HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION

2019 MOCK EXAMINATION

PHYSICS PAPER 1

8.30 am – 11.00 am (2 hours 30 minutes)

This paper must be answered in English

GENERAL INSTRUCTIONS

1. There are **TWO** sections, A and B, in this Paper. You are advised to finish Section A in about 50 minutes.

2. Section A consists of multiple-choice questions in this question paper, while Section B contains conventional questions printed separately in Question-Answer Book **B**.

3. Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in Question-Answer Book **B**. **The Answer Sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.**

4. The diagrams in this paper are **NOT** necessarily drawn to scale.

5. The last pages of this question paper contain a list of data, formulae and relationships which you may find useful.

INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

1. Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first stick a barcode label and insert the information required in the spaces provided. No extra time will be given for sticking on the barcode label after the 'Time is up' announcement.

2. When told to open this book, you should check that all the questions are there. Look for the words **'END OF SECTION A'** after the last question.

3. All questions carry equal marks.

4. **ANSWER ALL QUESTIONS.** You are advised to use an HB pencil to mark all the answers on Answer Sheet, so that wrong marks can be completely erased with a certain rubber. You must mark the answers clearly, otherwise you will lose marks if the answers cannot be captured.

5. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

6. No marks will be deducted for wrong answers.

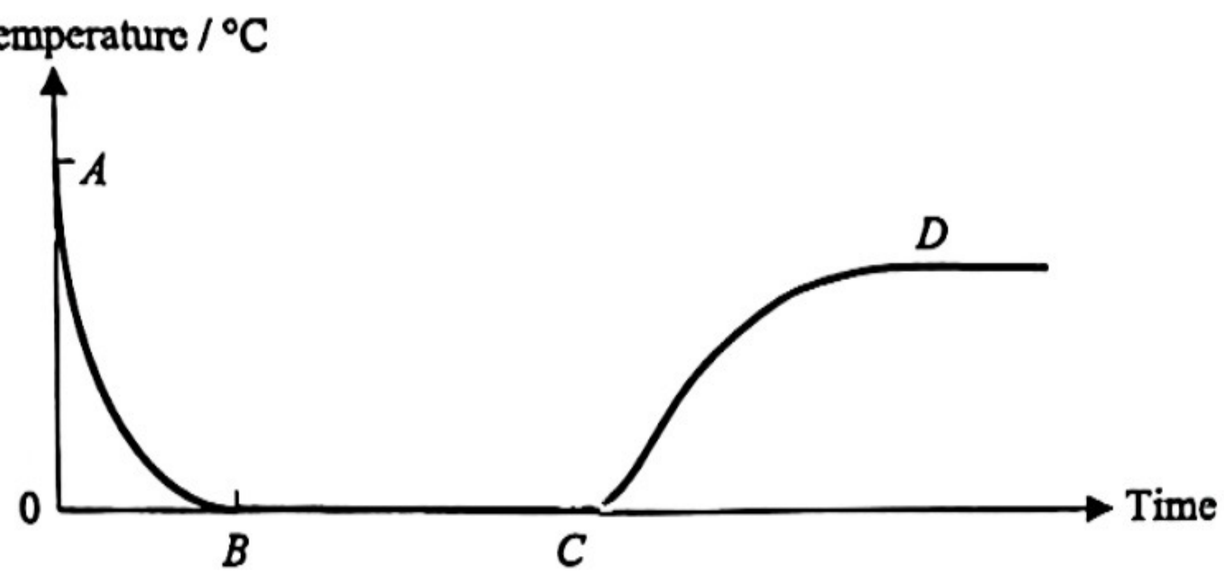
Section A

There are 33 questions.

1. A heater with a power of 250 W is used to heat 0.5 kg of a liquid which has a specific heat capacity of 2350 J kg^{-1} $°C^{-1}$. After 2 minutes, the temperature rise of the liquid is found to be 18°C. Neglect the heat capacity of the container, find the energy loss to the surroundings.

A. 4460 J
B. 5380 J
C 6400 J
D 8850 J

2.



At time $t = 0$, Peter adds several ice cubes at 0°C into a cup of warm water. The temperature-time graph of the water is shown in the Figure above. Which of the following statements is/are correct ?

(1) During time interval *AB*, the ice releases latent heat to the warm water.
(2) During time interval *BC*, the water absorbs latent heat from the surroundings.
(3) At instant *D*, the water reaches the temperature of surroundings.

A. (1) only
B (3) only
C. (1) and (2) only
D. (2) and (3) only

3.

Two identical vessels *X* and *Y* contain the same type of ideal gas. The pressure of gas inside *X* and *Y* are 240 kPa and 180 kPa respectively. The temperature of gas in *X* is 60°C. If the ratio of the number of mole of gas in *X* to that in *Y* is 5 : 4, calculate the temperature of gas in *Y*.

A 39°C
B. 53°C
C. 76°C
D. 88°C

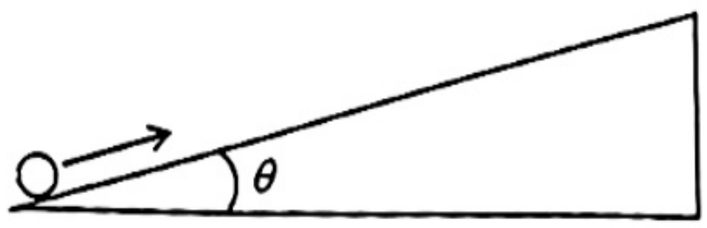
4. An ideal gas is at a temperature of 100 °C. If the mass of each gas molecule is 4.65×10^{-26} kg, find the r.m.s. speed of the gas molecules.

A. 528 m s^{-1}
B. 495 m s^{-1}
C 576 m s^{-1}
D. 616 m s^{-1}

5. Car A and truck B are travelling on a horizontal straight road in the same direction. Car A travels with a velocity of 15 m s^{-1} while truck B travels with 20 m s^{-1}. At a certain instant, car A lags behind truck B by 50 m. Car A then accelerates with 2 m s^{-2} and truck B maintains with uniform velocity of 20 m s^{-1}. How long does it need for A to overtake B ?

A. 5 s
B 8 s
C. 10 s
D. 15 s

6.



A small particle is projected upwards with an initial velocity of 12 m s^{-1} along a smooth inclined plane making an angle of θ with the horizontal. The particle moves up to the highest point and then returns to the original position after 3.6 s. Air resistance is assumed negligible. Find the angle θ.

A. 23.6°
B 34.2°
C. 42.8°
D. 47.2°

7. A boy of mass 40 kg is standing on a balance inside a lift. The lift is moving down from his home to the ground level. What is the balance reading during the time when the lift decelerates with 1.5 m s^{-2} to rest ? Take g to be 10 m s^{-2}.

A. 34 kg
B. 46 kg
C. 340 N
D 460 N

8.

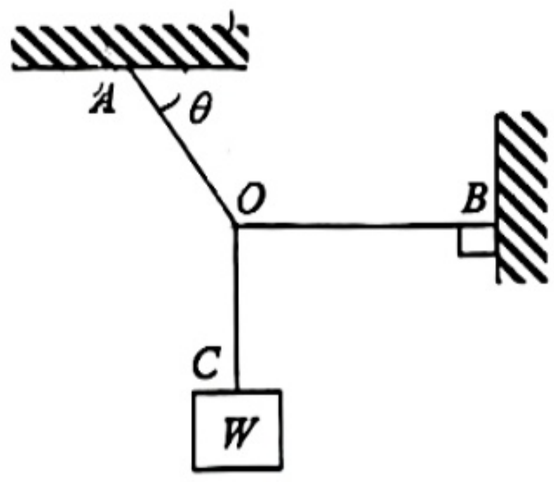


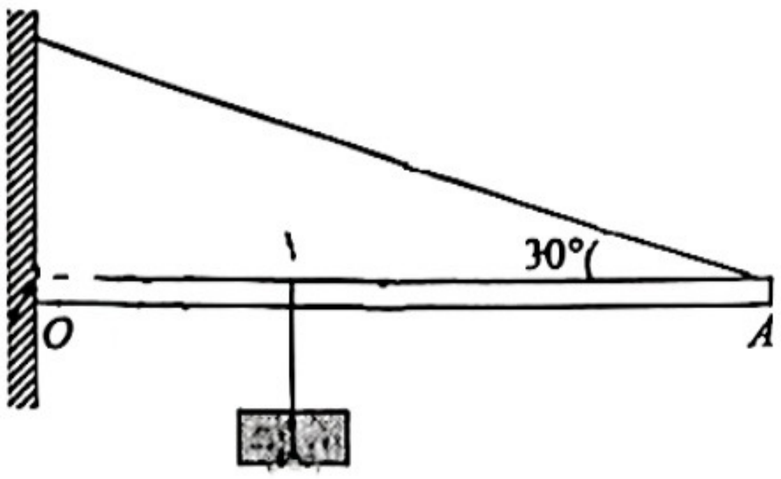
Diagram not drawn to scale

A body of weight W is suspended by three light strings OA, OB and OC as shown in the figure. String OA makes an angle θ with the horizontal while OB is horizontal. If the point A attached to the ceiling is now moved slightly towards the left so that the angle θ decreases, which of the following statements are correct ?

(1) Tension along OA must increase.
(2) Tension along OB must increase.
(3) Tension along OB must be greater than W.

A (1) and (2) only
B (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

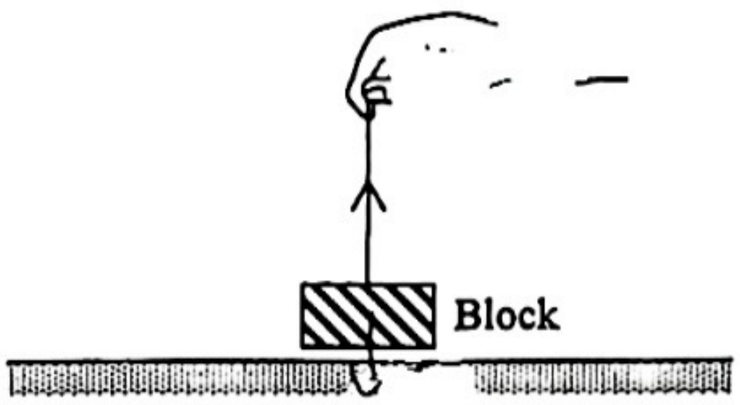
9.



A light rigid rod OA of length 80 cm is hinged to a wall at the end O. A weight of 24 N is attached to the point X where OX is equal to 30 cm. A light string is attached to the end A so that the string makes an angle of 30° with the rod. The rod remains horizontal. Calculate the reaction force acting on the rod by the wall.

A. 15.6 N
B. 18.0 N
C. 21.6 N
D. 22.5 N

10.

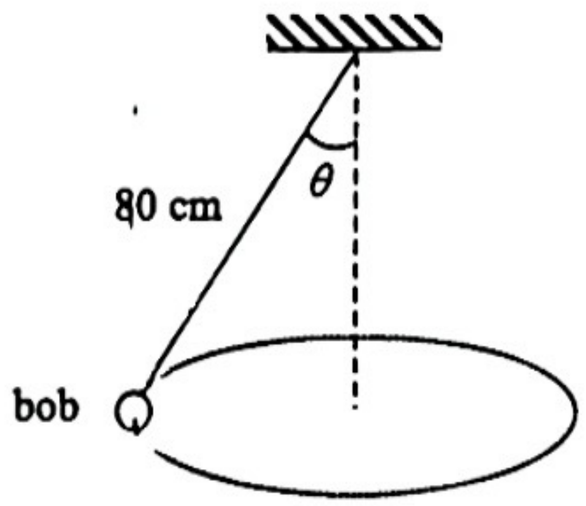


A block of mass 5 kg is initially at rest on the ground. A boy applies a force of 60 N to pull the block vertically upwards as shown to a height of 4 m within 2 s. Take the acceleration due to gravity be 10 m s^{-2} and neglect air resistance. Which of the following statements is/are correct ?

(1) Work done by the boy is equal to the gain of potential energy of the block.
(2) The power developed by the boy increases throughout the motion of upward pulling.
(3) The average power developed by the boy during these 2 s is 120 W.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

11.



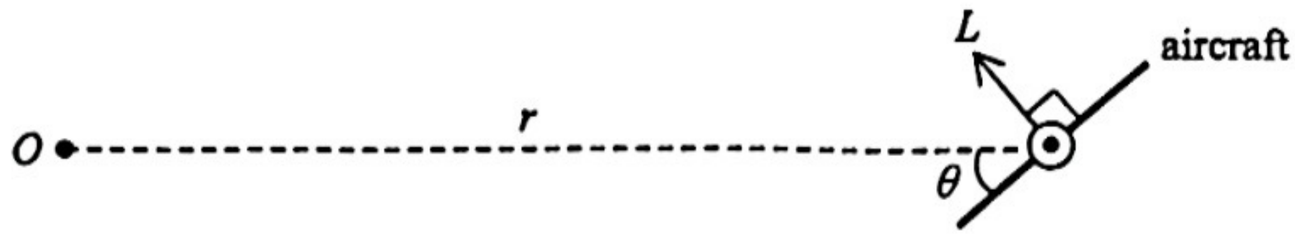
A bob of mass 750 g is connected to an inextensible string of length 80 cm. Find the angle θ of the string made with the vertical if the bob is swirled to perform horizontal circular motion with an angular speed of 4.5 rad s^{-1} as shown in the figure. Neglect air resistance.

A. 37.3°
B. 42.5°
C. 52.7°
D. 66.8°

12. A plasticine of mass 0.2 kg is released from rest at a height of 0.8 m above the ground. After a short duration of impact of 0.1 s with the ground, it comes to rest and sticks to the ground. What is the average force acting on the plasticine by the ground during the impact ? Take the acceleration due to gravity be 10 m s $^{-2}$.

A. 0 N
B 8 N
C. 10 N
D. 18 N

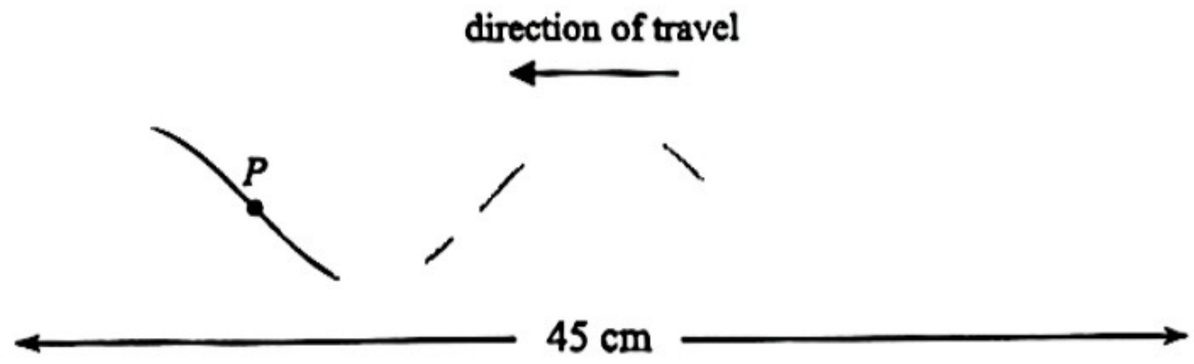
13.



An aircraft flies with a constant speed v in a horizontal circle with a radius r about the centre O as shown above. The aircraft tilts at an angle θ to the horizontal. The lift force L is always perpendicular to the two wings of the aircraft. Which of the following expressions is equal to the centripetal force acting on the aircraft ?

A. $mg \sin\theta \tan\theta$
B. $mg \sin\theta \cos\theta$
C. $mg \dfrac{\sin\theta}{\cos\theta}$
D. $mg \dfrac{\cos\theta}{\sin\theta}$

14.



The above figure an instant of the waveform of a transverse wave travelling towards the left. At this instant, particle P is at the equilibrium position. After 0.6 s, particle P reaches the crest position. What is the speed of the wave ?

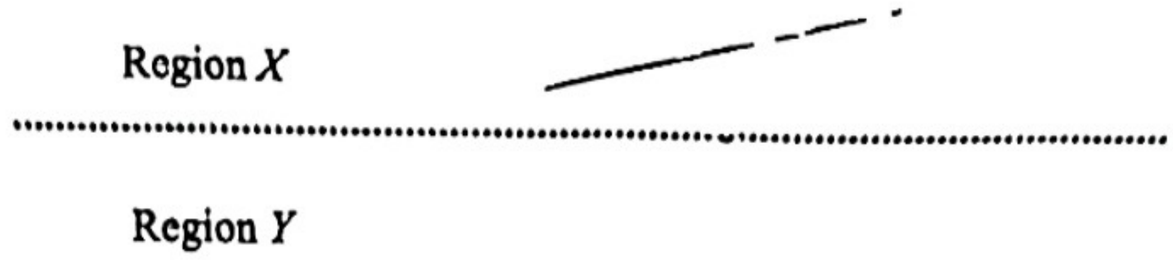
A. 7.5 cm s^{-1}
B. 15.0 cm s^{-1}
C. 22.5 cm s^{-1}
D. 30.0 cm s^{-1}

15. Two loudspeakers connected to the same signal generator acts as two coherent sources to give sound of adjustable frequency. The speed of sound in air is 324 m s $^{-1}$. At a certain point P, the distance from one loudspeaker is 2.4 m while the distance from another loudspeaker is 3.6 m. Which of the following frequencies can give a sound of minimum at point P ?

(1) 405 Hz
(2) 540 Hz
(3) 675 Hz

A. (1) and (2) only
B (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

16.



Plane water waves travels continuously from region X to region Y. The above figure shows one pulse in region X and one pulse in region Y. Which of the following deductions is/are correct ?

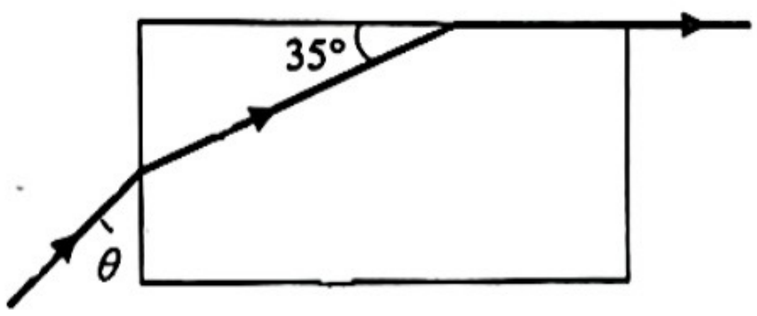
(1) Region X is a shallow region and region Y is a deep region.
(2) The waves bend towards the normal when it travels from X to Y
(3) The wavelength of water waves in region Y is greater than that in region X.

