INDIAN ASSOCIATION OF PHYSICS TEACHERS

NATIONAL STANDARD EXAMINATION IN PHYSICS 2012 - 2013

Date of Examination: 24th November 2012

Time 09.30 to 11.30 Hrs.

Q. P. Code No.	1	0	8
	ONE	ZERO	EIGHT

Instructions to Candidates

1. In addition to this question paper, you are given answer sheet for part A and an answer paper for part B.
2. On the answer sheet for part A, fill up all the entries carefully in the space provided, **ONLY IN BLOCK CAPITALS.**

   Incomplete / incorrect / carelessly filled information may disqualify your candidature.
3. On part A answer sheet, use only **BLUE or BLACK BALL PEN** for making entries and marking answers.
4. Part A has two parts. In Part A1 (Q. Nos. 1 to 40) each question has **FOUR** alternatives, out of which only one is correct. Choose the correct alternative and mark a cross **(X)** in the corresponding box on the answer sheet.

   For example,

Q.No.	a	b	c	d
22		X		

   Part A2 (Q. Nos. 41 to 50) has four alternatives in each question, but any number of these (4, 3, 2, or 1) may be correct. You have to mark **ALL** correct alternatives and mark a cross **(X)** for each, like

Q.No.	a	b	c	d
44		X		X

5. **For Part A1,** each correct answer gets 3 marks; wrong answer gets a penalty of 1 mark. **For Part A2** full marks are 6 for each question, you get them when **ALL** correct answers only are marked.
6. Any rough work should be done only on the sheets provided with part B answer paper.
7. Use of nonprogrammable calculator is allowed.
8. No candidate should leave the examination hall before the completion of the examination.
9. After submitting your answerpapers, read the instructions regarding evaluation given at the end of the question paper.

PLEASE DO NOT MAKE ANY MARK OTHER THAN (X) IN THE SPACE PROVIDED ON THE ANSWER SHEET OF PART A.

Answer sheets for part A are evaluated with the help of a machine. Hence, **CHANGE OF ENTRY IS NOT ALLOWED.**

Scratching or overwriting may result in wrong score.

DO NOT WRITE ANYTHING ON BACK SIDE OF PART A ANSWER SHEET.

INSTRUCTIONS TO CANDIDATES :

1. The answers / solutions to this question paper will be available on our website - **www.iapt.org.in** by 3 rd December 2011.

EVALUATION PROCEDURE (NSEP) :

2. Part 'A' Answers of ALL the candidates are examined .

3. Part B is evaluated of only those students who get marks above a certain "cut off" marks in Part A. (e.g. NSEP Total marks for Part A are 180. Students getting (say) 100 or more than 100 marks in Part A are identified and their Part B is evaluated. Thus "cut off" marks are 100 in this example.)

4. PART B IS NOT EVALUATED OF ALL THE CANDIDATES.

CERTIFICATES & AWARDS

Following certificates are awarded by the I.A.P.T. to students successful in NSEP.

i) Certificate for "Centre Top 10%" students on the basis of marks in part A only.

ii) Merit certificates to statewise Top 1% students on the basis of (A+B) marks.

iii) Merit certificate and a prize in the form of a book to Nationwise Top 1% students based on (A+B) marks.

5. **Result sheets** and the **"centre top 10%"** certificates of NSEP are dispatched to the Professor in charge of the centre. Thus you will get your marks from the Professor in charge of your centre by January 2012 end.

6. TOP 300 (or so) students are called for the next examination -Indian National Physics Olympiads (INPhO). Individual letters are sent to these students ONLY.

7. Gold medals will be awarded to TOP 35 students in this entire process.

8. No queries will be entertained in this regard.

INDIAN ASSOCIATION OF PHYSICS TEACHERS

NATIONAL STANDARD EXAMINATION IN PHYSICS 2012 – 2013

Total time: 120 minutes (A-1, A-2 & B)

PART A **MARKS : 180**

SUB-PART A – 1: ONLY ONE OUT OF FOUR OPTIONS IS CORRECT

N.B.: Physical constants are given at the end.

