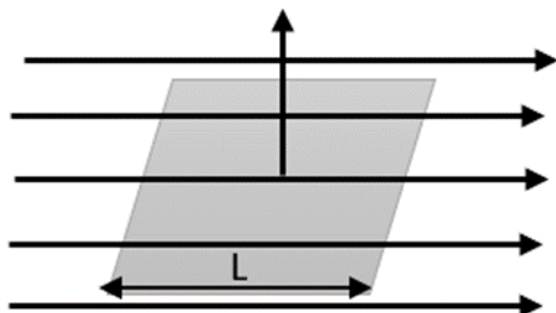ii.   What is the root-mean-square speed of the particles?   **[1]**

d)   A hollow sphere is filled with water through a small hole at the bottom. It is hung by   **[2]**
     a long thread and as water slowly flows out of the hole, the period of oscillations first
     increases and then decreases. Explain why?

e) After studying the concept of electromagnetic induction, we know that we can generate electricity from a rotating turbine. Explain how you can generate electricity with the help of a labelled diagram? **[3]**

Question 4

a) A square surface with the side L meter in the plane of the paper is placed in a uniform **[2]**
    electric field E (V/m) acting along the same plane at an angle with the horizontal side
    of the square as shown in the figure given below. What is the electric flux linked to
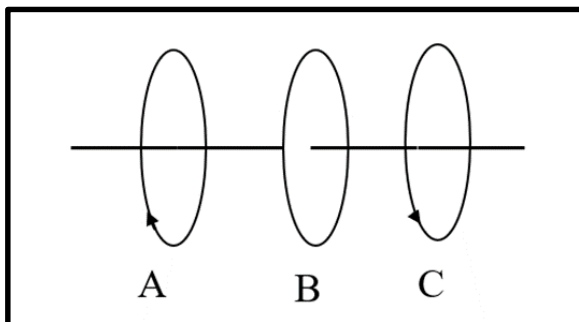   the surface in units of Vm?

b) State Kirchhoff's second law.   **[1]**

c) Out of the six quarks, which are most abundant in the universe and why?   **[2]**

d) Three identical closed coils A, B and C are placed with their planes parallel to one another. A and B carry equal currents as shown in the figure below. B and C are kept fixed and A is moved towards B uniformly. Is there any induced current in B? If yes, what will be its direction? **[2]**

e) Pemba is a passionate cyclist and cycles 5km daily taking an uphill route. He had to pedal harder as the road got steeper to keep up the momentum. Design a diagram to show why Pemba has to peddle faster and harder and explain using scientific terms and reasons. **[3]**

(blank answer box)

Question 5

a) **[2]**

i.   Explain the process of how a rocket gets lighter as it moves higher and higher? Can we change the direction of the rocket after it is launched?

(blank answer box)

ii.   How does NASA manage wastes which get detached from the rockets? **[1]**

(blank answer box)

b)   Dendup uses a convex lens to find the wave front by placing a point source at the focus. Draw a wavefront coming out from the convex lens. **[1]**
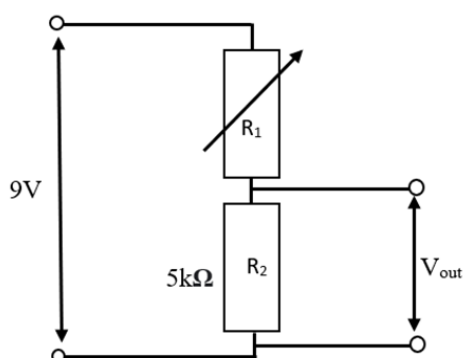
c)   Two different coils have self-inductances of 10 mH and 2 mH respectively. The current in the two coils is increased at the same constant rate and the power supplied to both the coils is same. Calculate the ratio of induced emf. **[2]**

d)   "Car lubricants play a major role in controlling friction and wear to the engine. If the   **[2]**
      car is used at high altitudes, we have to use lubricants of low viscosity". Do you agree
      with the statement? Support your answer with an appropriate reason.

e)   A variable resistor is used in a potential divider as shown below. R_1 is set at 7kΩ.