A (1) and (2) only
B (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

17. An object is placed 24 cm in front of a convex lens. An image magnified two times is formed by the lens. Find the focal length of the convex lens if the image is (1) real ; and (2) virtual.

	image is real	**image is virtual**
A.	f = 12 cm	f = 16 cm
B.	f = 12 cm	f = 48 cm
C	f = 16 cm	f = 36 cm
D	f = 16 cm	f = 48 cm

18.



A ray of light enters a rectangular block and travels along the path as shown in the above figure. Find the angle θ.

A. 38.5°
B. 44.4°
C. 45.6°
D. Insufficient information

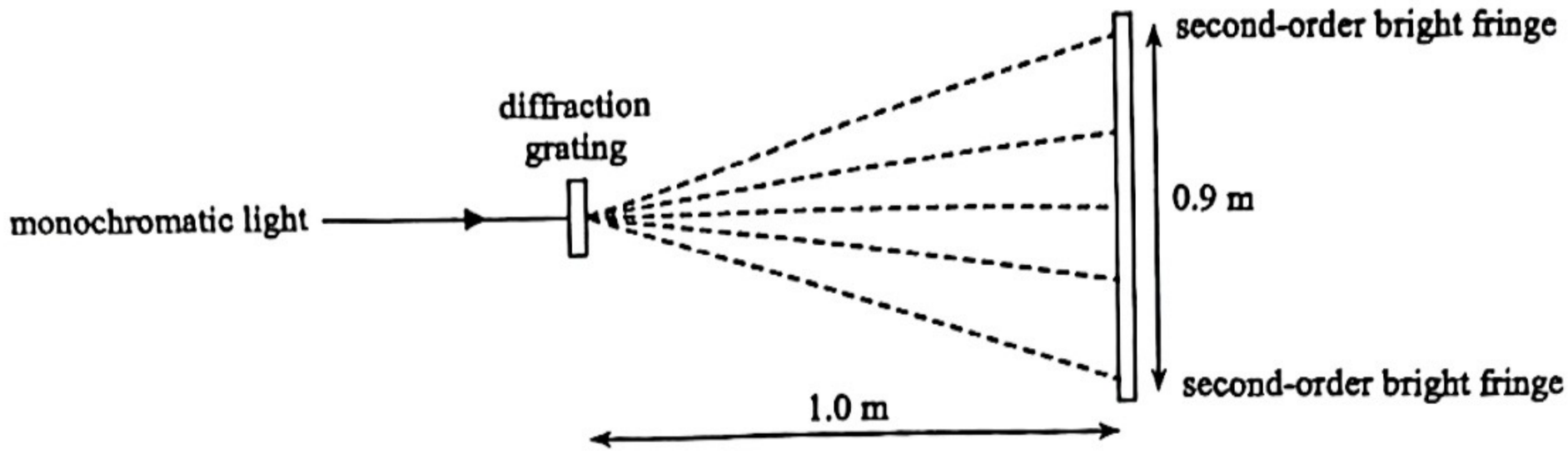
19. Compare the frequency of the following waves :

f_1 microwaves in a microwave oven
f_2 an audible sound
f_3 light emitted from a red flower

The frequency arranged in **ascending** order is

A. $f_1 < f_2 < f_3$
B. $f_1 < f_3 < f_2$
C. $f_2 < f_1 < f_3$
D. $f_2 < f_3 < f_1$

20.



A beam of monochromatic light is incident onto a diffraction grating of 3000 lines per cm. A screen placed at 1.0 from the grating captures 5 bright fringes. The two second-order bright fringes are separated at 0.9 m on the screen. Determine the wavelength of the incident light.

A. 4.57×10^{-7} m
B. 5.52×10^{-7} m
C. 6.27×10^{-7} m
D. 6.84×10^{-7} m

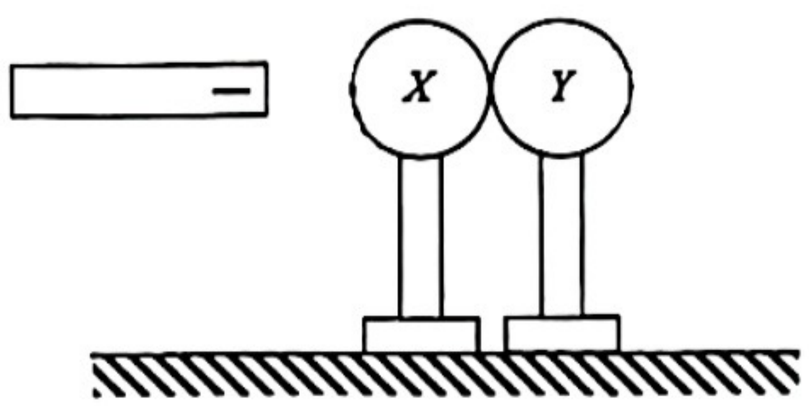
21. Which of the following statements about light and sound is correct ?

A. Both light and sound bends towards the normal when they travel from air to water.
B. Both light and sound belong to mechanical waves.
C. Both light and sound can form stationary waves.
D. Both light and sound can travel in vacuum.

22. *A* and *B* are two small metal spheres with the same size. *A* carries a charge of + 8 μC and *B* carries a charge of – 2 μC. When they are separated at a distance of 2 cm, the electrostatic force between them is F_1. If now they are brought to touch and then separated at a distance of 1 cm, the electrostatic force between them is F_2. Find the ratio $F_1 : F_2$.

A. 2 : 3
B. 4 : 9
C. 9 : 4
D. 16 : 9

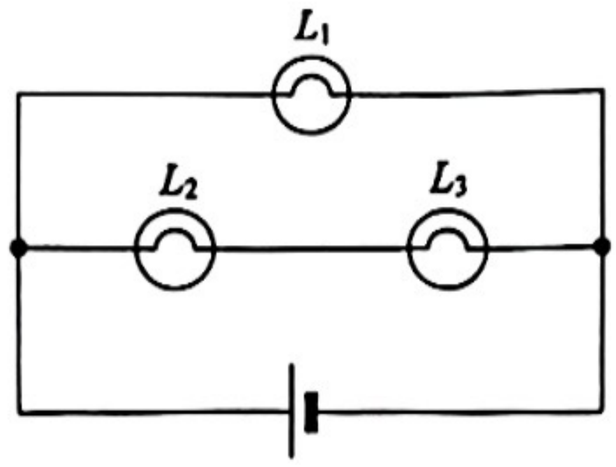
23.



Two insulated uncharged metal spheres *X* and *Y* are placed in contact. A negatively-charged rod is brought near *X* as shown. *X* is then touched by a finger momentarily and the charged rod is removed. The two spheres are then separated away from each other. Which of the following describes the charges on *X* and *Y* ?

	sphere *X*	sphere *Y*
A.	uncharged	uncharged
B.	uncharged	negative
C	positive	uncharged
D	positive	positive

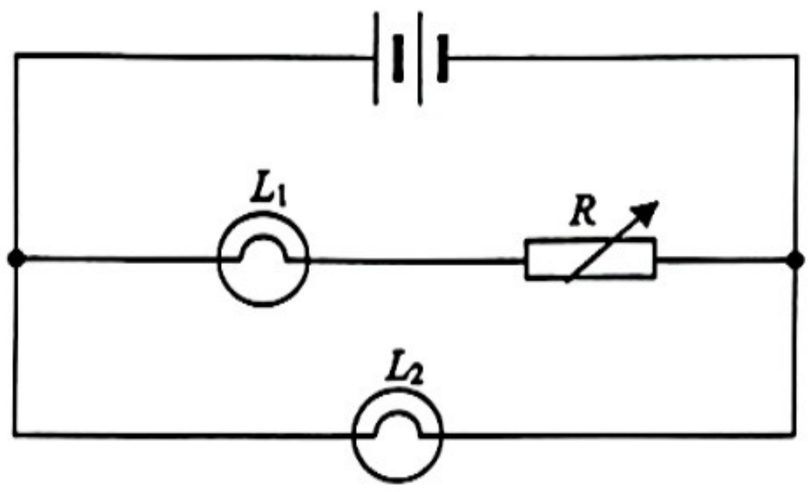
24.



In the above circuit, the three light bulbs give out the same amount of power. If the resistance of L_1 is 20 Ω, what is the resistance of L_2 ?

A 5 Ω
B. 10 Ω
C. 40 Ω
D 80 Ω

25.

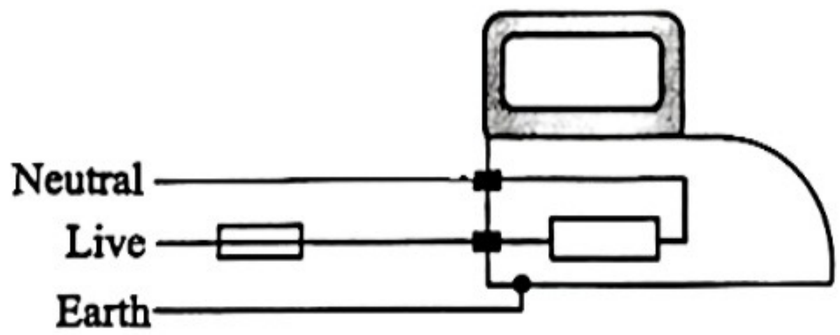


In the above circuit, a battery of negligible internal resistance is connected to two light bulbs L_1, L_2 and a rheostat R. If the resistance of the rheostat is slightly decreased, which of the following statements is correct ?

(1) The current delivered by the battery increases.
(2) The brightness of L_1 decreases.
(3) The brightness of L_2 increases.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

26.



The above figure shows a simplified domestic circuit for an electric iron. When the neutral wire accidentally touches the metal case, which of the followings may happen ?

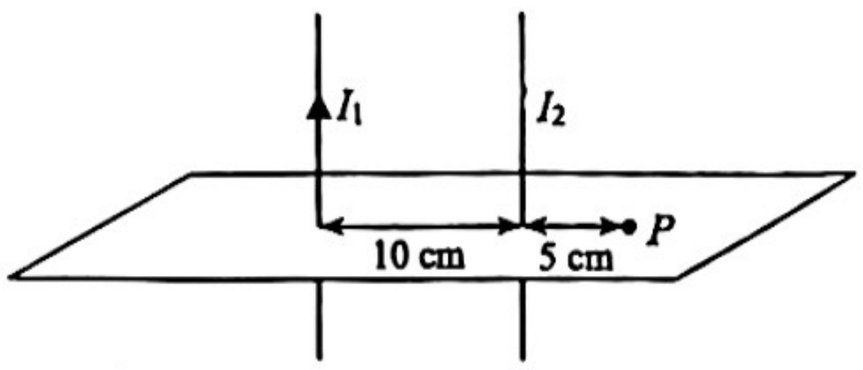
(1) The electric iron stops working.
(2) The fuse will blow.
(3) The current in the neutral wire will be different from that in the live wire.

A. (1) only
B (3) only
C. (1) and (2) only
D. (2) and (3) only

27. A beam of electrons travel perpendicularly into a region of uniform magnetic field of 1.25 mT. If the radius of the circular path performed by the beam of electrons is 5 cm, what is the speed of the electrons ?

A. 1.1×10^7 m s^{-1}
B 2.4×10^7 m s^{-1}
C. 3.5×10^7 m s^{-1}
D. 4.8×10^7 m s^{-1}

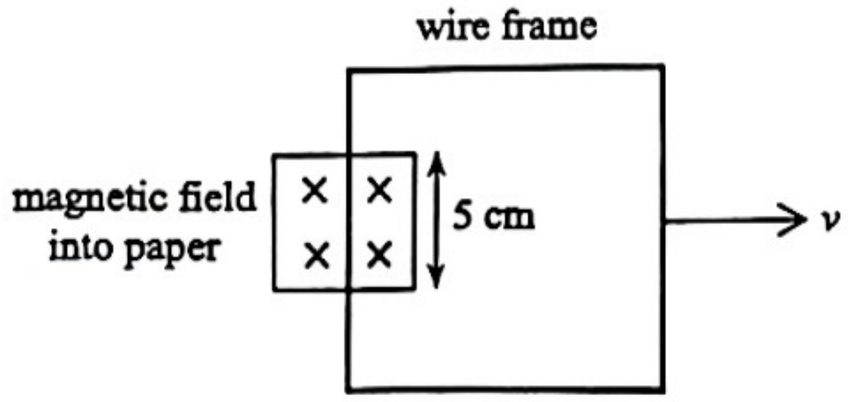
28.



Two parallel long wires carrying currents I_1 and I_2 with separation 10 cm are shown in the above figure. P is the neutral point and it is at 5 cm from I_2. If the current I_1 is equal to 2.4 A and flows in upward direction, what is the magnitude and direction of current I_2.

	magnitude	direction
A	0.8 A	upwards
B	0.8 A	downwards
C.	1.6 A	upwards
D.	1.6 A	downwards

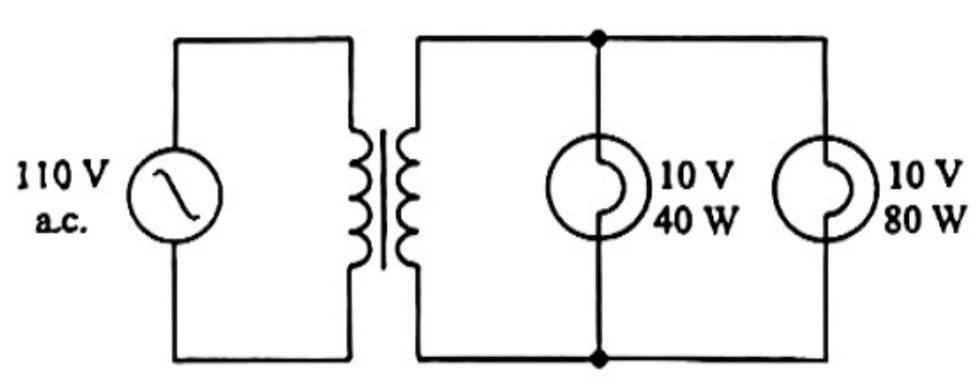
29.



A square wire frame is moving across a uniform magnetic field within a square region of length 5 cm as shown in the above figure. The direction of the magnetic field is perpendicularly into paper and the magnitude of the magnetic field is 0.2 T. If the wire frame is moving with a velocity of 2 m s^{-1}, which of the following statements is NOT correct ?

A. The magnitude of the induced e.m.f. is 0.02 V.
B. The induced e.m.f. depends on the resistance of the wire frame.
C. The induced current in the wire frame flows in clockwise direction.
D. There is a magnetic force acting on the wire frame in leftward direction.

30.



The efficiency of the above transformer is 80%. If the two lamps are working normally, find the primary current.

A. 1.09 A
B. 1.13 A
C. 1.28 A
D 1.36 A

31. A radioactive source has a half-life of 2 hours. A counter placed near the source registers an initial count rate of 500 c.p.m. After two hours, the count rate drops to 298 c.p.m. What is the count rate after one more hour ?

A 148 c.p.m.
B 185 c.p.m.
C. 228 c.p.m.
D. 248 c.p.m.

32. A sample of Co-60 has a mass of 5×10^{-6} g. If the half-life of Co-60 is 5.3 years, find the activity of the sample. Given that the molar mass of Co-60 is 60 g.

A. 5.63×10^{6} Bq
B 8.12×10^{6} Bq
C 2.08×10^{8} Bq
D 4.46×10^{8} Bq

33. A star radiates energy by nuclear fusion process. The mass of the star decreases at a rate of 5×10^{10} kg per day. Estimate the radiation power emitted by the star.

A. 1.3×10^{22} W
B. 5.2×10^{22} W
C. 1.3×10^{24} W
D. 5.2×10^{24} W

End of Section A

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
speed of light in vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
charge of electron	$e = 1.60 \times 10^{-19}\ \text{C}$
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
atomic mass unit	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$ (1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$

Rectilinear motion

For uniformly accelerated motion :

$$v = u + at$$

$$s = ut + \tfrac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \tfrac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radian)

Astronomy and Space Science

$U = -\dfrac{GMm}{r}$	gravitational potential energy
$P = \sigma A T^4$	Stefan's law
$\left\|\dfrac{\Delta f}{f_0}\right\| \approx \dfrac{v}{c} \approx \left\|\dfrac{\Delta\lambda}{\lambda_0}\right\|$	Doppler effect

Energy and Use of Energy

$E = \dfrac{\Phi}{A}$	illuminance
$\dfrac{Q}{t} = k\dfrac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \dfrac{k}{d}$	thermal transmittance U-value
$P = \dfrac{1}{2}\rho A v^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e v_{max}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\dfrac{13.6}{n^2}\text{eV}$	energy level equation for hydrogen atom
$\lambda = \dfrac{h}{p} = \dfrac{h}{mv}$	de Broglie formula
$\theta \approx \dfrac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \dfrac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \dfrac{1}{f}$	power of a lens
$L = 10\log\dfrac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \dfrac{I_1}{I_0} = \dfrac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	

transmitted intensity through a medium

A1.	$E = mc\Delta T$	energy transfer during heating and cooling
A2.	$E = l\Delta m$	energy transfer during change of state
A3.	$pV = nRT$	equation of state for an ideal gas
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation
A5.	$E_k = \frac{3RT}{2N_A}$	molecular kinetic energy

B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force
B2.	moment $= F \times d$	moment of a force
B3.	$E_p = mgh$	gravitational potential energy
B4.	$E_k = \frac{1}{2}mv^2$	kinetic energy
B5.	$P = Fv = \frac{W}{t}$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation

C1.	$\Delta y = \frac{\lambda D}{a}$	fringe width in double-slit interference
C2.	$d\sin\theta = n\lambda$	diffraction grating equation
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens

D1.	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
D5.	$R = R_1 + R_2$	resistors in series
D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D7.	$P = IV = I^2R$	power in a circuit
D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D13.	$\frac{V_s}{V_p} = \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer

E1.	$N = N_0e^{-\lambda t}$	law of radioactive decay
E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$E = mc^2$	mass-energy relationship

Hong Kong Diploma of Secondary Education Examination

2019

Mock Examination

PHYSICS PAPER 1

SECTION B : Question-Answer Book B

This paper must be answered in English

INSTRUCTIONS FOR SECTION B

(1) After the announcement of the start of the examination, you should first write you Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided.

(2) Refer to the general instructions on the cover of the Question Paper for Section A.

(3) Answer **ALL** questions.

(4) Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.

(5) Graph paper and supplementary answer sheets will be provided on request. Write your candidate number, mark the questions box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

(6) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

Please stick the barcode label here.

Candidate Number

Question No.	Marks
1	6
2	6
3	11
4	9
5	6
6	6
7	7
8	6
9	9
10	8
11	10

Section B : Answer ALL questions. Write your answers in the spaces provided.