SUB-PART A – 1

1) Two pendulums differ in lengths by 22 cm. They oscillate at the same place so that one of them makes 30 oscillations and the other makes 36 oscillations during the same time. The lengths (in cm) of the pendulums are

(a) 72 and 50 (b) 60 and 38 (c) 50 and 28 (d) 80 and 58

2) Three waves of the same amplitude have frequencies $(n - 1)$, n and $(n + 1)$ Hz. They superpose on one another to produce beats. The number of beats produced per second is

(a) n (b) 2 (c) 1 (d) $3n$

3) A spherical ball of mass m_1 collides head on with another ball of mass m_2 at rest. The collision is elastic. The fraction of kinetic energy lost by m_1 is

(a) $\frac{4m_1m_2}{(m_1+m_2)^2}$ (b) $\frac{m_1}{m_1+m_2}$ (c) $\frac{m_2}{m_1+m_2}$ (d) $\frac{m_1m_2}{(m_1+m_2)^2}$

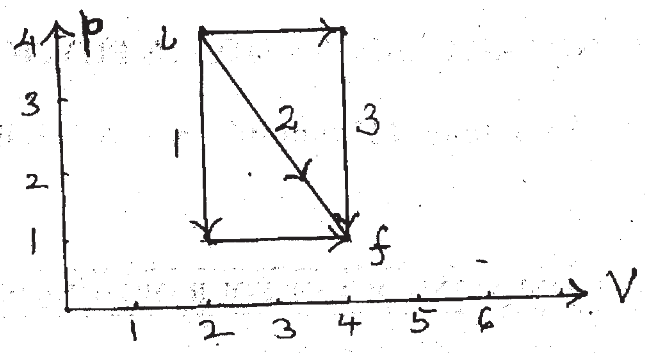
4) Two equal masses are connected by a spring satisfying Hooke's law and are placed on a frictionless table. The spring is elongated a little and allowed to go. Let the angular frequency of oscillations be ω. Now one of the masses is stopped. The square of the new angular frequency is

(a) ω^2 (b) $\frac{\omega^2}{2}$ (c) $\frac{\omega^2}{3}$ (d) $2\,\omega^2$

5) When a particle oscillates in simple harmonic motion, both its potential energy and kinetic energy vary sinusoidally with time. If v be the frequency of the motion of the particle, the frequency associated with the kinetic energy is

(a) $4\,v$ (b) $2\,v$ (c) v (d) $\frac{v}{2}$

6) A gas expands from i to f along the three paths indicated. The work done along the three paths denoted by W_1, W_2 and W_3 have the relationship



(a) $W_1 < W_2 < W_3$ (b) $W_2 < W_1 = W_3$ (c) $W_2 < W_1 < W_3$ (d) $W_1 > W_2 > W_3$

7) An ideal gas at 30° C enclosed in cylinder with perfectly non conducting side and a piston moving without friction in it. The base of the cylinder is perfectly conducting. Cylinder is first placed on a heat source till the gas is heated to 100° C and the piston raised by 20 cm and the atmospheric pressure is 100 kPa. The piston is then held in final position and cylinder is placed on the heat sink to cool the gas to 30° C. Denoting ΔQ_1 as the heat supplied during heating and ΔQ_2 as the heat lost during the cooling, then $[\Delta Q_1 \sim \Delta Q_2]$ would be equal to

(a) 436 J (b) 336 J (c) 236 J (d) 136 J

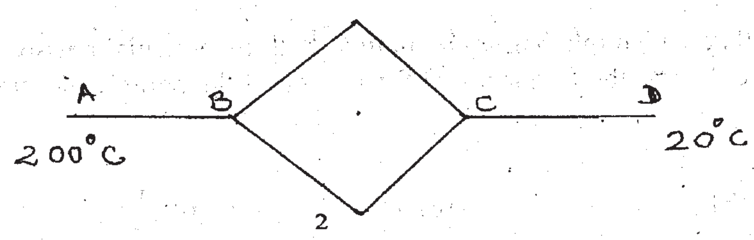
8) Equal amounts liquid helium and water at their respective boiling points are boiled by supplying the heat from identical heaters in time t_{He} and t_w. The latent heats of vaporization of He and Water are 2.09×10^4 J / kg and 540 kcal / kg, then t_{He} is

(a) about 0.1 t_w
(b) about 0.05 t_w
(c) just greater than 0.01 t_w
(d) just less than 0.01 t_w