i.   Find the reading on the voltmeter used to measure V_{out}.   **[1]**

ii.   If the value of R1 is doubled, what is the reading at V_{out}?   **[1]**

Question 6

a)   Why do people not use blotting paper or newspaper to write with an ink pen?   **[1]**

b)   While conducting an experiment to find the electromotive force of a dry cell, students are encouraged to use a potentiometer when it can be done easily and quickly by using a voltmeter. Why do you think a potentiometer is preferred compared to a voltmeter?   **[2]**
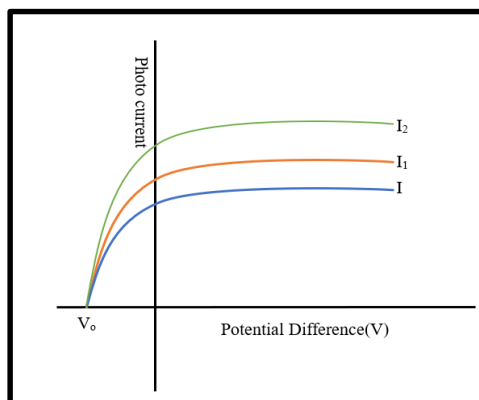
c) Prove the law of refraction of waves using the concept of Huygen's Principle. **[4]**

d) While teaching the concepts of photoelectric effect, Mr Passang used online simulation to see how photoelectric current depends on the intensity of light. His students were working in groups and one of the groups obtained the graph given below. The graph illustrates the photoelectric experiment. Study the graph and answer the questions that follow.

i. When the potential decreases, the photocurrent decreases but does not become zero at zero potential. Why? **[1]**

ii. Do the intensities of incident light affect the stopping potential or cut-off potential? Why? **[1]**

iii.   Write any **TWO** conclusions from the graph.   **[1]**

Question 7

a)   When charged particles are placed in a uniform electric field, they experience a force.   **[2]**
     When a charged particle enters perpendicularly to the uniform electric field, it is
     found to move in a parabolic path. Using the information given above, derive an
     equation to prove this statement.

b)   When a tiny circular obstacle is placed in the path of light from a distant source, a **[2]**
        bright spot is seen at the centre of the shadow of the obstacles. What caused this
        phenomenon to happen and why?

c)   Show that the charge of a proton is positive and the charge of a neutron is zero using **[2]**
        quark models.

d) When you travel on a rough road, you will go through up and down motions. Can you reduce such motions? Give appropriate reasons. **[2]**

e) Can quantum physics be helpful to lead a better life? Give a reason to support your answer. **[2]**

Question 8

a) Zam was standing in front of a unique-shaped mirror which was divided into two parts. She observes that her image has a small head and a fat body. Name the type of mirrors used with the characteristics of the image formed. **[2]**

b) The nitrogen nucleus (N_7^{14}) is made up of an equal number of protons and neutrons with the specific masses of,

Mass of proton= 1.007834 U

Mass of neutron= 1.00867 U

Mass of nitrogen nucleus = 14.00307 U

Using the given information above, answer the following questions.

Calculate:

i. the binding energy in Mev. **[1]**

ii. binding energy per nucleon in MeV. **[1]**

iii. What is the main importance of calculating binding energy per nucleon? **[1]**

c) Younten was doing an experiment to find the relationship between current and voltage using one of the circuits given below: **[2]**

Pure resistive circuit

Pure inductive circuit

Pure capacitive circuit

In his conclusion, the current was leading by 90 degrees to voltage. Do you agree with his finding? Give appropriate reasons with an equation to support your answer.

d) Do you think it is possible to give any desired charge to a capacitor? Justify your answer. **[1]**

e)   With the rapid development around the world, satellite communication is gaining importance and many countries are striving to have their own satellite.

i.   Why do you think satellite communication is important?   **[1]**

ii.   How can satellite support in managing disasters?   **[1]**

Question 9

a)   What affects the rate of charging and discharging of a capacitor?   **[1]**

b)   Two thin lenses of focal lengths +10cm and -5cm are kept in contact. Calculate its:

i.   focal length.   **[1]**

ii.   power of combination.   **[1]**

c)   While watering her garden, Pema observed that the speed of water can be increased **[2]** by pressing the mouth of the pipe with the thumb and the water also travels a longer distance. Justify the above statement with a diagram and an equation.

d) Nuclear fission is normally used in generating electricity and similarly nuclear fusion. There are many countries that are exploring different ways to generate electricity using nuclear fusion reactions. Mention any **TWO** reasons for adopting fusion reactions over fission reactions. **[2]**

e) A nurse measured the average heartbeat of a patient and reported to the doctor in terms of time period as 0.8*s*. Express the heartbeat of the patient in terms of a number of beats measured per minute. **[2]**

f) Mention any **TWO** basic postulates of kinetic theory. **[1]**

[PHYSICAL CONSTANTS]

Acceleration due to gravity	$g = 9.8$ m/s^2
Gravitational Constant	$G = 6.67408 \times 10^{-11}$ Nm^2 kg^{-2}
Avogadro's number	$N_A = 6.022 \times 10^{23}$
Boltzmann constant	$k = 1.38 \times 10^{-23}$ J/K
Density of water at 4˚C	$\rho = 1000$ kg/m^3
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^{2}N^{-1}m^{-2}
Planck's constant	$h = 6.63 \times 10^{-34}$ J.s
Speed of electromagnetic wave	$c = 3 \times 10^8$ 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
	$\pi = 3.14$