1. A beaker contains hot milk of mass 500 g at a temperature of 80°C. In order to lower the temperature of the milk, Jack takes out 150 g of ice cubes from the refrigerator. The temperature of the ice cubes is known to be – 10 °C.

   Given : specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}
   specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
   specific heat capacity of ice = 2140 J kg^{-1} °C^{-1}
   specific heat capacity of milk = 3900 J kg^{-1} °C^{-1}

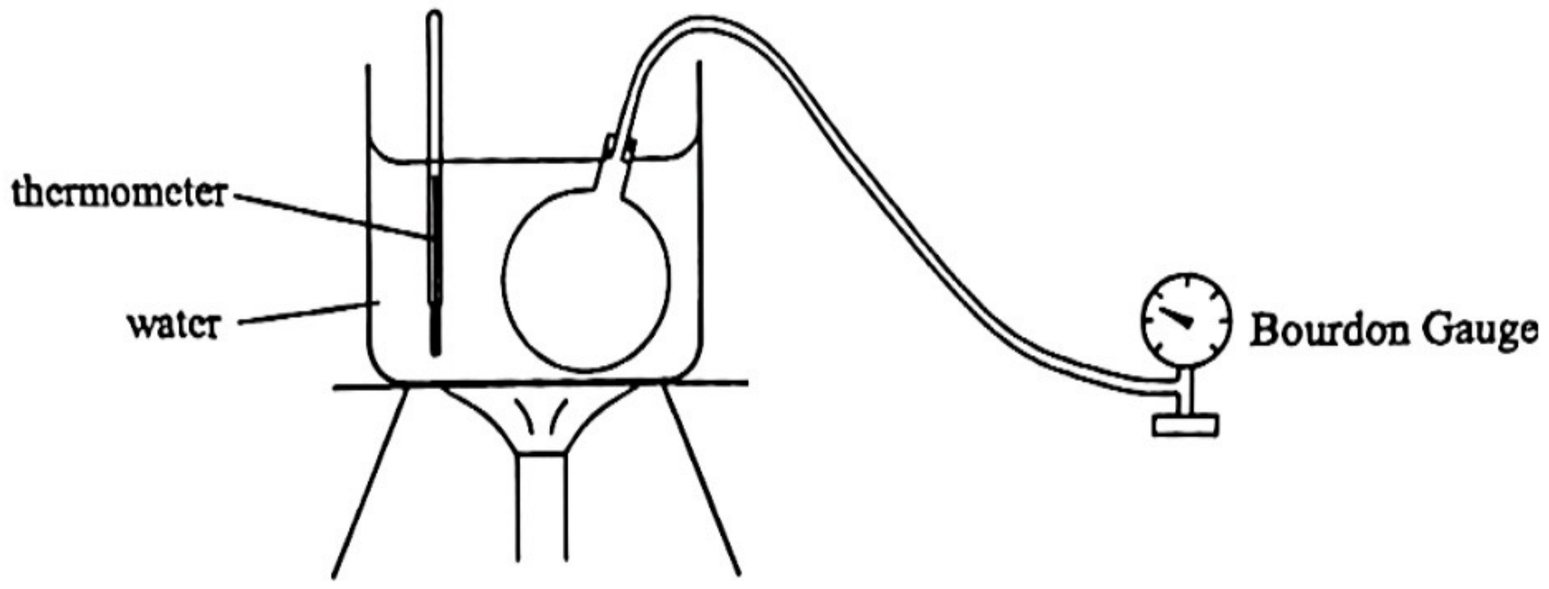
   (a) Calculate the total amount of heat absorbed when the ice cubes at – 10 °C changes to 0 °C of water. (2 marks)

   (b) If all the ice cubes are put into the beaker containing the hot milk, using the result in part (a), calculate the final temperature of the mixture. Neglect the heat exchange with the surroundings. (2 marks)

   (c) Take into the account of the heat capacity of the beaker, explain whether the actual temperature of the mixture be higher or lower than the value found in part (b). (2 marks)

Answers written in the margins will not be marked.

2. The figure shows an experiment to find the variation of pressure of air inside a gas flask with temperature. The pressure P and the temperature θ are measured by Bourdon Gauge and thermometer respectively.



Some of the results are shown in the table below :

Temperature θ / °C	36		80
Pressure P / kPa	109		124

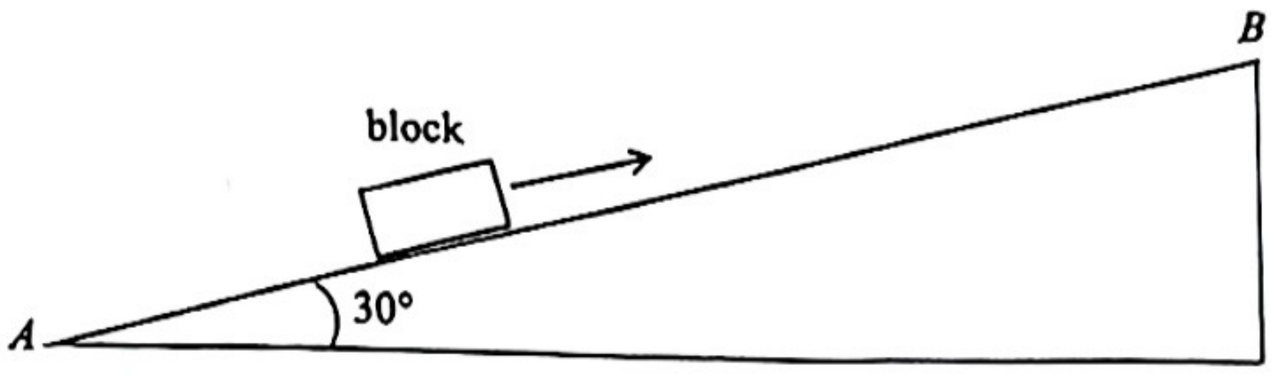
(a) From the above data, determine the absolute zero of temperature. (2 marks)

(b) If the volume of the gas flask is 480 cm^3, calculate the number of mole of air inside the gas flask. (2 marks)

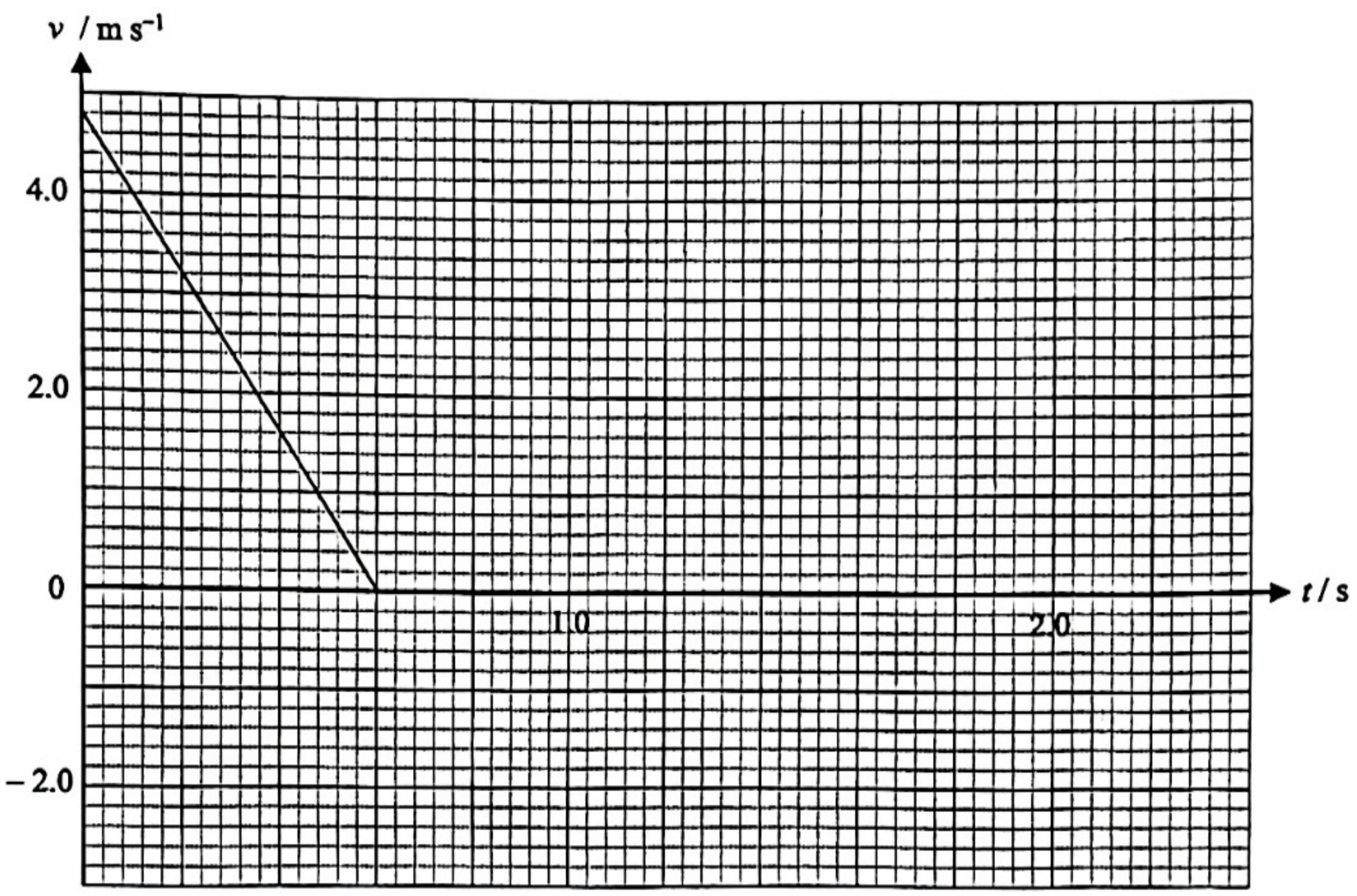
(c) By using Kinetic Theory, explain how the gas molecules inside the gas flask exerts a pressure. (2 marks)

Answers written in the margins will not be marked.

3.



A small block of mass 0.5 kg is projected upwards from A with an initial velocity of 4.8 m s^{-1} along a rough inclined plane making an angle of 30° with the horizontal. The block just reaches the highest point B as shown in the above figure. The variation of the velocity v of the block with time t is shown below. Air resistance is assumed negligible. Take g to be 10 m s^{-2}.



(a) Draw and name all the forces acting on the block when it moves from A to B. (2 marks)

(b) Calculate the distance between AB on the inclined plane. (1 mark)

Answers written in the margins will not be marked.

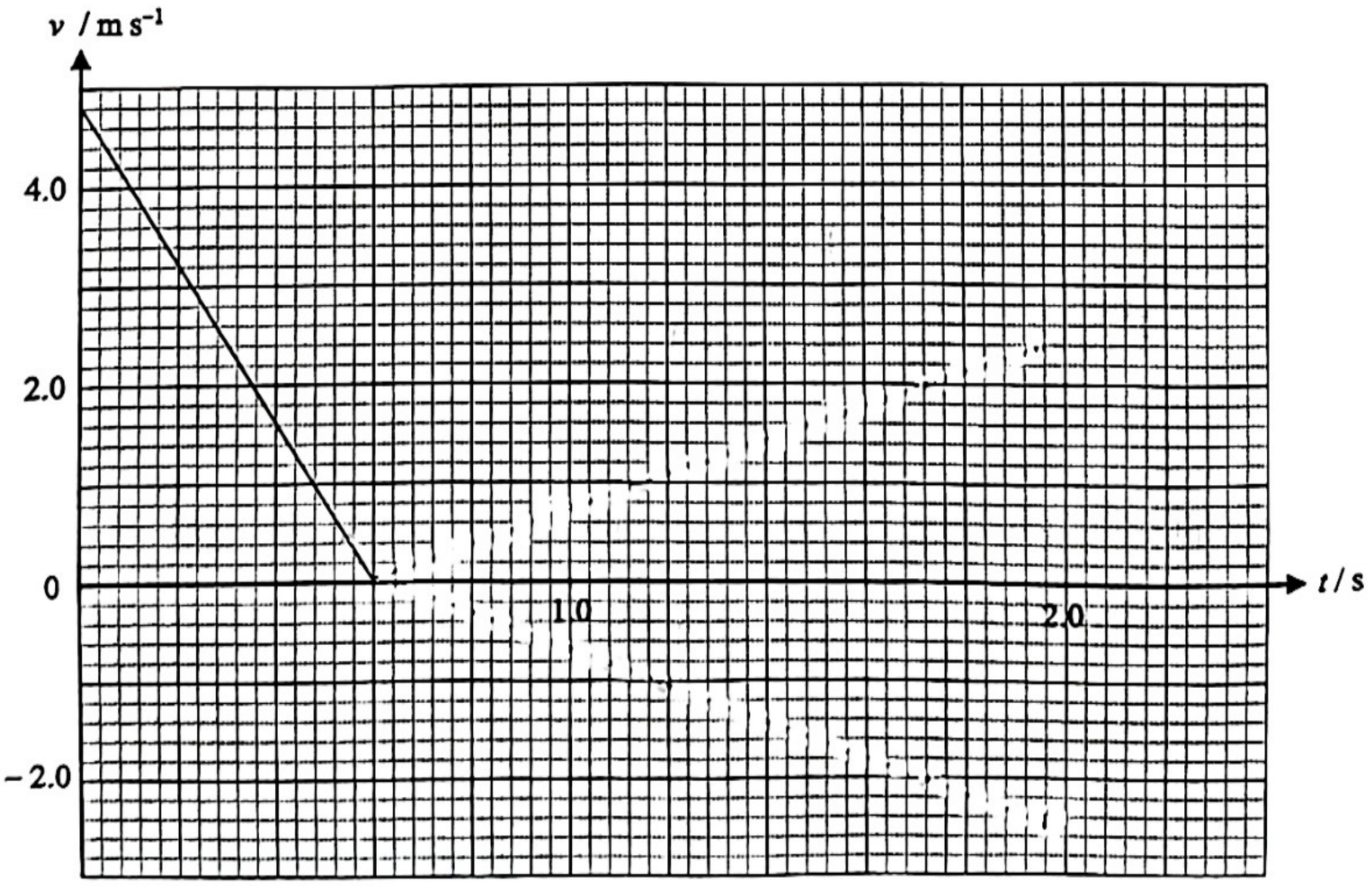
(c) Find the friction acting on the block when it moves from A to B along the inclined plane. (3 marks)

(d) After the block reaches the highest point B, it then moves downwards from B to A.

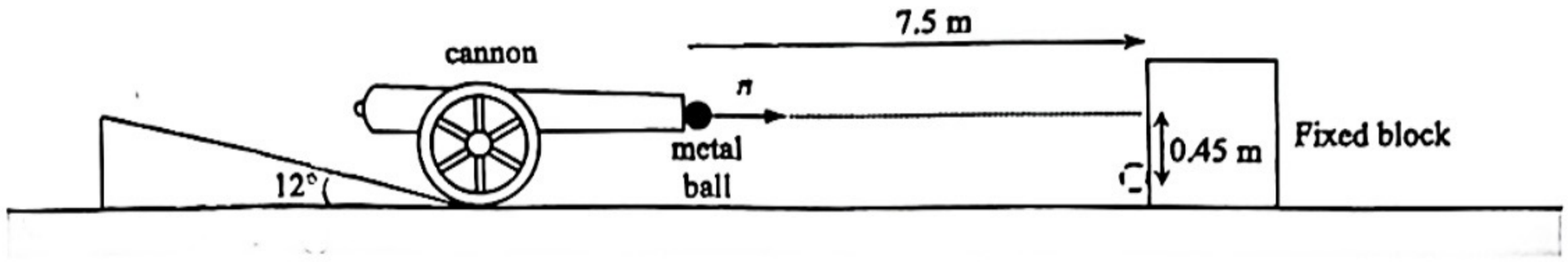
(i) Calculate the acceleration of the block as it moves down along the inclined plane. (2 marks)

(ii) Find the time that it takes to travel from B to A. (2 marks)

(iii) On the velocity-time graph below, draw a line to represent the motion of the block from B to A. (1 mark)



4.



The above figure shows a cannon of mass 400 kg initially at rest. It fires a metal ball of mass 12 kg horizontally towards a fixed block. The ball travels along a parabolic path to hit a fixed block 7.5 m away. It hits the block at a point 0.45 m below the horizontal line of firing as shown in the figure. Assume air resistance is negligible. Take the acceleration due to gravity to be 10 m s $^{-2}$.

(a) Calculate the firing speed u of the metal ball when it just leaves the cannon. (2 marks)

(b) Calculate the kinetic energy of the metal ball when it hits the block. (2 marks)

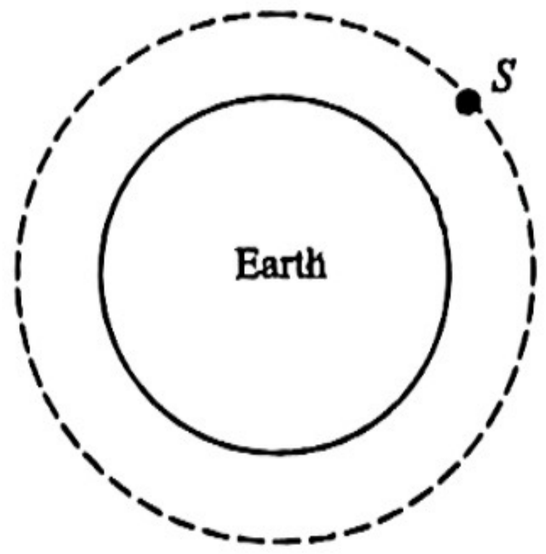
(c) When the ball hits the block, explain whether the total momentum of the ball and the target is conserved. (1 mark)

(d) The cannon recoils as the ball is fired. Calculate the recoil speed of the cannon. (2 marks)

(e) The cannon is just placed at the bottom of a rough plane inclined at 12° to the horizontal as shown in the figure. If the friction between the cannon and the plane is 200 N, how far will the cannon move along the inclined plane ? (2 marks)

Answers written in the margins will not be marked.

5. The radius of the Earth is 6400 km. A space station S is built at a height of 400 km above the Earth's surface orbiting round the Earth in circular motion.