9) A 5 litre vessel contains 2 mole of oxygen gas at a pressure of 8 atm. The average translational kinetic energy of an oxygen molecule under this condition is

(a) 8.4×10^{-14} J (b) 4.98×10^{-21} J (c) 7.4×10^{-16} J (d) 4.2×10^{-21} J

10) Six identical conducting rods are joined as shown. The ends A and D are maintained at 200° C and 20° C respectively. No heat is lost to surroundings. The temperature of the junction C will be



(a) 60° C (b) 80° C (c) 100° C (d) 120° C

(a) 63.91 kV (b) 255.64 kV (c) 200.34 kV (d) 127.82 kV

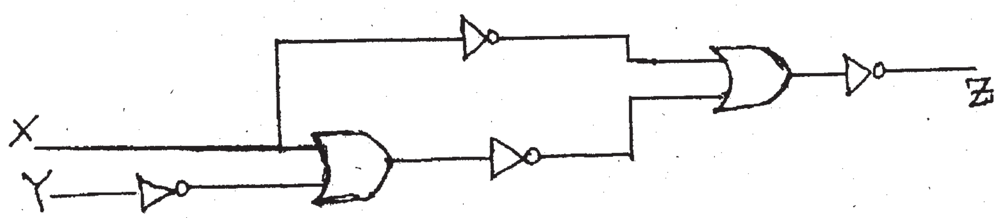
18) In an electrolytic process certain amount of charge liberates 0.8 gram of oxygen. Then the amount of silver liberated by the same amount of charge is

(a) 10.8 gram (b) 1.08 gram (c) 0.9 gram (d) 9,0 gram

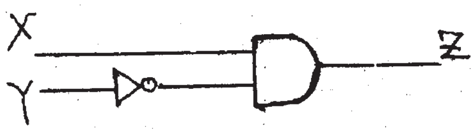
19) The energy state of doubly ionized lithium having the same energy as that of the first excited state of hydrogen is

(a) 4 (b) 6 (c) 3 (d) 2

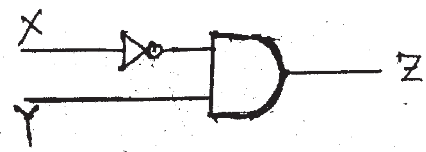
20) The logic circuit shown below is equivalent to



(a)

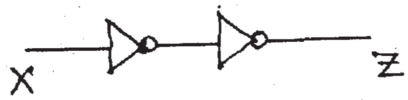


(b)

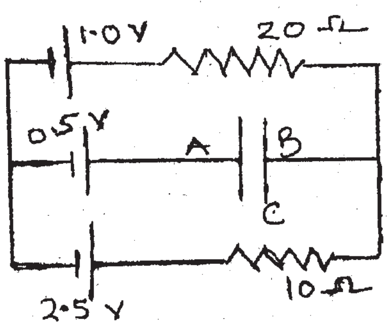


(c)

(d)



21) In the circuit shown below, the potential of A with respect to B of the capacitor C is



(a) 2.00 volt (b) – 2.00 volt (c) – 1.50 volt (d) +1.50 volt

22) Two thermally insulated compartments 1 and 2 are filled with a perfect gas and are connected by a short tube having a valve which is closed. The pressures, volumes and absolute temperatures of the two compartments are respectively (p_1, V_1, T_1) and (p_2, V_2, T_2). After opening the valve, the temperature and the pressure of both the compartments respectively are

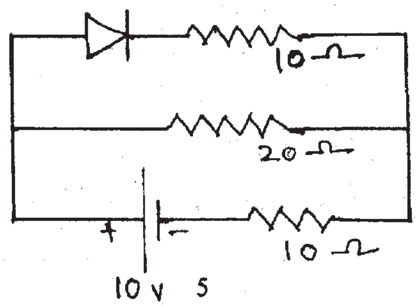
(a) $\frac{T_1T_2(p_1V_1+p_2V_2)}{(p_1V_1T_1+p_2V_2T_2)}, \frac{p_1V_1+p_2V_2}{V_1+V_2}$