(a) Calculate the acccleration due to gravity at the space station. (2 marks)

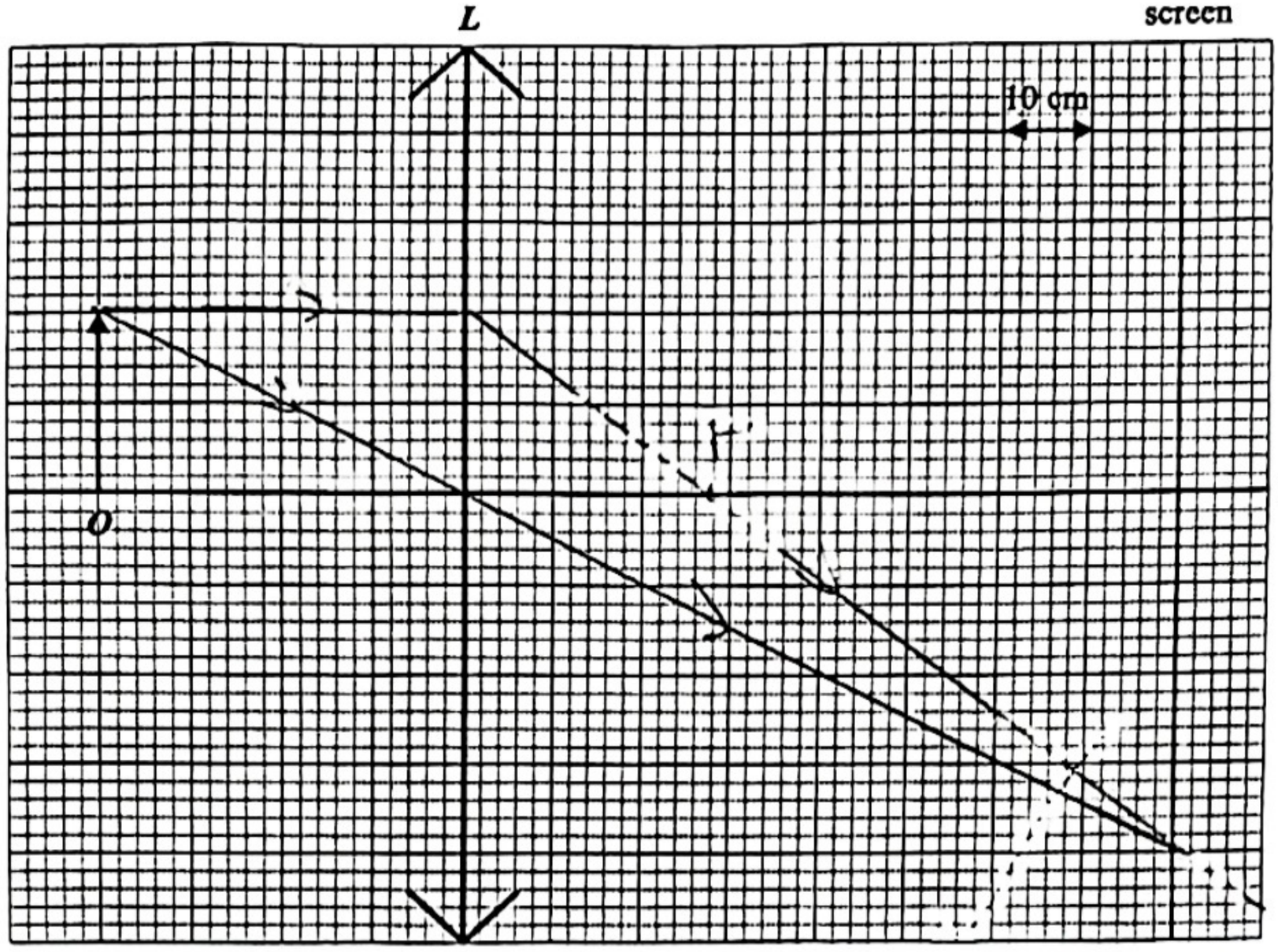
(b) Explain why the centre of the orbit of the space station must be coincide with the centre of the Earth. (1 mark)

(c) Calculate the time taken for the space station to make a complete revolution around the Earth. (2 marks)

(d) Explain why astronauts experience weightlessness in the space station although their weights are not zero. (1 mark)

Answers written in the margins will not be marked.

6.



In the above figure, an object is placed in front of a convex lens. A screen placed at the other side of the lens capture a sharp image onto it.

(a) By drawing suitable rays, draw the image and locate the position of the principal focus in the above figure. (2 marks)

(b) If the object is placed 20 cm in front of the lens, the screen cannot capture any sharp image onto it. Explain the reason. (1 mark)

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(c) Suppose the lens L is now placed by another convex lens of focal length 30 cm. Calculate the magnification of the image. (3 marks)

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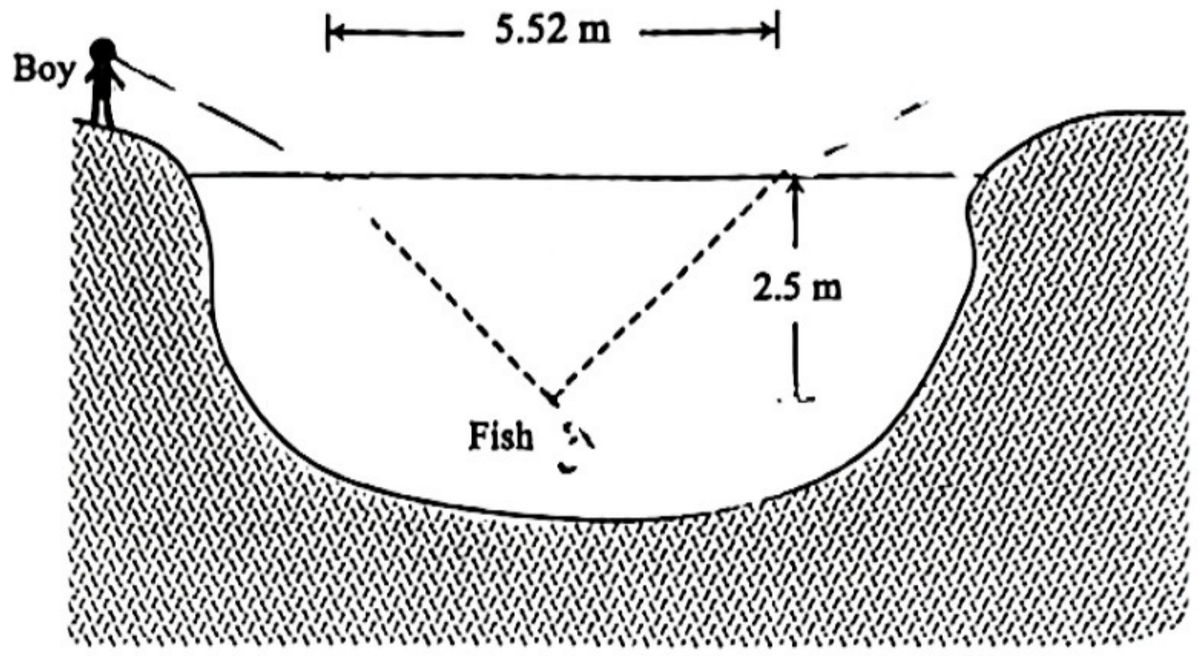
Answers written in the margins will not be marked.

7. (a) A boy is standing beside a small pool as shown in the below figure.



A fish at a depth of 2.5 m looks upwards. The scene above the water surface is compressed into a circular patch of diameter 5.52 m.

(i) In the above figure, draw a light ray to show how the boy can see the fish in water. (1 mark)

(ii) Calculate the critical angle of water. (2 marks)

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(iii) Calculate the refractive index of water. (2 marks)

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(b) Diamond has a refractive index of 2.42, which is much higher than glass of 1.5. Explain why a piece of diamond is more sparkling than a piece of glass of similar shape when light shines onto it. (2 marks)

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Answers written in the margins will not be marked.

8. You are given the following apparatus :

a battery

a piece of nichrome wire

an ammeter

a voltmeter

a switch

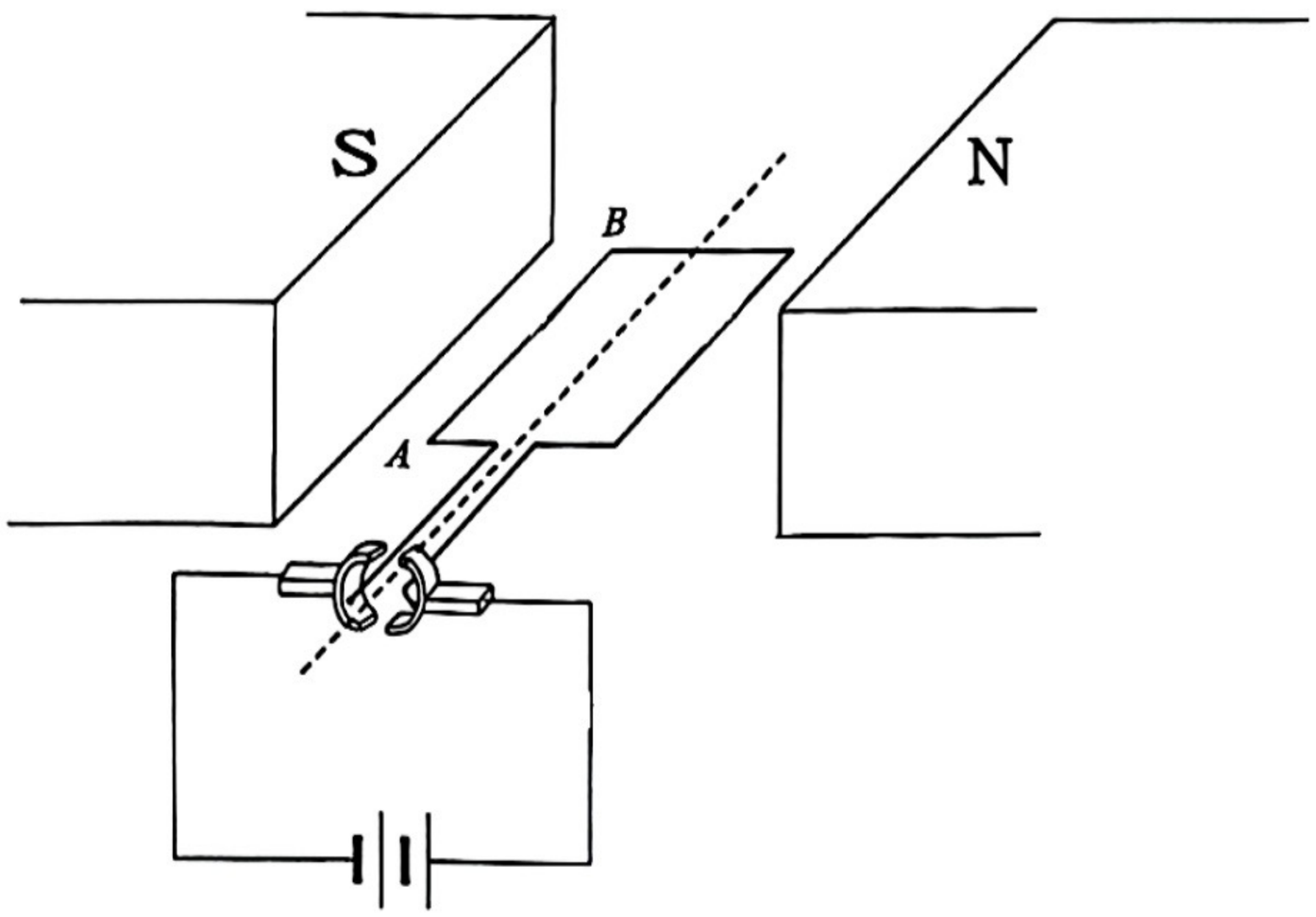
a rheostat

connecting wires

Using the apparatus provided, describe the procedure of an experiment to show that the nichrome wire obey Ohm's Law. Your description should include the connection of circuit, the physical quantities to be measured, and the result expected. State ONE precaution in the experiment. (6 marks)

Answers written in the margins will not be marked.

9. The figure below shows a simplified structure of a motor with the plane of coil at horizontal position. A battery of 3 V supplies current to the coil via a commutator. The strength of the magnetic flux density at the coil is 0.6 T. The resistance of the coil is 10 Ω and the coil has 50 turns (not shown in the figure).



(a) State the direction of magnetic force (upwards or downwards) acting on side *AB* of the coil. (1 mark)

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(b) The length of *AB* is 8 cm. Calculate the magnetic force acting on the side *AB* of the coil. (2 marks)

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(c) State the change of the magnitude of the magnetic force on *AB* when the plane of coil makes an angle 30° with the direction of the magnetic field lines. (1 mark)

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(d) State the importance of the commutator in the motor. (1 mark)

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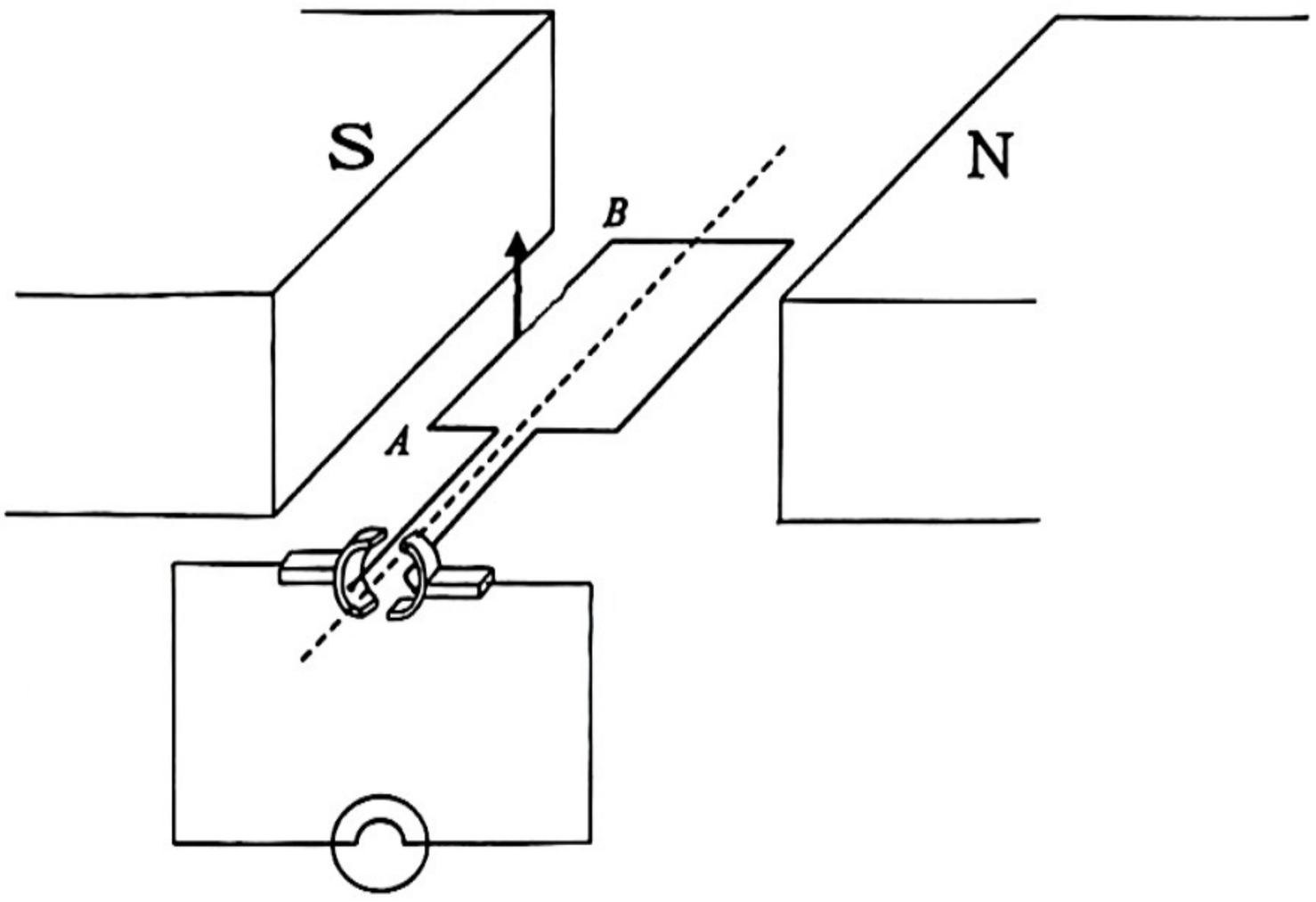
Answers written in the margins will not be marked.

(e) Suppose now the battery is replaced by a light bulb and the coil is rotated continuously by external forces in clockwise direction. At a certain instant, the coil is at horizontal position and *AB* is at the left hand side that is moving upwards as shown in the figure below.



(i) State the direction of the induced current along *AB*. State which point is at a higher potential. (2 marks)

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(ii) State the direction of the magnetic force acting on *AB* at this instant. (1 mark)

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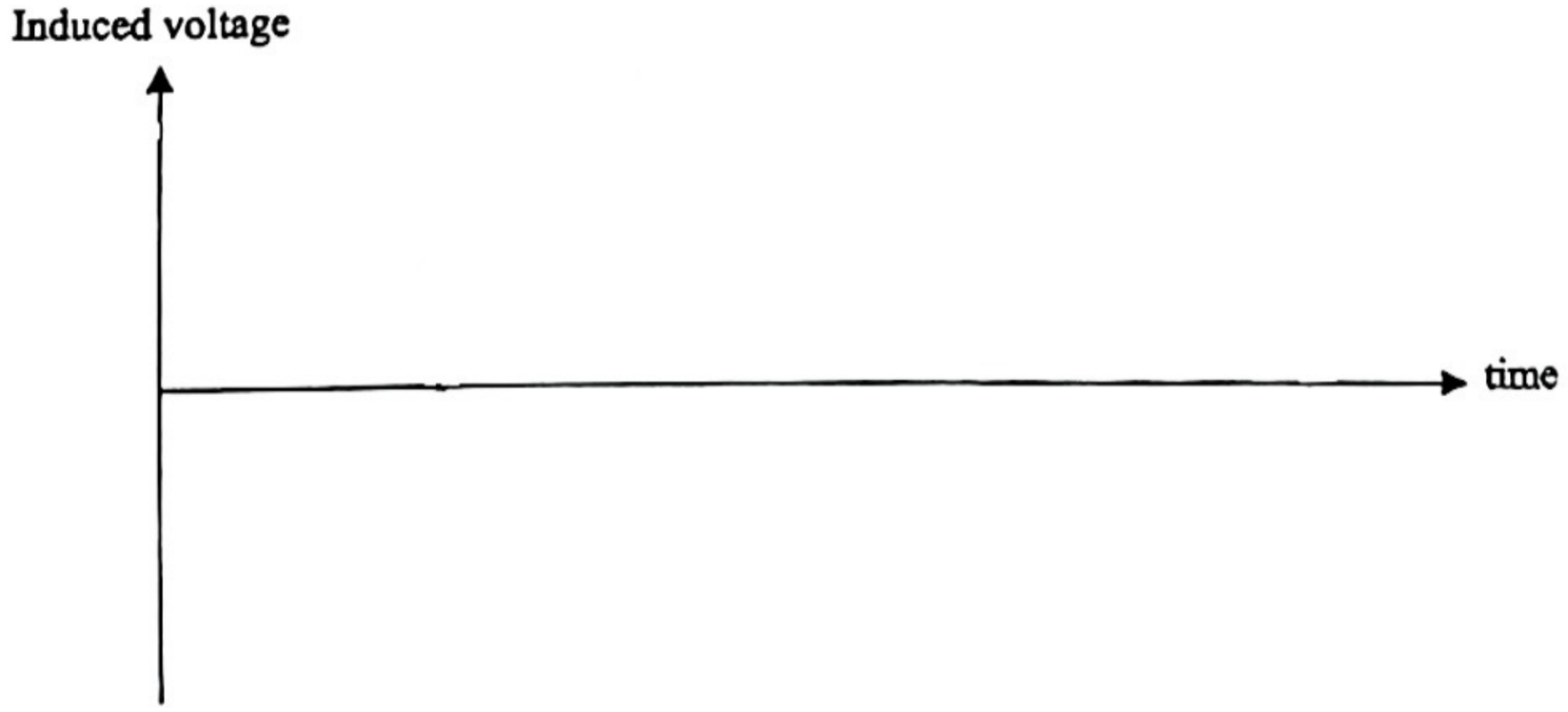
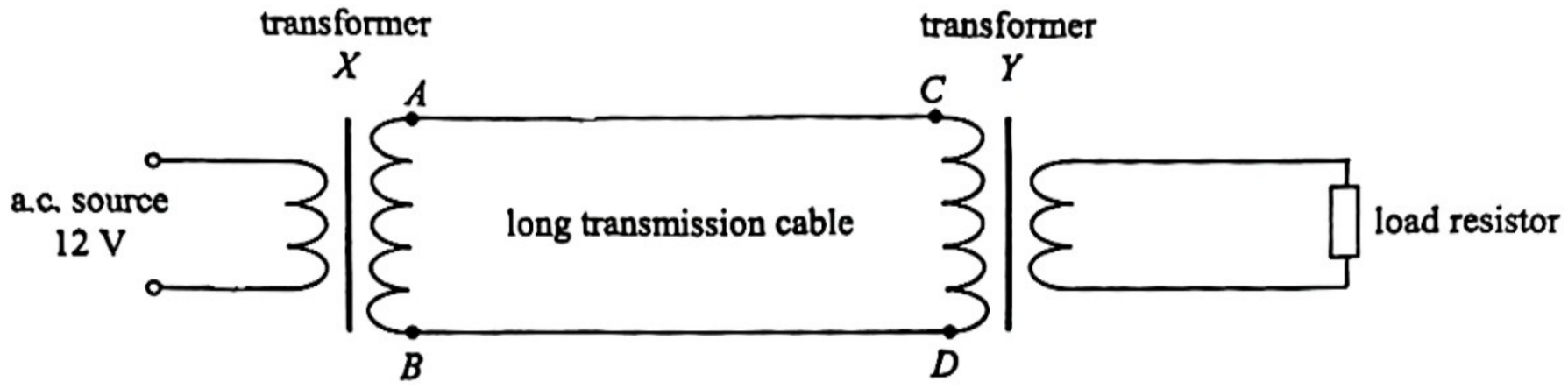
(iii) Sketch the variation of the induced voltage against time across the light bulb for 1 complete cycle of rotation of the coil, starting from the instant that the coil is at horizontal position. (1 mark)



Answers written in the margins will not be marked.

10. The figure below shows a simplified system of power transmission from a power source to a load resistor. The r.m.s. voltage of the power source is 12 V. It is connected to a step-up transformer *X* and transmitted to another step-down transformer *Y* via long transmission cables *AC* and *BD*. Each of the cable *AC* and *BD* has a resistance of 10 Ω. Assume that the two transformers are ideal.



(a) If the turn ratio of the step-up transformer is 50 : 600, calculate the voltage across *AB*. (1 mark)

(b) Suppose the current flowing in the transmission cables is 0.2 A, find the voltage across *CD*. (2 marks)

(c) Calculate the power loss in the transmission cables. (2 marks)

(d) Find the efficiency of this power transmission system. (2 marks)

(e) Suggest a method to improve the efficiency of this power transmission system. (1 mark)

Answers written in the margins will not be marked.

11. Plutonium-238 is a radioactive source that emits α radiation. The half-life of plutonium-238 is 87.7 years. On average, each decay of plutonium-238 atom releases 5.4 MeV of energy. The plutonium-238 can be used to equip a thermoelectric generator that can convert nuclear energy of decay into electrical energy.

(a) Suppose a thermoelectric generator requires an initial input power of 7.5 kW for proper operation.

(i) Calculate the initial activity of the plutonium-238 source to meet the above requirement. (2 marks)

(ii) Given that the molar mass of plutonium-238 is 238 g. Find the initial mass of the radioactive source, assuming that the source consists of pure plutonium-238 atoms. (3 marks)

(iii) Estimate the power released by the source after the thermoelectric generator has operated for 20 years. (2 marks)

(b) After a series of decay, plutonium-238 ($^{238}_{94}\text{Pu}$) would change to a final product lead-206 ($^{206}_{82}\text{Pb}$).

(i) Determine the total number of α particles and β particles emitted in the series. (2 marks)

(ii) In the series of decay, some nuclides may emit γ-radiation when they decay. However, it is impossible to identify these nuclides from the decay products. Give the reason to explain this. (1 mark)

END OF PAPER

Answers written in the margins will not be marked.

Hong Kong Diploma of Secondary Education Examination

Please stick the barcode label here.

Candidate Number

2019

Mock Examination

PHYSICS PAPER 2

Question-Answer Book

(1 hour)

This paper must be answered in English

INSTRUCTIONS

(1) After the announcement of the start of the examination, you should first write you Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided.

(2) This paper consists of **FOUR** sections, Section A, B, C and D. Each section contains eight multiple-choice questions and one structured question which carries 10 marks. Attempt **ALL** question in any **TWO** sections.

(3) Write your answers to the structured questions in the **ANSWER Book** provided. For multiple-choice questions, blacken the appropriate circle with an HB pencil. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

(4) Graph paper and supplementary answer sheets will be provided on request. Write your candidate number, mark the questions box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

(5) The Question-Answer Book and Answer Book will be collected **SEPARATELY** at the end of the examination.

(6) The diagrams in this paper are **NOT** necessarily drawn to scale.

(7) The last two pages of this Question-Answer Book contain a list of data, formulae and relationship which you may find useful.

(8) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

Section A : Astronomy and Space Science

Q.1 : Multiple-choice questions

1.1 A galaxy is approximately in the form of a circular disc. Its diameter is 6×10^5 ly and the thickness is 5×10^3 ly. If the average separation between two neighbouring stars within the galaxy is 4.5 ly, estimate the order of magnitude of the number of stars in the galaxy.

A. 10^{11}
B. 10^{13}
C. 10^{15}
D. 10^{17}

A	B	C	D
○	○	○	○

1.2 According to Kepler's laws of planetary motion, which of the following deductions are correct ?

(1) The orbits of planets revolving around the Sun are not circular.
(2) The planets do not move around the Sun with constant speed.
(3) The Sun is not at the centre of the orbit of each planet.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

1.3 John observed that the position of Mars has shifted towards the West across the background stars compared with that a few nights before. Which of the following statements concerning this motion are correct ?

(1) Mars is undergoing retrograde motion.
(2) Mars and Earth must be at the same side of the Sun.
(3) This motion can be explained by Copernican's heliocentric model but not by Ptolemy's geocentric model.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

1.4 A star has a radius of 4×10^{11} m. The angular size of the star is 2×10^{-6} rad. What is the parallax of the star ?

A. 0.049 arc second
B. 0.053 arc second
C. 0.077 arc second
D. 0.085 arc second

A	B	C	D
○	○	○	○

1.5 A star has a brightness of 6.5×10^{-9} W m ^{2} observed from the Earth. Distance of the star from the Earth is 15 pc. If the radius of the star is 4×10^8 m, estimate the surface temperature of the star.

A. 15 000 K
B. 20 000 K
C. 25 000 K
D. 30 000 K

A	B	C	D
○	○	○	○

1.6 The spectral line of 415 nm from a distant celestial body is red shifted and this wavelength is observed to have a Doppler shift of 40 nm when observed from the Earth. What is the observed wavelength of another spectral line of 572 nm from the same source ?

A. 517 nm
B. 544 nm
C. 600 nm
D. 627 nm

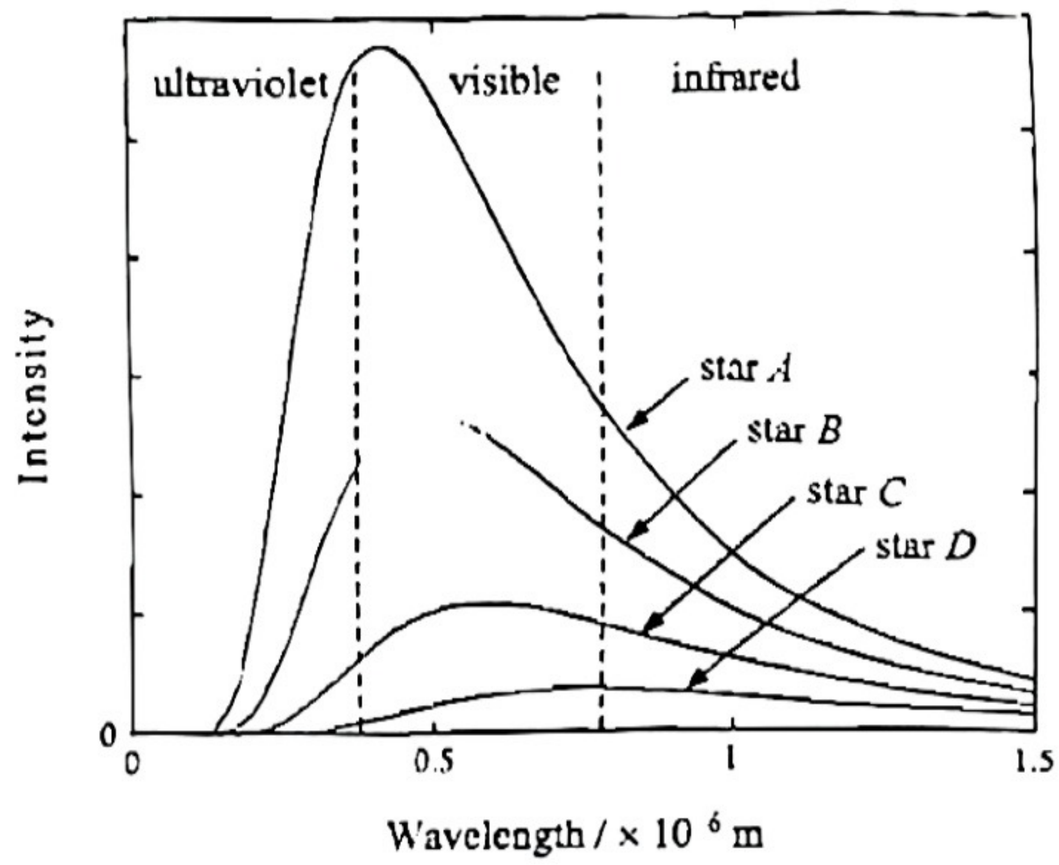
A	B	C	D
○	○	○	○

1.7 In the Milky Way galaxy, the Sun rotates about the galactic centre with a rotational speed of 220 km s^{-1}. It takes a time 2.25×10^8 years for the Sun to complete one rotation about the galactic centre. Estimate the distance of the Sun from the galactic centre.

A. 2 kpc
B. 4 kpc
C. 6 kpc
D. 8 kpc

A	B	C	D
○	○	○	○

1.8 The figure below shows the radiation curves of four stars. All the stars are assumed to follow black-body radiation.



Which of the following deductions are correct ?

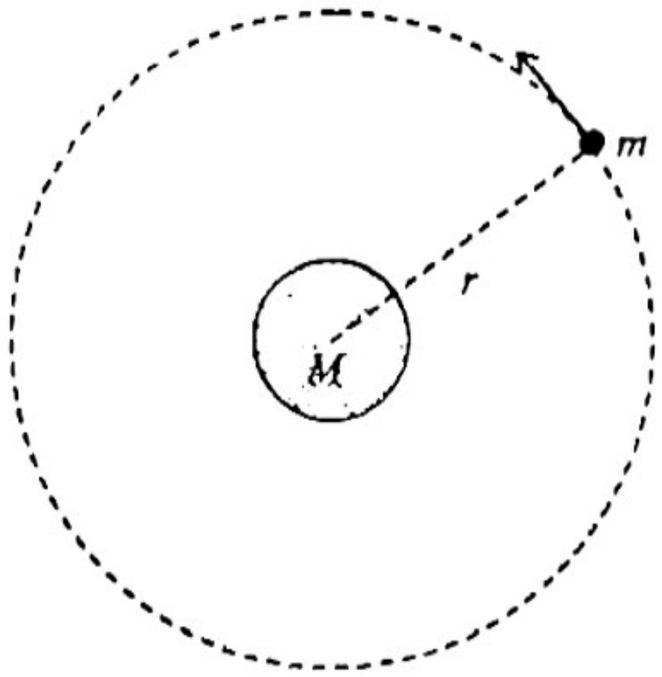
(1) The area under the curve represents the total intensity emitted by the star.
(2) The area under the curve is proportional to the surface temperature of the star.
(3) If star *A* and star *D* has the same luminosity, then star *A* has greater radius than star *D*.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A	B	C	D
○	○	○	○

Q.1 : Structural question

A satellite of mass m orbits around the Earth in circular motion. It is at a distance r from the centre of the Earth. Mass of the Earth is M. The gravitational potential energy at infinity is taken to be zero.



(a) (i) State the force that provides the centripetal acceleration of the satellite. (1 mark)

(ii) By considering the circular motion of the satellite, derive an expression for the kinetic energy K of the satellite in terms of the above given variables. Hence, write down the expression for the total mechanical energy E of the satellite. (3 marks)

(iii) After a certain time of orbital motion in a certain orbit r, the mechanical energy of the satellite would decrease. Would the satellite transit to another orbit of greater radius or smaller radius ? Hence, state the subsequent change of the kinetic energy of the satellite. (2 marks)

(b) Given that the mass of Earth is 6×10^{24} kg. A satellite of mass 5000 kg is designed to have a period of 12 hours.

(i) Calculate the total mechanical energy of the satellite in the orbit. (2 marks)

(ii) If now a small rocket in the satellite is ignited to transfer an extra energy of 4×10^{10} J to the satellite, the satellite can escape away from the attraction of the Earth. Determine the speed of the satellite when it reaches a very far distance from the Earth. (2 marks)

Section B : Atomic World

Q.2: Multiple-choice questions

2.1 Concerning Rutherford's atomic model for a hydrogen atom, which of the following deductions can be made according to classical electromagnetic theory ?

(1) The electron would emit electromagnetic radiation continuously.
(2) The electron would stay in a certain orbit with constant energy.
(3) The atom can emit discrete line spectrum.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

2.2 When monochromatic light of wavelength 650 nm is incident on the cathode surface of a photocell, the stopping potential is V_0. If another monochromatic light of wavelength 450 nm is incident on the cathode surface of the same photocell, the stopping potential becomes 1.5 V_0. Determine the work function of the cathode metal.

A. 3.4×10^{-19} J
B. 6.8×10^{-20} J
C. 3.4×10^{-20} J
D. 6.8×10^{-20} J

A B C D
○ ○ ○ ○

2.3 A monochromatic light is incident onto the cathode of a photocell. Which of the following would NOT affect the maximum kinetic energy of the photoelectrons reaching the anode ?

A. The colour of the monochromatic light
B. The intensity of the monochromatic light
C. The material of the cathode metal
D. The potential difference across the photocell

A B C D
○ ○ ○ ○

2.4 A beam of protons, each of mass m and charge q, are accelerated in a transmission electron microscope. The de Broglie wavelength of the protons is λ. If now another beam of alpha particles, each of mass $4m$ and charge $2q$, are accelerated in the same transmission electron microscope, what is their de Broglie wavelength ?

A. $0.35\ \lambda$
B. $0.50\ \lambda$
C. $0.71\ \lambda$
D. $2.83\ \lambda$

A B C D
○ ○ ○ ○

2.5 A beam of monochromatic light of frequency f is incident onto the cathode metal of a photocell to give a saturation current of I. If now another beam of monochromatic light of frequency $1.2\ f$ with the same intensity is incident onto the same cathode metal of the photocell, what is the saturation current ?

A. $0.64\ I$
B. $0.83\ I$
C. I
D. $1.2\ I$

A B C D
○ ○ ○ ○

2.6 A telescope is used to view objects 5 km away. It can just distinguish two close objects separated at 4 cm. If the average wavelength of the light reflected by the objects is 550 nm, estimate the diameter of the aperture of the telescope.

A. 4.2 cm
B. 6.3 cm
C. 8.4 cm
D. 9.6 cm

A B C D
○ ○ ○ ○

2.7 The leaves of Lotus are covered with waxy material and nanoscale bumps on the surface. Which of the following statements concerning the Lotus leaves is/are correct ?

(1) The bumps on the leave surface can be observed by a powerful optical microscope.
(2) Water forms spherical droplets on the leave surface.
(3) The surface of the leave is always clean without dirt.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

2.8 Which of the following statements concerning a transmission electron microscope (TEM) is/are correct ?

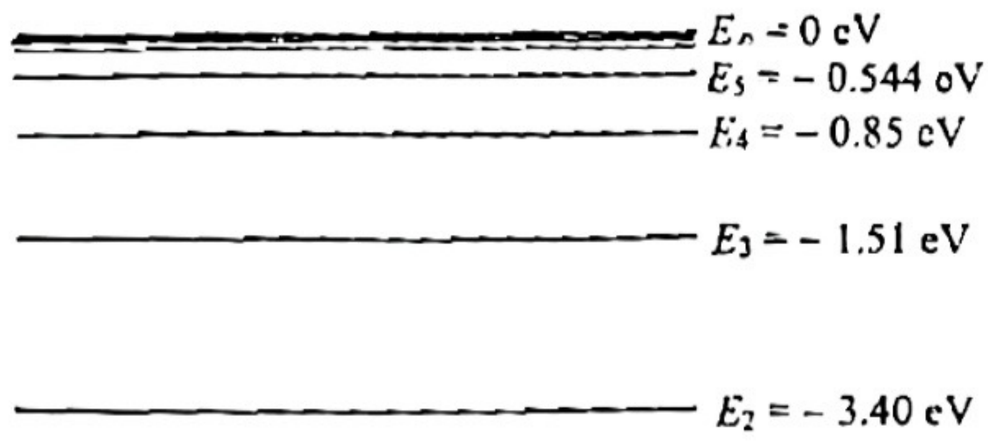
(1) Its working principle is similar to an optical microscope except that electron beam is used to replace visible light and magnetic lenses are used to replace glass lenses.
(2) The resolving power of TEM can be increased by decreasing the voltage across the cathode and anode.
(3) After the electron beam passing through the sample to be observed, it is projected onto the fluorescent plate by a magnetic condensing lens.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

Q.2 : Structural question

The graph below shows some of the energy levels of a hydrogen atom (not drawn to scale).