(b) $\sqrt{T_1T_2}, \frac{p_1V_1+p_2V_2}{V_1+V_2}$

(c) $\frac{T_1T_2(p_1V_1+p_2V_2)}{(p_1V_1T_1+p_2V_2T_2)}, \frac{p_1V_1T_1+p_2V_2T_2}{V_1T_1+V_2T_2}$

(d) $\frac{T_1+T_2}{2}, \frac{p_1V_1+p_2V_2}{V_1+V_2}$

23) The voltage drop across a forward biased diode is 0.7 volt. In the following circuit, the voltages across the 10 ohm resistance in series with the diode and 20 ohm resistance are



(a) 0.70 V, 4.28 V (b) 3.58 V, 4.28 V (c) 5.35 V, 2.14 V (d) 3.58 V, 9.3 V

24) The magnetic flux φ through a stationary loop of wire having a resistance R varies with time as $\varphi = at^2 + bt$ (a and b are positive constants). The average emf and the total charge flowing in the loop in the time interval $t = 0$ to $t = \tau$ respectively are

(a) $a\tau + b, \frac{a\tau^2+b\tau}{R}$

(b) $a\tau + b, \frac{a\tau^2+b\tau}{2R}$

(c) $\frac{a\tau+b}{2}, \frac{a\tau^2+b\tau}{R}$

(d) $2(a\tau + b), \frac{a\tau^2+b\tau}{2R}$

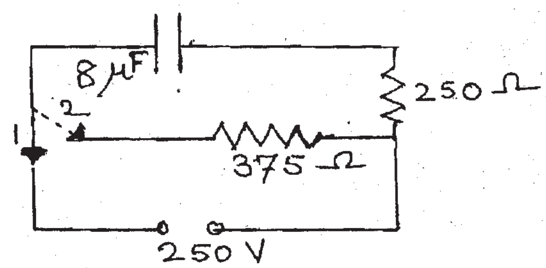
25) An inductance coil is connected to an ac source through a 60 ohm resistance in series. The source voltage, voltage across the coil and voltage across the resistance are found to be 33 V, 27 V and 12 respectively. Therefore, the resistance of the coil is

(a) 30 ohm (b) 45 ohm (c) 105 ohm (d) 75 ohm

26) An ideal inductance coil is connected to a parallel plate capacitor. Electrical oscillations with energy W are set up in this circuit. The capacitor plates are slowly drawn apart till the frequency of oscillations is doubled. The work done in this process will be

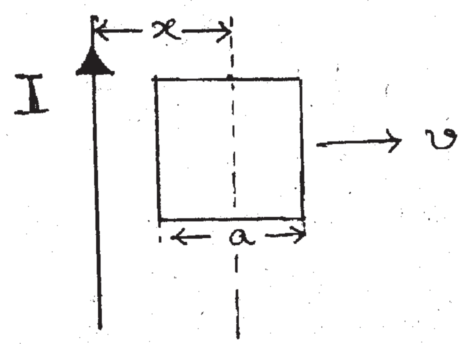
(a) W (b) 2 W (c) 3 W (d) 4 W

27) In the circuit shown below, the switch is in position 1 for a long time. At some moment after that the switch is thrown in position 2. The quantity of heat generated in the resistance of 375 ohm after the switch is changed to position 2 is



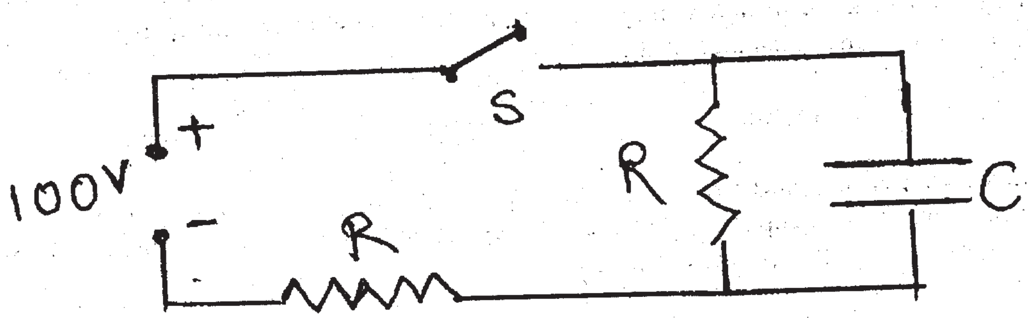
(a) 0.15 J (b) 0.25 J (c) 0.50 J (d) 0.10 J