(a) Explain why the energy levels of the hydrogen atom are all negative. (1 mark)

(b) When the electron transits from a higher excited level to the first excited level, a photon of wavelength 4.875×10^{-7} m is emitted.

(i) Calculate the energy of this photon in eV. (1 mark)

(ii) State the transition of the electron that can emit this photon. (2 marks)

(c) The kinetic energy of the electron in the ground state of a hydrogen atom is 13.6 eV.

(i) Calculate the momentum of the electron in the ground state. Hence determine the de Broglie wavelength of the electron in the ground state. (2 marks)

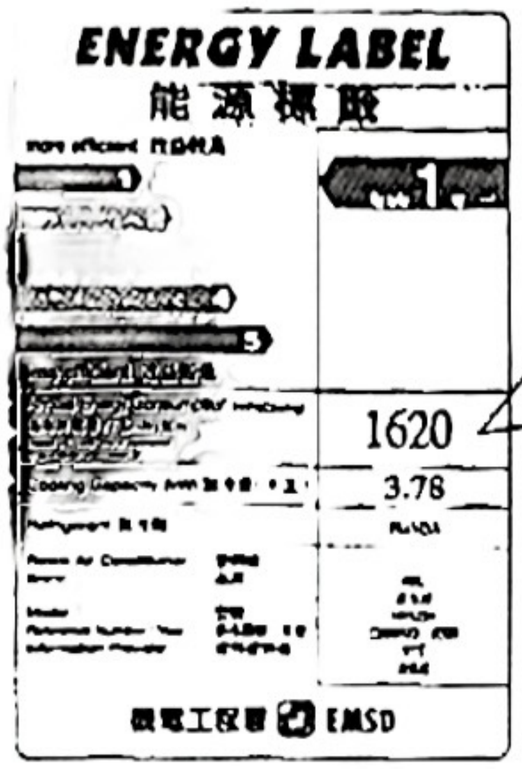
(ii) Determine the radius of the electron orbit in the ground state. (2 marks)

(d) Give an evidence that energy levels inside a hydrogen atom is discrete. Explain briefly. (2 marks)

Section C : Energy and Use of Energy

Q.3 : Multiple-choice questions

3.1 The energy label of the air-conditioner is shown in the Figure below.



Annual energy consumption (kWh) (cooling)

Based on 1200 hrs/yr operation = 1620

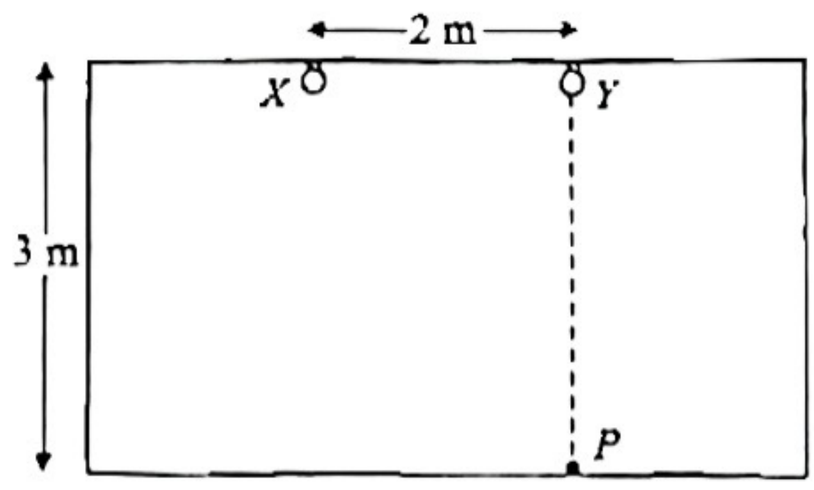
Cooling capacity (kW) – 3.78

From the above data, determine the coefficient of performance (COP) and the rate of heat rejected to the environment during the operation of the air-conditioner.

	coefficient of performance	rate of heat rejected
A.	2.8	1.35 kW
B.	2.8	5.13 kW
C.	3.8	1.35 kW
D.	3.8	5.13 kW

A ○ B ○ C ○ D ○

3.2



Two identical lamps *X* and *Y*, each emitting a luminous flux of 500 lm, are installed at the ceiling of a room. Point *P* is a point on the floor directly below one of the lamps. Assuming that the lamp emits light evenly in all directions, and neglect reflection of light by walls and ceiling, what is the illuminance at point *P* ?

A. 2.5 lux
B. 4.4 lux
C. 7.0 lux
D. 7.5 lux

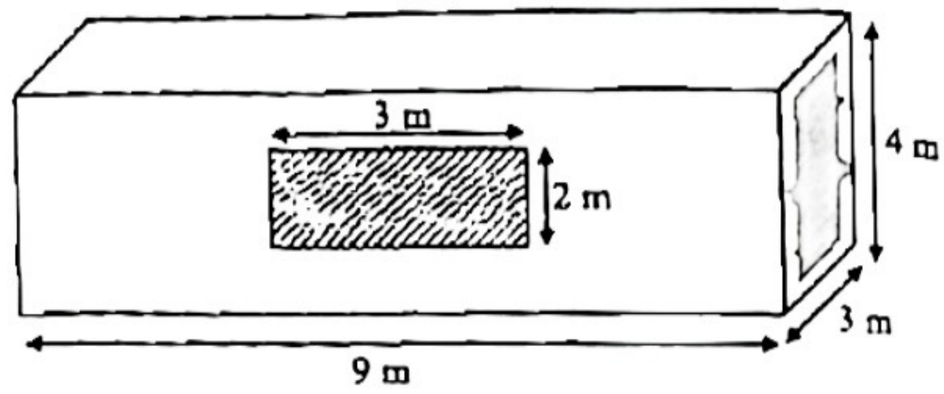
A ○ B ○ C ○ D ○

3.3 Which of the following concerning the working of an induction cooker is correct ?

A. The bottom of the cookware should be in contact with the surface of induction cooker for effective working.
B. The eddy current induced at the surface of the cooker produces heating effect to cook the food in cookware.
C. The solenoid inside the cooker produces a high strength of steady magnetic field.
D. The surface of an induction cooker must be made of ferrous material.

A ○ B ○ C ○ D ○

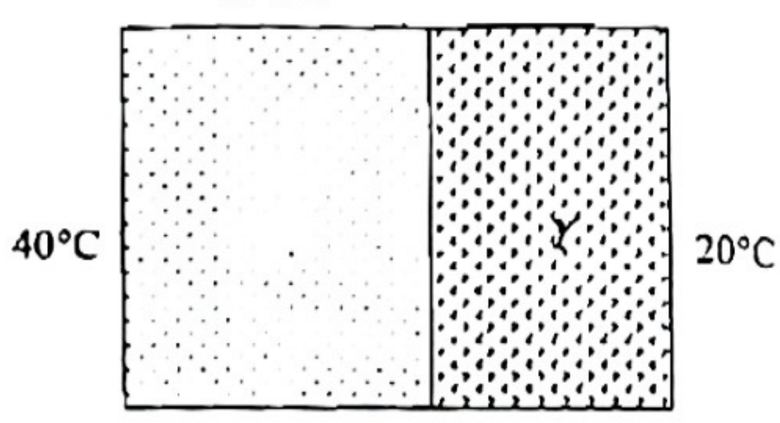
3.4 The Overall Thermal Transfer Value (OTTV) of the house shown is 30 W m^{-2}. The rate of heat generated by human activities is 1500 W and the heat generated by lighting system is 300 W. If an air-conditioner of COP 2.25 is used to maintain constant temperature inside the house, what is the minimum power rating of the air-conditioner ?



A. 1840 W
B. 2160 W
C. 2440 W
D. 2800 W

A B C D
○ ○ ○ ○

3.5 A composite wall is composed of two different building materials *X* and *Y*. The thickness of *X* and *Y* are 15 cm and 10 cm respectively. The thermal conductivity of *X* and *Y* are 1.2 W m^{-1} K^{-1} and 1.5 W m^{-1} K^{-1} respectively. If the two sides of the wall are maintained at steady temperatures of 40°C and 20°C as shown, what is the temperature at the interface between *X* and *Y* when steady state has been achieved ?



A. 24 °C
B. 27 °C
C. 30 °C
D. 33 °C

A B C D
○ ○ ○ ○

3.6 An electric vehicle is driven by a battery pack. When the battery is used up, it can be fully charged by a charger operating at 220 V with average current of 15 A for a time of 5 hours. If the energy required for overcoming air resistance and friction in travelling a distance of 1 km is 180 kJ, estimate the travel range of this vehicle, assuming that 65% of the energy supplied by the battery can be used to overcome air resistance and friction.

A. 182 km
B. 215 km
C. 231 km
D. 258 km

A B C D
○ ○ ○ ○

3.7 A solar cell consists of p-type and n-type semiconductor layers. It is connected to an external load. Which of the following concerning the working of the solar cells are correct ?

(1) There is an intrinsic electric field pointing from n-type layer to p-type layer in the p-n junction.
(2) When incident light shines onto the p-n junction, pairs of holes and electrons are created.
(3) The electrons flow from the p-type layer to the n-type layer via the external load.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A B C D
○ ○ ○ ○

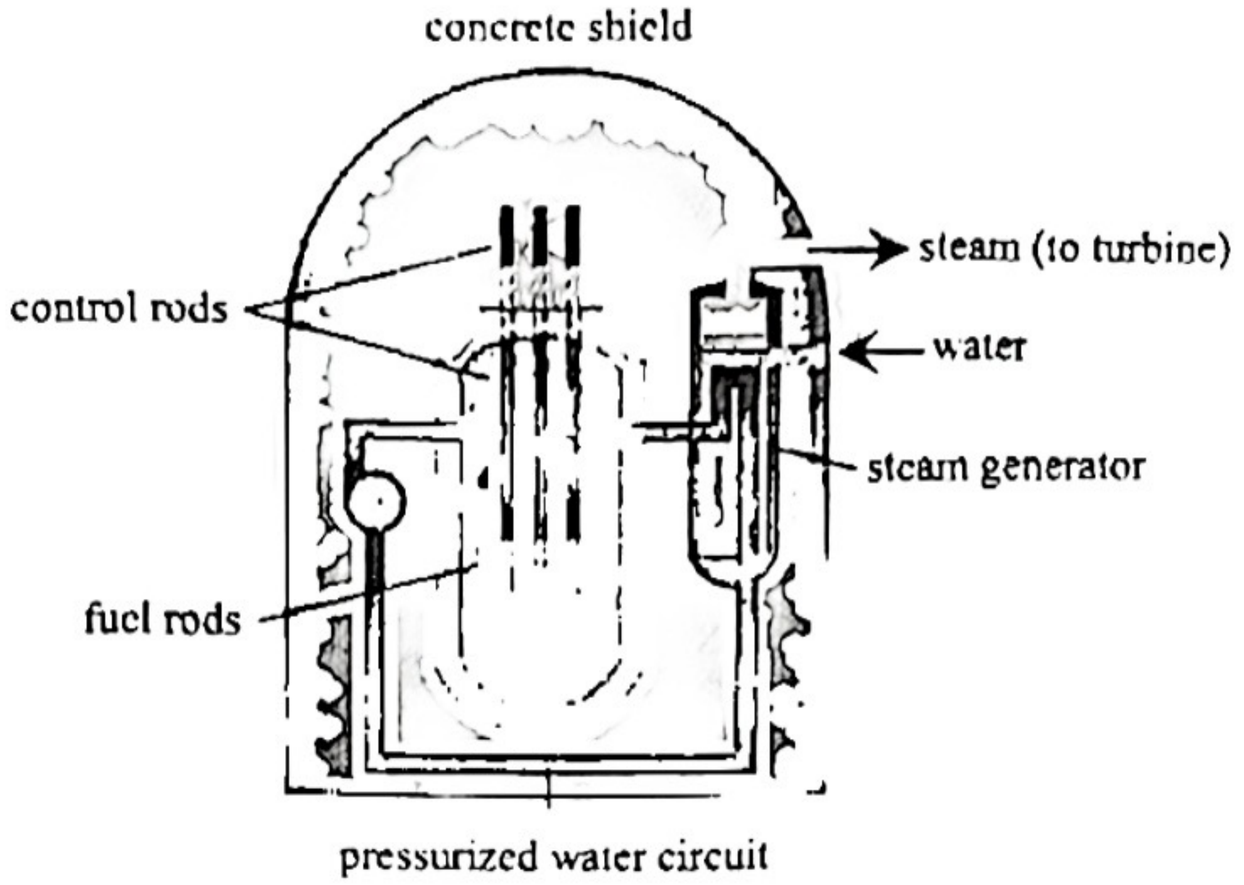
3.8 A wind turbine has an efficiency of 35%. When wind of constant velocity 12 m s^{-1} blows normally to the turbine, it gives an electrical power output of 250 kW. If the density of air is 1.2 kg m^{-3}, what is the diameter of the wind turbine ?

A. 14.8 m
B. 22.2 m
C. 25.6 m
D. 29.6 m

A B C D
○ ○ ○ ○

Q.3 : Structural question

The diagram below shows a simplified nuclear power plant for generation of electricity. The power plant generates an electrical power of 500 MW continuously throughout a year.



The nuclear reaction involved in the reactor is :

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{144}_{56}Ba + {}^{90}_{36}Kr + 2\,{}^{1}_{0}n$$

Given : mass of a U-235 nucleus = 235.044 u

mass of a Ba-144 nucleus = 143.912 u

mass of a Kr-90 nucleus = 89.902 u

mass of a neutron = 1.0087 u

(a) From the above information, calculate the nuclear energy release in each fission of U-235. Express the answer in joule. (2 marks)

(b) If the efficiency of converting nuclear energy to electrical energy is 35%, calculate the mass of U-235 consumed in one day. (Mass of one mole of U-235 is 235 g.) (2 marks)

(c) The pressurized water in the nuclear plant plays two important roles. State and explain these two roles. (2 marks)

(d) A pump storage system is built near the power plant. During the low demand period, the average demand of electrical power is only 350 MW. The excess electrical power is used to pump water from lower reservoir to higher reservoir with an average height of 250 m. If the energy conversion efficiency is 72%, calculate the average mass flow rate of the pump storage system to meet the requirement. (2 marks)

(e) State TWO safety precautions of the nuclear power plant. (2 marks)

Section D : Medical Physics

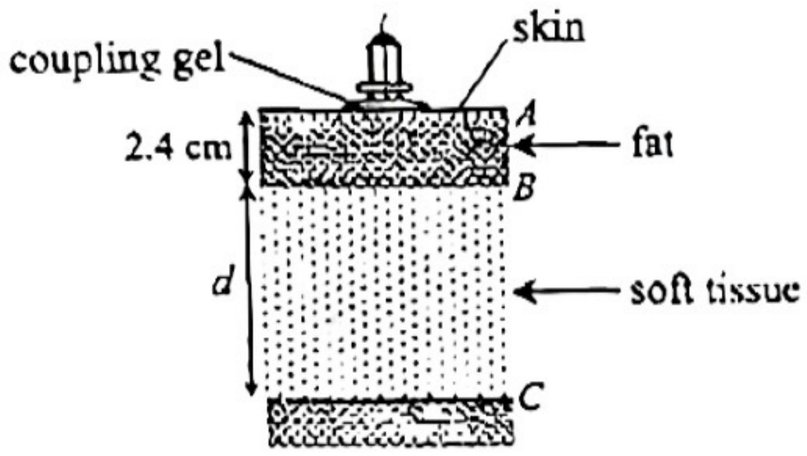
Q.4 : Multiple-choice questions

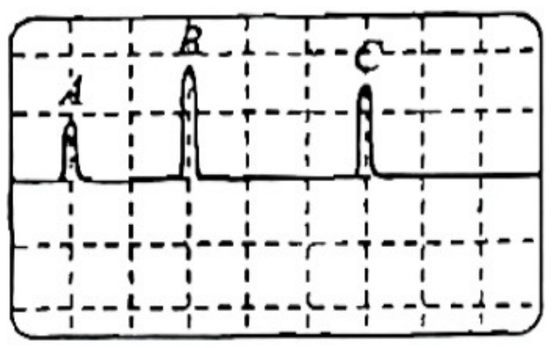
4.1 A small loudspeaker gives out a sound of steady intensity. Peter stands at 2 m away hears a loudness level of 70 dB. If now he walks away from the loudspeaker to a certain position, he hears a loudness level of 55 dB. How far is he from the loudspeaker ?

A. 11.2 m
B. 24.6 m
C. 48.2 m
D. 63.3 m

A	B	C	D
○	○	○	○

4.2 The figure below shows part of a cross-section of human body. An ultrasound transducer with coupling gel is applied to the skin. The ultrasound pulses reflected from various boundaries *A*, *B* and *C* are displayed on a CRO as shown. The speed of ultrasound in the fat layer is 1460 m s^{-1} while that in the soft tissue layer is 1550 m s^{-1}.





Determine the thickness of the soft tissue from the above information.

A. 3.39 cm
B. 3.82 cm
C. 4.26 cm
D. 4.85 cm

A	B	C	D
○	○	○	○

4.3 The intensity of a beam of 3 MHz ultrasound is 22.5 mW cm^{1}. It is incident onto the interface between fat and liver. If the speed of ultrasound in fat and liver are 1450 m s^{-1} and 1620 m s^{-1} respectively and their density are 952 kg m^{-3} and 1032 kg m^{-3} respectively, what is the intensity of the reflected ultrasound from the interface ?

A. 0.16 mW cm^{-2}
B. 0.20 mW cm^{-2}
C. 0.24 mW cm^{-2}
D. 0.28 mW cm^{-2}

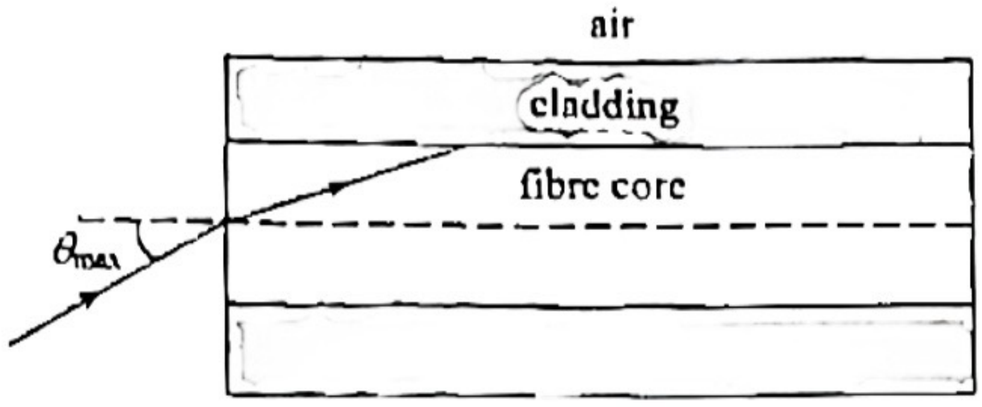
A	B	C	D
○	○	○	○

4.4 After passing through a tissue of thickness χ and attenuation coefficient μ, the intensity of the X-ray beam is reduced to 40%. If the same beam of X-ray passes through another tissue of thickness 1.5 χ and attenuation coefficient 0.8 μ, what is the percentage of intensity that can be transmitted ?

A. 25.3%
B. 33.3%
C. 42.5%
D. 48.0%

A	B	C	D
○	○	○	○

4.5



The above figure shows an optical fibre with cladding material surrounding the fibre core. If the refractive index of the fibre core is 1.64 and that of cladding is 1.38, what is the maximum angle of incidence θ_{max} so that incident light would fall into the range of guided mode to reach the other end by total internal reflection.

A. 32.7°
B. 44.8°
C. 57.3°
D. 62.4°

A	B	C	D
○	○	○	○

4.6 A boy hurt in a soccer competition is suspected to have internal bleeding in the brain. The doctor decides to have a CT (computed tomography) examination of the brain. Which of the followings are the reasons for taking CT scan imaging ?

(1) CT scan can distinguish very small difference in tissue contrast.
(2) CT scan does not have the problem of superimposition of different tissues.
(3) CT scan has less radiation dosage than radiographic imaging.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

4.7 A certain tracer with an initial activity of 1250 Bq is injected into the body of a patient to examine the function of an organ. The physical half-life of the tracer is 6 hours and the biological half-life is 2 days. What is the activity of the tracer left in the body of the patient after 3 hours ?

A. 313 Bq
B. 544 Bq
C. 846 Bq
D. 884 Bq

A	B	C	D
○	○	○	○

4.8 Which of the following statements concerning radionuclide imaging (RNI) is/are correct ?

(1) The whiter part of the RNI image shows that there is high attenuation of γ radiation by the body tissue.
(2) The image of RNI shows clearly the anatomical structure of the organ.
(3) A hot spot or cold spot shows that there is abnormality of the organ or tissue.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A	B	C	D
○	○	○	○

Q.4 : Structured question

(a) There are two types of light sensitive cells in the retina of a human eye. State their names and outline their main functions. (2 marks)

(b) David is observing two close objects separated at a small distance of 2.4 mm. The objects emit blue light of wavelength 625 nm. At day time, the diameter of his eye's pupil is 3.5 mm

(i) Determine the longest distance L of the objects from his eye so that he can just resolve these two close objects. (2 marks)

(ii) Explain whether this distance L would be affected if the environmental light becomes dimmer. (1 mark)

(c) Peter has a near point distance of 25 cm. His lens-to-retina distance is 2.6 cm. He suffers from short-sightedness and he has to wear spectacles with power of – 1.36 D so that he can view distant objects. Assume that the refracting power is mainly contributed by the eye lens.

(i) What is the far-point distance of Peter without wearing spectacles ? (2 marks)

(ii) Determine the power of the eye lens when Peter is wearing spectacles to observe distant objects. (1 mark)

(iii) What is the near-point distance of Peter after he wears the spectacles ? (2 marks)

END OF PAPER

Section A

Answers

1.	D	6	C	11.	C	16.	B	21.	C	26.	B	31.	C
2.	B	7.	D	12.	C	17.	D	22.	B	27.	A	32.	C
3.	A	8.	A	13.	C	18.	C	23.	D	28.	B	33.	B
4.	C	9.	C	14.	C	19.	C	24.	A	29.	B		
5.	C	10.	D	15.	B	20.	D	25.	A	30.	D		

Solution

1 D

By $Pt = mc\Delta T + E_{loss}$

$\therefore (250)(2\times60) = (0.5)(2350)(18) + E_{loss}$

$\therefore E_{loss} = 8850\ J$

2. B

× (1) During interval AB, the ice should absorb latent heat of fusion from warm water and melts.

× (2) At instant B, only part of ice has melted. Thus, there is a mixture of water and ice at 0°C.
During interval BC, the water does not absorb heat, but the ice absorbs latent heat from surroundings.

(3) At instant C, all the ice is melted.
The water then absorbs heat from the surroundings to increase temperature until it reaches the surrounding temperature at D.

3. A

By $PV = nRT$ $P \propto nT$ (same V)

$\frac{P_X}{P_Y} = \frac{n_X}{n_Y}\cdot\frac{T_X}{T_Y}$ $\therefore \frac{(240)}{(180)} = \frac{5}{4}\frac{(60+273)}{(\theta+273)}$ $\therefore \theta = 39°C$

4. C

By $E_K = \frac{3}{2}\cdot\frac{R}{N_A}\cdot T = \frac{1}{2}mc^2$

$\frac{3}{2}\cdot\frac{(8.31)}{(6.02\times10^{23})}(100-273) = \frac{1}{2}(4.65\times10^{-26})c^2$

$c = 576\ m\,s^{-1}$

5. C

A $s_A = ut + \frac{1}{2}at^2$ $\therefore s_A = (15)t + \frac{1}{2}(2)t^2$

B: $s_B = vt$ $\therefore s_B = (20)t$

By $s_A - s_B = 50$

$\therefore (15)t + \frac{1}{2}(2)t^2 - (20)t = 50$

$\therefore t^2 - 5t - 50 = 0$ $\therefore t = 10\ s$

6. C

By $s = ut + \frac{1}{2}at^2$ $\therefore (0) = (12)(3.6) + \frac{1}{2}a(3.6)^2$ $\therefore a = -6.67\ m\,s^{-2}$

By $a = g\sin\theta$ $\therefore (6.67) = (9.81)\sin\theta$ $\therefore \theta = 42.8°$

7 D

When the lift decelerates downwards, the direction of a is upwards

The balance reads the normal reaction acting on the balance.

Consider the boy :

By $R - mg = ma$

$\therefore R - (40)(10) = (40)(1.5)$ $\therefore R = 460\ N$

8. A

Resolve the tension along OA into two components : vertical component $T_A\sin\theta$ and horizontal component $T_A\cos\theta$

Since point O is in equilibrium,

$T_A\sin\theta = W$ and $T_A\cos\theta = T_B$ $\therefore \tan\theta = \frac{W}{T_B}$

(1) By $T_A\sin\theta = W$ $\therefore \theta\downarrow \Rightarrow \sin\theta\downarrow \Rightarrow T_A\uparrow$

(2) By $T_A\cos\theta = T_B$ $\therefore \theta\downarrow \Rightarrow \cos\theta\uparrow$ and $T_A\uparrow \Rightarrow T_B\uparrow$

(3) By $\tan\theta = \frac{W}{T_B}$, as $\tan\theta$ may be greater than 1 or smaller than 1, T_B may be smaller than W or greater than W.

9 C

Take moment about point O.

$T\sin30°\times(80) = (24)\times(30)$ $\therefore T = 18\ N$

Let the reaction force acting on the rod by the wall be R,

that can be resolved into horizontal component R_X and vertical component R_Y

Horizontal equilibrium :

$R_X = T\cos\theta = (18)\cos30° = 15.6\ N$

Vertical equilibrium :

$R_Y + T\sin\theta = W$ $\therefore R_Y + (18)\sin30° = 24$ $\therefore R_Y = 15\ N$

Reaction : $R = \sqrt{(15.6)^2 + (15)^2} = 21.6\ N$

10. D

(1) Since the applied force is greater than the weight of the block, there is net force on the block.
Thus, the block would have upward acceleration and kinetic energy should increase.
Therefore, work done by the boy should equal the gain of kinetic energy and potential energy

(2) By power (instantaneous power) $P = Fv$ where F is the applied force,
as the velocity of the block continuously increases due to acceleration,
the power increases continuously throughout the upward motion.

(3) Work done by the boy : $W = Fs = (60)(4) = 240$ J

Average power : $P = \frac{W}{t} = \frac{(240)}{(2)} = 120$ W

11. C

The horizontal component of the tension provides the centripetal force.

$T \sin\theta = m r \omega^2 = m L \sin\theta \omega^2$

$\therefore T = (0.750) \times (0.80) \times (4.5)^2 = 12.15$ N

The vertical component of the tension balances the weight of the bob.

$T \cos\theta = m g$

$\therefore (12.15) \cos\theta = (0.750)(9.81)$

$\therefore \theta = 52.7°$

12. C

During the falling, mechanical energy of the plasticine is conserved.

$m g h = \frac{1}{2} m v^2$

$\therefore (10)(0.8) = \frac{1}{2} v^2$

$\therefore v = 4$ m s^{-1}

During the impact, average force acting on the plasticine by the ground is the normal reaction force

By $R - mg = \frac{mv - mu}{t}$

$R - (0.2)(10) = \frac{(0.2)(0) - (0.2)(-4)}{(0.1)}$

$\therefore R = 10$ N

13. C

Resolve the lift force L into two components

The vertical component balances the weight : $L \cos\theta = mg$

The horizontal component provides the centripetal force F $L \sin\theta = F$

$\therefore \frac{L \sin\theta}{L \cos\theta} = \frac{F}{mg}$

$\therefore F = mg \frac{\sin\theta}{\cos\theta}$

14. C

From the graph, wavelength : $2.5\lambda = 45$ $\therefore \lambda = 18$ cm

As the wave is travelling towards the left, at this instant, particle P is moving downwards.

From the equilibrium position to move downwards to reach the crest, particle P performs $\frac{1}{4}$ cycle that takes a time of $\frac{1}{4} T$

$\therefore \frac{1}{4} T = 0.6$ $\therefore T = 0.8$ s

Frequency :

$f = \frac{1}{T} = \frac{1}{0.8} = 1.25$ Hz

Speed : $v = f\lambda = (1.25)(18) = 22.5$ cm s^{-1}

15 B

Path difference at point $P = 3.6 - 2.4 = 1.2$ m

(1) By $v = f\lambda$ $\therefore (324) = (405)\lambda$ $\therefore \lambda = 0.8$ m

$\Delta = 1.2$ m $= 1.5\lambda$ $\therefore$ destructive interference occurs to give a sound of minimum

(2) By $v = f\lambda$ $\therefore (324) = (540)\lambda$ $\therefore \lambda = 0.6$ m

$\Delta = 1.2$ m $= 2\lambda$ $\therefore$ constructive interference occurs to give a sound of maximum

(3) By $v = f\lambda$ $\therefore (324) = (675)\lambda$ $\therefore \lambda = 0.48$ m

$\Delta = 1.2$ m $= 2.5\lambda$ $\therefore$ destructive interference occurs to give a sound of minimum

16. B

(1) The angle that the wavefront made with the interface is the incident angle θ_X
and the angle that the wavefront made with the interface is the refracted angle θ_Y.
From the figure, $\theta_Y > \theta_X$, thus speed in region Y is greater as $v \propto \sin\theta$
Therefore, region Y is a deeper region.

(2) Since angle in region Y is greater, the waves should bend away from the normal.

(3) Since $\lambda \propto \sin\theta$, wavelength in region Y is longer.

17. D

Magnification : $m = 2$

Image distance : $v = mu = 2 \times 24 = 48$ cm

Image is real :

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{(24)} + \frac{1}{(48)}$

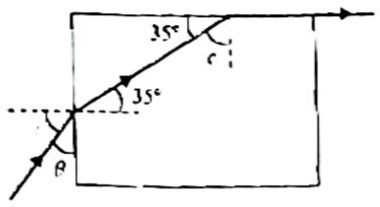
$\therefore f = +16$ cm

Image is virtual :

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{(24)} + \frac{1}{(-48)}$

$f = +48$ cm

18 C



From the figure, critical angle : $c = 90 - 35 = 55°$

By $n = \frac{1}{\sin c} = \frac{1}{\sin 55°} = 1.22$

When light ray enters the block from air, incident angle is i and refracted angle is 35°.

By $n = \frac{\sin i}{\sin r}$ $\therefore (1.22) = \frac{\sin i}{\sin 35°}$

$\therefore i = 44.4°$ $\therefore \theta = 90° - 44.4° = 45.6°$

19. C

The typical order of wavelength of microwaves is 10^{-2} m.

By $c = f\lambda$ $\therefore (3 \times 10^8) = f_1 (10^{-2})$ $\therefore f_1 = 10^{10}$ Hz

For an audible sound : $f_2 = 20$ Hz to 20000 Hz

The wavelength of red light is about 7×10^{-7} m.

By $c = f\lambda$ $\therefore (3 \times 10^8) = f_3 (7 \times 10^{-7})$ $\therefore f_3 = 10^{14}$ Hz

Frequency in ascending order :

$f_2 < f_1 < f_3$

20. D

Consider the second order bright fringe from the central line

$\tan\theta = \frac{0.9 \times 2}{1.0}$ $\therefore \theta = 24.2°$

By $d \sin\theta = n\lambda$

$\left(\frac{0.01}{3000}\right) \sin 24.2° = (2)\lambda$

$\therefore \lambda = 6.84 \times 10^{-7}$ m

21. C

× A. When light travels from air to water, it bends towards the normal since it travels slower in water
When sound travels from air to water, it bends away from the normal since it travels faster in water

× B. Light is a type of electromagnetic waves but sound is a type of mechanical waves.

✓ C. All waves, including light and sound, can form stationary waves

× D. Light can travel in vacuum but sound cannot travel in vacuum

22. H

For sharing of charges, $Q_1 + Q_2 = Q + Q$ where Q is the final charge at each of the two spheres

$(-8) + (-2) = Q + Q$ $\therefore Q = +3$

∴ After sharing, each sphere carries charge of + 3 μC

Electrostatic force : $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$

① $F_1 = \frac{(8)(2)}{4\pi\varepsilon_0 (2)^2}$ ② $F_2 = \frac{(3)(3)}{4\pi\varepsilon_0 (1)^2}$ $F_1 : F_2 = 4 : 9$

23 D

When the negatively charged rod is brought near X,
there is positive charges induced in X and negative charges induced in Y

When X is touched by the finger, the positive charges are attracted by the rod and remains unchanged but the negative induced charges in Y flow to earth and Y becomes uncharged.

When the rod is removed, the positive charges in X is shared between X and Y.

After they are separated, both X and Y carry positive charges.

24. A

Since L_2 and L_3 are in series, they have the same current.

As they give out the same power, by $P = I^2 R$, they have the same resistance.

If the voltage across L_2 is V, the voltage across L_3 is also V, then the voltage across L_1 is $2V$

By $P = \frac{V^2}{R}$ and $P_1 = P_2$

$\therefore \frac{(2V)^2}{(20)} = \frac{(V)^2}{R_2}$ $\therefore R_2 = 5\,\Omega$

25. A

✓ (1) As the resistance R decreases, the equivalent resistance of the whole circuit decreases, therefore, current delivered from the battery increases.

× (2) As the resistance R decreases, voltage across R decreases, therefore, voltage across L_2 increases, thus L_1 should become brighter.

× (3) Since the voltage across L_2 is unchanged, thus the brightness of L_2 should remain unchanged.

26. B

× (1) Although neutral touches the metal case (earth wire), current still flows from live to the heating elements inside the iron, thus the iron still works properly.

× (2) Since current stills flows through the heating element, current is limited to the normal value, the fuse will not blow.

✓ (3) After the current passes the heating element, it flow to the neutral wire that is in contact with the earth wire, current will divide and some will flow to neutral wire and some will flow to earth wire, thus, the current in live wire will be different from that in neutral wire

27. A

Magnetic force acting on the electrons provides the centripetal force for the circular motion.

$Bqv = \frac{mv^2}{r}$ (charge of electron and mass of electron are given in the provided data)

$\therefore v = \frac{Bqr}{m} = \frac{(1.25\times10^{-3})(1.6\times10^{-19})(0.05)}{(9.11\times10^{-31})} = 1.1\times10^{7}\ m\,s^{-1}$

28. B

At the neutral point, the resultant magnetic field is zero, thus the magnitude of field due to each current must be equal.

$B_1 = B_2 \quad \therefore \frac{\mu_r (2A)}{2\pi(15)} = \frac{\mu_0 I_2}{2\pi(5)} \quad I_2 = 0.8\ A$

I_2 must be in the opposite direction of I_1 so that the direction of the magnetic field produced is opposite to that by I_1.

29. B

✓ A Induced e.m.f. $= Bvl = (0.2)(2)(0.05) = 0.02\ V$

× B. Induced e.m.f. does not depend on resistance, only induced current depends on resistance

✓ C By Right hand rule, the induced current flows in upward direction at the left side of the wire frame, thus in clockwise direction.

× D Whenever, there is induced current, there is a magnetic force to oppose the motion, thus the direction of the magnetic force is towards the left.

30 D

$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{V_p I_p} \quad \therefore 80\% = \frac{(40-80)}{(110) I_p} \quad \therefore I_p = 1.36\ A$

31. C

Let C_b be the background radiation.

$(500 - C_b)\times\frac{1}{2} = (290 - C_b) \qquad C_b = 80$ cpm

Corrected count rate after one more hour $= (290 - 80)(\frac{1}{2})^{1/2} = 148$ c.p.m.

Count rate after one more hour $= 148 + 80 = 228$ c.p.m.

32. C

Decay constant : $k = \frac{\ln 2}{5.3\times365\times24\times3600} = 4.147\times10^{-9}\ s^{-1}$

Number of nuclei : $N = \frac{5\times10^{-6}}{60}\times6.02\times10^{23} = 5.017\times10^{15}$

Activity : $A = kN = (4.147\times10^{-9})\times(5.017\times10^{15}) = 2.08\times10^{7}$ Bq

33. B

By $E = \Delta m c^2 = Pt$

$(5\times10^{10})(3\times10^{8})^2 = P(24\times3600) \qquad P = 5.2\times10^{22}$ W

Section B

1. (a) $E = mc\Delta T + mL$

$= (0.150)(2140)(10) + (0.150)(3.34\times10^{5})$ [1]

$= 53310\ J$ [1]

(b) $(53310) + (0.150)(4200)(\theta - 0) = (0.500)(3900)(80 - \theta)$ [1]

$\therefore \theta = 39.8$ °C <accept 40 °C> [1]

(c) The actual temperature of the mixture would be higher [1]

since the beaker would release heat to the mixture. [1]

2. (a) Let the absolute zero be θ.