28) A conducting square frame of side a and a long straight wire carrying current I are located in the same plane as shown in the figure. The frame moves to the right with a constant velocity v. The emf induced in the frame will be proportional to

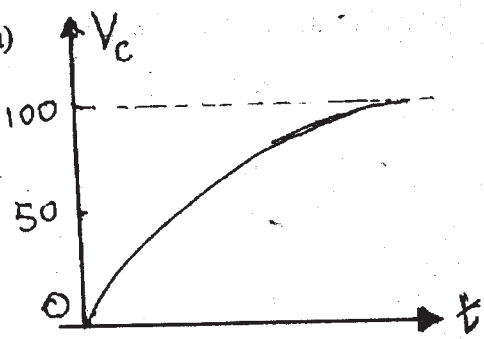


(a) $\frac{1}{x^2}$ (b) $\frac{1}{(2x-a)^2}$ (c) $\frac{1}{(2x+a)^2}$ (d) $\frac{1}{(2x-a)(2x+a)}$

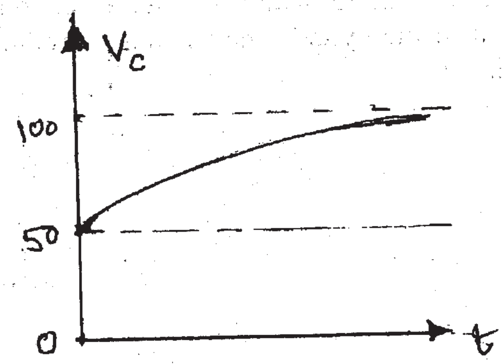
29) In the circuit shown below, the switch S is closed at the moment $t = 0$. As a result the voltage across the capacitor C will change with time as



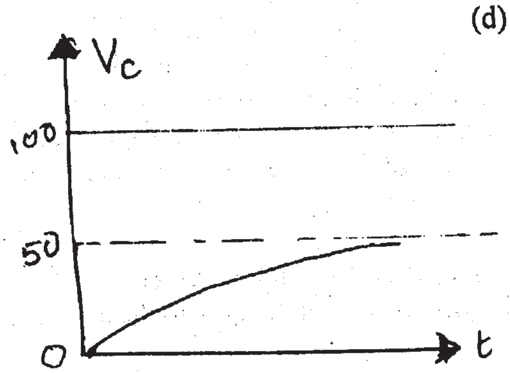
(a)



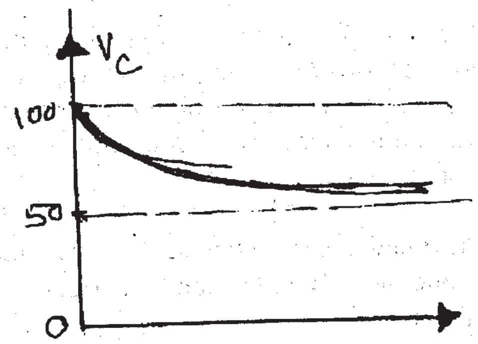
(b)



(c)



(d)



30) The ratio of the rotational kinetic energy to the total kinetic energy of one mole of a gas of rigid diatomic molecules is

(a) $\frac{2}{3}$ (b) $\frac{2}{5}$ (c) $\frac{3}{5}$ (d) $\frac{5}{2}$

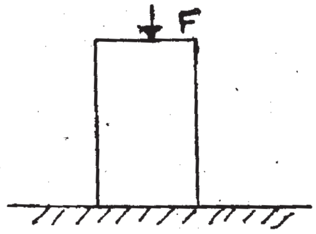
31) When a metal surface is illuminated with light of wavelength λ, the stopping potential is V_0. When the same surface is illuminated with light of wavelength 2λ, the stopping potential is $\frac{V_0}{4}$. If the velocity of light in air is c, the threshold frequency of photoelectric emission is

(a) $\frac{c}{6\lambda}$ (b) $\frac{c}{3\lambda}$ (c) $\frac{2c}{3\lambda}$ (d) $\frac{4c}{3\lambda}$

32) Two elastic waves move along the same direction in the same medium. The pressure amplitudes of both the waves are equal, but the wavelength of the first wave is three times that of the second. If the average power transmitted through unit area by the first wave is W_1 and that by the second is W_2, then

(a) $W_1 = W_2$ (b) $W_1 = 3\ W_2$ (c) $W_2 = 3\ W_1$ (d) $W_1 = 9\ W_2$

33) A metal cylinder of length L is subjected to a uniform compressive force F as shown in the figure. The material of the cylinder has Young's modulus Y and Poisson's ratio μ. The change in volume of the cylinder is



(a) $\frac{\mu FL}{Y}$ (b) $\frac{(1-\mu)FL}{Y}$ (c) $\frac{(1+2\mu)FL}{Y}$ (d) $\frac{(1-2\mu)FL}{Y}$

34) Three persons A, B, and C note the time taken by their train to cover the distance between two successive stations by observing the digital clocks on the platforms of two stations. The clocks display time in hours and minutes. The three persons find the intervals 3, 5 and 4 minutes respectively. Assume the maximum discrepancy of 2 seconds in actual starting and stopping of the train and ~~the observations~~ by A,B and C. Then,

(a) All A, B and C can be correct. (b) Only A and B or B and C can be correct
(c) Only one of A, B and C can be correct (d) C is correct since it is equal to the average of the three observations.

35) When two drops of water coalesce – (I) Total surface area decreases. (II) There is some rise in temperature.
Which of the following is correct?

(a) Both (I) and (II) are wrong statements.
(b) Statement (I) is true but (II) is not true.
(c) Both (I) and (II) are true and the two statements are independent of each other.
(d) Both (I) and (II) are true and (I) is the cause of (II).

36) Two capacitors 0.5 μF and 1.0 μF in series are connected to a dc source of 30 V. The voltages across the capacitors respectively are

(a) 10 V, 20 volt (b) 15 V, 15 V (c) 20 V, 10 V (d) 30 V, 30 V

37) The Th_{90}^{232} atom has successive alpha and beta decays to the end product Pb_{82}^{208}. The numbers of alpha and beta particles emitted in the process respectively are

(a) 4, 6 (b) 4, 4 (c) 6, 2 (d) 6, 4

38) If the breakdown field of air is 2.0×10^{6} V / m, the maximum charge that can be given to a sphere of diameter 10 cm is

(a) 2.0×10^{-4} C (b) 5.6×10^{-7} C (c) 5.6×10^{-5} C (d) 2.0×10^{2} C

39) Density of ocean water varies with depth. This is due to

(a) elasticity (b) viscosity (c) surface tension (d) all the three.

40) A spring of certain length and having spring constant k is cut into two pieces of lengths in a ratio 1:2. The spring constants of the two pieces are in a ratio

(a) 1:1 (b) 1:4 (c) 1:2 (d) none of the above

SUB-PART A – 2

In question 41 to 50 any number of options (1 or 2 or 3 r all 4) may be correct. You are to identify all of them correctly to get 6 marks. Even if one answer identified is incorrect or one correct answer is missed, you get zero

41) A cube floats both in water and in a liquid of specific gravity 0.8. Therefore,

(a) apparent weight of the cube is the same in water and in the liquid.
(b) the cube has displaced equal volume of water and the liquid while floating.
(c) the cube has displaced equal weight of water and the liquid while floating.
(d) if some weights are placed on the top surface of the cube to make it just sink, the load is case of water will be 0.8 times of that to be used in case of the liquid.

42) On the basis of the kinetic theory of gases one compares 1 gram of hydrogen with 1 gram of argon both at 0° C. Then,

(a) the same temperature implies that the average kinetic energy of the molecules is the same in both the cases.
(b) the same temperature implies that the average potential energy of the molecules is the same in both the cases.
(c) internal energies in both the cases are equal.
(d) when both the samples are heated through 1° C, the total energy added to both of them is not the same.

43) While explaining the action of heat engine, one can say that

(a) heat cannot be fully converted into mechanical work.
(b) the first law of thermodynamics is necessary but not sufficient.
(c) heat under no circumstances can flow from lower to higher temperature.
(d) A body can not be cooled to absolute zero.

44) The rate of change of angular momentum of a system of particles about the centre of mass is equal to the sum of external torques about the centre of mass when the centre of mass is

(a) fixed with respect to an inertial frame.
(b) in linear acceleration.
(c) in rotational motion.
(d) is in a translational motion.

45) Light is traveling in vacuum along the Z axis. The sets of possible electric and magnetic fields could be

(a) $\vec{E} = \hat{i}\vec{E}_0 \sin(\omega t - kz), \vec{B} = \hat{j}B_0 \sin(\omega t - kz)$
(b) $\vec{E} = \hat{i}\vec{E}_0 \sin(\omega t - kz), \vec{B} = \hat{j}B_0 \cos(\omega t - kz)$
(c) $\vec{E} = \hat{j}\vec{E}_0 \sin(\omega t - kz), \vec{B} = -\hat{i}B_0 \sin(\omega t - kz)$
(d) $\vec{E} = \hat{i}\vec{E}_0 \sin(\omega t - kz), \vec{B} = \hat{j}B_0 \sin(\omega t - kz + \delta)$

46) In case of photoelectric effect,

(a) since photons are absorbed as a single unit, there is no significant time delay in the emission of photoelectrons.
(b) Einstein's analysis gives a critical frequency $\nu_0 = \frac{e\varphi}{h}$, where φ is the work function and the light of this frequency ejects electrons with maximum kinetic energy.
(c) only a small fraction of the incident photons succeed in ejecting photoelectrons while most of them are absorbed by the system as a whole and generate thermal energy.
(d) the maximum kinetic energy of the electrons is dependent on the intensity of radiation.

47) A parallel combination of an inductor coil and a resistance of 60 ohm is connected to an ac source. The current in the coil, current in the resistance and the source current are respectively 3A, 2.5 A and 4.5 A respectively. Therefore,

(a) Kirchhoff's current law is NOT applicable to ac circuits.
(b) impedance of the coil is 50 ohm.
(c) electric power dissipated in the coil is 150 watt.
(d) impedance of the circuit is 33.3 ohm.

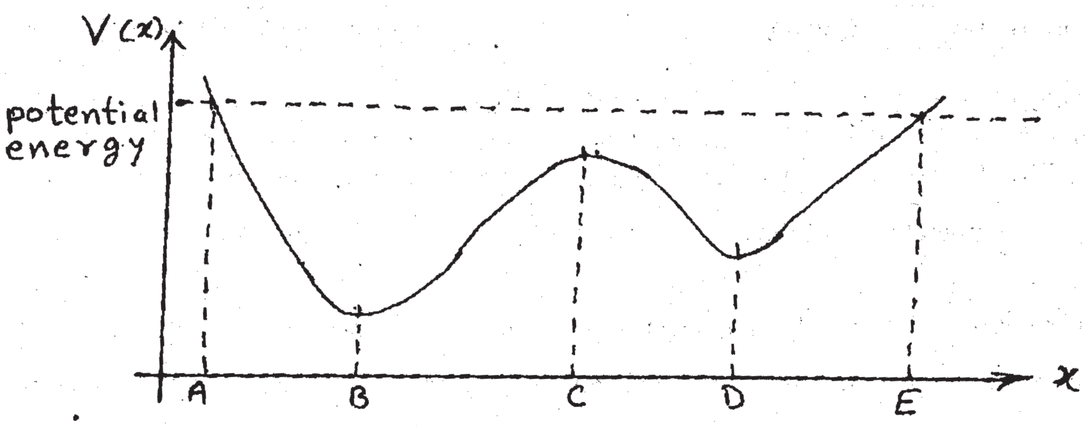
48) The nuclear forces

(a) are stronger being roughly hundred times that of electromagnetic forces.
(b) have a short range dominant over a distance of about a few fermi.
(c) are central forces independent of the spin of the nucleons.
(d) are independent of the nuclear charge.

49) Consider a mole of a sample of hydrogen gas at NTP.

(a) The volume of the gas is exactly 2.24×10^{-2} m^3.
(b) The volume of the gas is approximately 2.24×10^{-2} m^3.
(c) The gas will be in thermal equilibrium with 1 mole of oxygen gas at NTP.
(d) The gas will be in thermodynamic equilibrium with 1 mole of oxygen at NTP.

50) A particle moves in one dimension in a conservative force field. The potential energy is depicted in the graph below.



If the particle starts to move from rest from the point A, then
(a) the speed is zero at the points A and E.
(b) the acceleration vanishes at the points A, B, C, D, E.
(c) the acceleration vanishes at the points B, C, D.
(d) the speed is maximum at the point D.

PART B **Marks - 60**

All questions are compulsory. **All questions carry equal marks.**

1) (a) A conductor having resistance R (independent of temperature) and thermal capacity C is initially at temperature T_0 same as that of the surrounding. At time $t = 0$ it is connected to a source with constant voltage V. The thermal power dissipated by the conductor to the surrounding varies as $q = k\,(T - T_0)$. Determine the temperature T of the conductor at any time t and at the time $t = \frac{C}{k}$.

(b) A particle moves rectilinearly in an electric field $E = E_0 - ax$ where a is a positive constant and x is the distance from the point where the particle is initially at rest. Let the particle have a specific charge $\frac{q}{m}$. Find (I) the distance covered by the particle till the moment at which it once again comes to rest, and (II) acceleration of the particle at this moment.

2) One mole of an ideal gas ($\gamma = 1.4$) with initial pressure of 2 atm and temperature of 57°C is taken to twice its volume through different processes that include isothermal, isobaric and adiabatic processes. Determine the process where maximum work is done and the amount of work in this case. By what percentage is this work larger than the work done in a process in which it is the least?

3) A railway carriage of mass M_c filled with sand of mass M_s moves along the rails. The carriage is given an impulse and it starts with a velocity v_0. At the same time it is observed that the sand starts leaking through a hole at the bottom of the carriage at a constant mass rate λ. Find the distance at which the carriage becomes empty and the velocity attained by the carriage at that time. (Neglect the friction along the rails.)

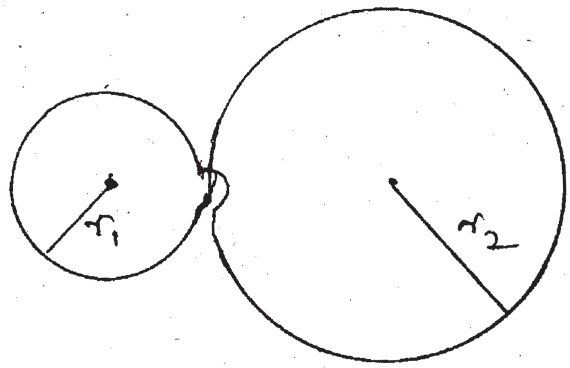
4) Show that, for any angle of incidence on a prism

$$\frac{\sin\frac{1}{2}(A+\delta)}{\sin\frac{1}{2}(A)} = \mu\,\frac{\cos\frac{1}{2}(r_1 - r_2)}{\cos\frac{1}{2}(i - e)}$$

(symbols have usual meanings)
and that the right-hand side reduces to at minimum deviation

5 (a) A small amount of solution containing Na^{24} nuclides with activity 20500 disintegrations per second was injected in the blood stream of a person. The activity of 1 ml of blood sample taken after 5 hours later, was found to be 20 disintegration per minute. The half life of the radioactive nuclides is 15 hours. Find the total volume of the blood of this person.

(b)The wire loop shown in the figure lies in uniform magnetic induction $B = B_0 \cos \omega t$ perpendicular to its plane. (Given $r_1 = 10$ cm and $r_2 = 20$ cm , B_0= 20mT and $\omega = 100\pi$) Find the amplitude of the current induced in the loop if its resistance is 0.1 Ω/m



x-x-x-x-x-x-x-x-x-x-x

Physical constants you may need -----

1. Charge on electron $e = 1.6 \times 10^{-19}$ C
2. Mass of electron $m_e = 9.1 \times 10^{-31}$ kg
3. Universal gravitational constant $G = 6.67 \times 10^{-11}$ Nm^2/kg^2
4. Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N\,m^2$
5. Gas constant R= 8.31 J/ K mol
6. Planck constant $h = 6.62 \times 10^{-34}$ Js
7. Stefan constant $\sigma = 5.67 \times 10^{-8}$ $W/m^2 K^4$
8. Boltzman constant $k = 1.38 \times 10^{-23}$ J/K