By $\frac{P}{T}$ = constant

$\frac{(109)}{(36-\theta)} = \frac{(124)}{(80-\theta)}$ [1]

$\theta = -284$ °C [1]

(b) By $PV = nRT$

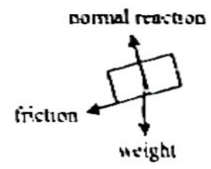
$\therefore (109\times10^{3})(480\times10^{-6}) = n(8.31)(36 + 284)$ [1]

$\therefore n = 0.0197$ mol [1]

(c) The gas molecules hit wall of the gas flask and rebound. [1]

It results in momentum change of gas molecules and thus gives pressure to the walls of the flask. [1]

3. (a)



<correct drawing and naming of weight and normal reaction> [1]

<correct drawing and naming of friction> [1]

(b) Distance = area of the graph $= \frac{1}{2}(4.8)(0.6) = 1.44$ m [1]

(c) Acceleration a = slope $= -\frac{4.8}{0.6} = -8\ m\,s^{-2}$ [1]

By $mg\sin\theta + f = ma$

$(0.5)(10)\sin30^{\circ} + f = (0.5)(8)$ [1]

$f = 1.5$ N [1]

3. (d) (i) By $mg\sin\theta - f = ma$

$\therefore$ $(0.5)(10)\sin 30^\circ - (1.5) = (0.5)a$ [1]

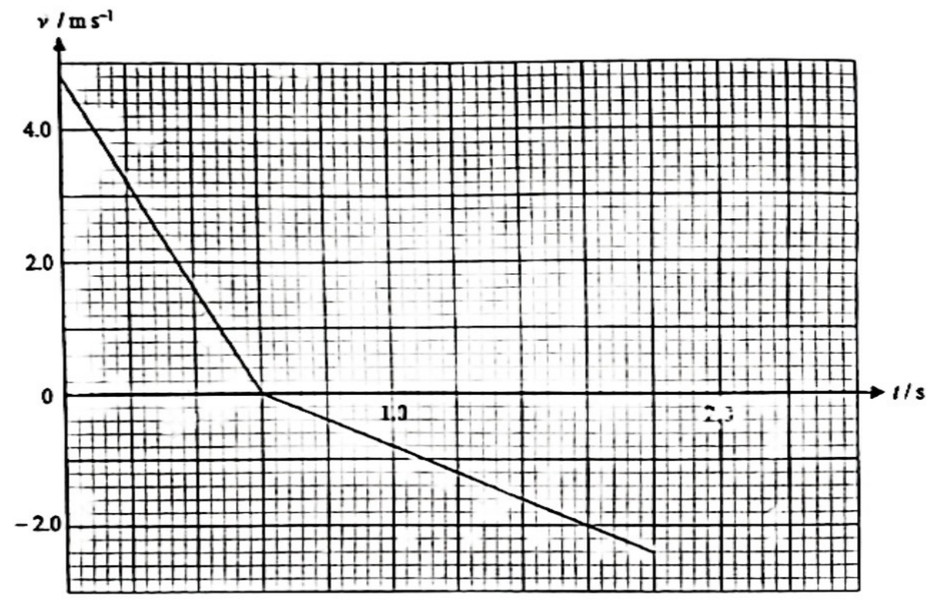
$\therefore$ $a = 2\ \text{m s}^{-2}$ [1]

(ii) By $s = ut + \frac{1}{2}at^2$

$\therefore$ $(1.44) = (0) + \frac{1}{2}(2)t^2$ [1]

$\therefore$ $t = 1.2\ \text{s}$ [1]

(iii)



< line drawn to meet $t = 1.8$ s and $v = -2.4\ \text{m s}^{-1}$ (slope is $-2\ \text{m s}^{-2}$ and time taken is 1.2 s) > [1]

4. (a) By $y = \frac{1}{2}gt^2$

$\therefore$ $(0.45) = \frac{1}{2}(10)t^2$ $\therefore$ $t = 0.3$ s [1]

By $x = ut$

$\therefore$ $(7.5) = u(0.3)$ $\therefore$ $u = 25\ \text{m s}^{-1}$ [1]

(b) By $\frac{1}{2}(12)(25)^2 + (12)(10)(0.45) = KE$ [1]

$\therefore$ $KE = 3804$ J [1]

(c) Their total momentum is not conserved since there is external force acting on the block. < The block is fixed. > [1]

(d) By $m_1 v_1 = m_2 v_2$

$\therefore$ $(400)\, v_1 = (12)(25)$ [1]

$v_1 = 0.75\ \text{m s}^{-1}$ [1]

4. (c) By $\frac{1}{2}mv^2 = mgh + fs$

$\frac{1}{2}(400)(0.75)^2 = (400)(10)(s\sin 12^\circ) + (200)s$ [1]

$\therefore$ $s = 0.109$ m [1]

5. (a) By $\frac{g'}{(9.81)} = \left(\frac{6400}{6400+400}\right)^2$ [1]

$g' = 8.69\ \text{m s}^{-2}$ [1]

(b) The gravitational force provides the centripetal force for the orbital motion of the station. [1]

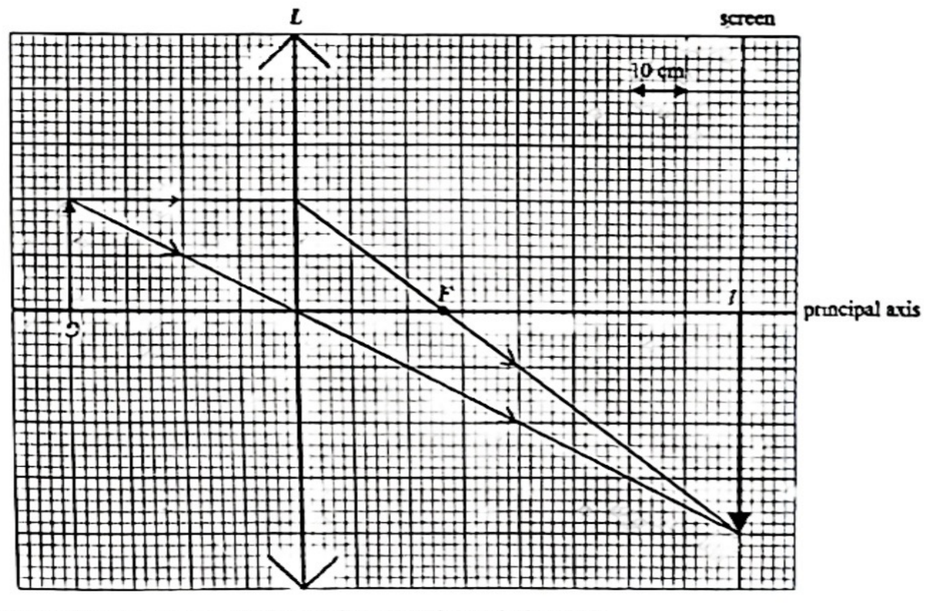
(c) By $mg = mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2$

$\therefore$ $(8.69) = (6400+400)\times 10^3 \times \left(\frac{2\pi}{T}\right)^2$ [1]

$\therefore$ $T = 5560$ s < accept 5558 s OR 92.6 minutes > [1]

(d) Their weights are used completely to provide the centripetal force, no normal reaction act on them. [1]

6. (a)



< a ray passing through the optical centre is drawn to locate the image I > [1]

< a ray parallel to the principal axis is drawn to locate the focus F > [1]

(deduct 1 mark if no arrow on the rays)

(b) Since the object distance is less than the focal length, the image becomes virtual. [1]

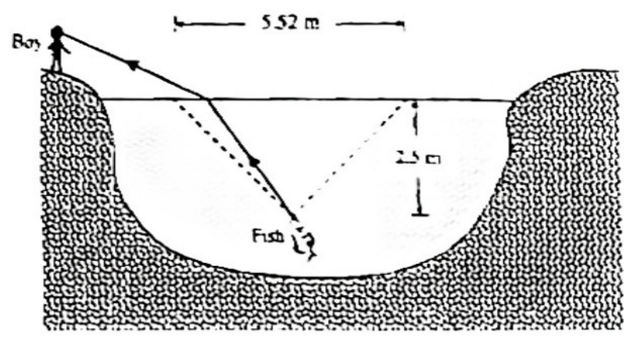
6. (c) By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{(30)} = \frac{1}{(40)} + \frac{1}{v}$ [1]

$\therefore v = 120$ cm [1]

$m = \frac{v}{u} = \frac{120}{40} = 3$ [1]

7. (a) (i)



< a light ray correctly drawn with arrows from fish to the eye of the boy > [1]

(ii) $\tan\theta = \frac{5.52/2}{2.5}$ [1]

$\theta = 47.8°$ [1]

(iii) $n = \frac{1}{\sin c} = \frac{1}{\sin 47.8°}$ [1]

$n = 1.35$ [1]

(b) As the refractive index of diamond is larger than that of glass,
the critical angle of diamond is smaller than that of glass.
Therefore, more light would have total internal reflection inside the diamond than inside the glass.
So more light would leave the upper surface and make diamond more sparkling [1]

8. Connect the battery, the nichrome wire, the ammeter, the rheostat and the switch in series. [1]
Connect the voltmeter in parallel across the nichrome wire. [1]
Switch on the circuit. Record the reading of ammeter I and the reading of voltmeter V. [1]
Adjust the resistance of the rheostat to give a few more readings of V and I [1]
Plot a graph of V against I. (OR Plot a graph of I against V) [1]
A straight line passing through the origin shows that the nichrome wire obeys Ohm's Law. [1]

8. Precaution : (any ONE of the followings) [1]
* Set the resistance of the rheostat to the maximum value at the start of the experiment
* Switch off the circuit after taken each set of readings
* Ensure the polarities of ammeter and voltmeter are correct.

9. (a) downwards [1]

(b) $F = BIL \times N = (0.6)(\frac{3}{10})(0.08) \times 50$ [1]
$= 0.72$ N [1]

(c) The magnetic force remains unchanged. [1]

(d) The commutator is used to reverse the direction of current whenever the coil has rotated half cycle. [1]

(e) (i) Induced current is from B to A. [1]
A is at a higher potential [1]

(ii) downwards [1]

(iii) Induced voltage

< correct shape (d.c. generator) > [1]

10. (a) $V_{AB} = 12 \times \frac{600}{50} = 144$ V [1]

(b) $V_{CD} = 144 - 0.2 \times 10 - 0.2 \times 10$ [1]
$= 140$ V [1]

(c) $P_{wire} = I^2 R = (0.2)^2 (10 + 10)$ [1]
$= 0.8$ W [1]

(d) $P_{in} = 144 \times 0.2 = 28.8$ W [1]
$P_{out} = 28.8 - 0.8 = 28$ W OR $P_{out} = 140 \times 0.2 = 28$ W
$\eta = \frac{28}{28.8} \times 100\% = 97.2\%$ [1]

10. (c) Any ONE of the followings : [1]

* Use another transformer to step up the voltage AB to a higher voltage.
* Replace the transmission cables with another one of lower resistance

< Since the transformers are ideal, answers involving reduce power loss of transformers are not accepted >

11. (a) (i) By $P = EA$

$\therefore (7.5 \times 10^3) = (5.4 \times 10^6 \times 1.6 \times 10^{-19}) A$ [1]

$\therefore A = 8.68 \times 10^{13}$ Bq [1]

(ii) Decay constant .

$k = \dfrac{\ln 2}{87.7 \times 365 \times 24 \times 3600} = 2.506 \times 10^{-10}\ s^{-1}$ [1]

By $A = kN$

$\therefore (8.68 \times 10^{13}) = (2.506 \times 10^{-10}) N$

$\therefore N = 3.46 \times 10^{23}$ [1]

Initial mass :

$M = \dfrac{3.46 \times 10^{23}}{6.02 \times 10^{23}} \times 0.238 = 13.7$ kg < accept 13.6 to 13.8 kg > [1]

(iii) $P = (7500)\left(\dfrac{1}{2}\right)^{\frac{36.7}{87.7}}$ [1]

$= 6400$ W [1]

OR

$P = (7500)\, e^{-\frac{0.693 \times 36.7}{87.7}}$ [1]

$= 6400$ W

(b) (i) $^{238}_{94}Pu \longrightarrow {}^{206}_{82}Pb + a(^4_2\alpha) + b(^0_{-1}\beta)$

$238 = 206 + 4a \qquad \therefore a = 8$ [1]

$94 = 82 + 8 \times 2 - b \qquad \therefore b = 4$ [1]

There are 8 alpha particles and 4 beta particles emitted in the series.

(ii) There is no change of atomic number and mass number for γ emission. [1]

OR

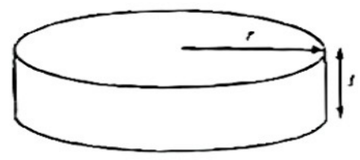
No new element is formed for γ emission

Section A : Astronomy and Space Science

1.1 B

Total volume of the galaxy $= \pi r^2 \times t = \pi \times (6 \times 10^5 \times \frac{1}{2})^2 \times (5 \times 10^3) = 1.41 \times 10^{15}$ ly^3

Average volume occupied by each star $= s^3 = (4.5)^3 = 91.1$ ly^3



Let the number of stars in the galaxy be n.

$\therefore 91.1 \times n = 1.41 \times 10^{15}$

$\therefore n = 1.55 \times 10^{13} \approx 10^{13}$

1.2 D

(1) According to Kepler's 1st law, the orbit is elliptical, not circular.

(2) According to Kepler's 2nd law, the planets sweep equal area in equal time, that means the planets move faster when they are close to the Sun, and move slower when they are far away from the Sun

(3) According to Kepler's 1st law, the Sun is at the focus of the ellipse, not at the centre.

1.3 A

(1) When Mars moves across the background stars from East to West night by night, it undergoes retrograde motion.

(2) During retrograde motion, Earth overtakes Mars at the same side of the Sun.

(3) Both of the two models can explain retrograde motion by using different approaches.

1.4 C

By $\theta = \dfrac{2R}{d}$

$\therefore (2 \times 10^{-6}) = \dfrac{2 \times (4 \times 10^{11})}{d}$

$d = 4 \times 10^{17}$ m $= \dfrac{4 \times 10^{17}}{3.09 \times 10^{16}}$ pc $= 12.945$ pc

By $p = \dfrac{1}{d}$

$\therefore p = \dfrac{1}{12.945} = 0.077$ arc second

1.5 B

By $b = \dfrac{L}{4\pi d^2}$ $\quad (6.5 \times 10^{-9}) = \dfrac{L}{4\pi (15 \times 3.09 \times 10^{16})^2}$ $\quad L = 1.755 \times 10^{31}$ W

By $L = 4\pi R^2 \sigma T^4$ $\quad (1.755 \times 10^{31}) = 4\pi (4 \times 10^9)^2 (5.67 \times 10^{-8}) T^4$

$\therefore T = 19800 \approx 20\,000$ K

1.6 D

By $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

With the same source, the speed v of the source is the same.

$\therefore \frac{(40)}{(415)} = \frac{v}{c} = \frac{\Delta\lambda}{(572)}$ $\quad \therefore \Delta\lambda = 55$ nm

To have red shifted, the wavelength is longer

$\therefore \lambda' = 572 + 55 = 627$ nm

1.7 D

By $T = \frac{2\pi r}{v}$

$\therefore (2.25\times10^8\times365\times24\times3600) = \frac{2\pi r}{(220\times10^3)}$

$\therefore r = 2.48\times10^{20}$ m $= \frac{2.48\times10^{20}}{3.09\times10^{16}}$ pc $= 8040$ pc $= 8$ kpc

1.8 A

✓ (1) Since the curve shows the intensity of each wavelength,
the total area under the curve represents the total intensity emitted by the star

✗ (2) The area under the curve should be proportional to T^4, where T is the surface temperature of the star

✗ (3) By $L = \sigma A T^4 = 4\pi R^2 \sigma T^4$, as the temperature T of A is higher, the radius R of A should be smalle

Q1. (a) (i) gravitational force [1]

(ii) By $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $\quad \therefore mv^2 = \frac{GMm}{r}$ [1]

$\therefore K = \frac{1}{2}mv^2 = \frac{GMm}{2r}$ [1]

Gravitational potential energy : $U = -\frac{GMm}{r}$

Total mechanical energy : $E = K + U = (\frac{GMm}{2r}) + (-\frac{GMm}{r}) = -\frac{GMm}{2r}$ [1]

(iii) By $E = -\frac{GMm}{2r}$

as E decreases, radius of orbit r decreases. [1]

By $K = \frac{GMm}{2r}$

as r decreases, kinetic energy K increases. [1]

(b) (i) By $\frac{GMm}{r^2} = mr\omega^2$

$\therefore \frac{GM}{r^3} = \omega^2 = \left(\frac{2\pi}{T}\right)^2$

$\therefore \frac{(6.67\times10^{-11})(6\times10^{24})}{r^3} = \left(\frac{2\pi}{12\times3600}\right)^2$

$\therefore r = 2.66\times10^7$ m [1]

Total mechanical energy :

$E = -\frac{GMm}{2r} = -\frac{(6.67\times10^{-11})(6\times10^{24})(5000)}{2(2.66\times10^7)} = -3.75\times10^{10}$ J <accept -3.76×10^{10} J> [1]

(ii) By conservation of energy :

$\therefore (-3.75\times10^{10}) + (4\times10^{10}) = \frac{1}{2}(5000)v^2$ [1]

$\therefore v = 990$ m s^{-1} < accept 975 to 985 m s^{-1} > [1]

Section B : Atomic World

2.1 A

✓ (1) According to classical electromagnetic theory,
a moving charge would emit electromagnetic radiation continuously.

× (2) Since the electron emits radiation, its energy would gradually decrease and cannot be constant.
Moreover, as the energy decreases, the electron would move gradually towards the nucleus
and the atom would collapse.

× (3) Since the energy of the electron varies continuously,
the spectrum emitted by the electron should be continuous but not discrete.

2.2 C

By Einstein's Photoelectric equation : $E = \phi + K_{max}$

① $\frac{hc}{\lambda_1} = \phi + e(V_s)$

② $\frac{hc}{\lambda_2} = \phi + e(1.5V_s)$

$\frac{\frac{hc}{\lambda_1} - \phi}{\frac{hc}{\lambda_2} - \phi} = \frac{V_s}{1.5V_s} = \frac{2}{3}$

$\therefore \phi = \frac{3hc}{\lambda_1} - \frac{2hc}{\lambda_2} = (6.63\times10^{-34})(3\times10^8)\left(\frac{3}{650\times10^{-9}} - \frac{2}{450\times10^{-9}}\right) = 3.4\times10^{-20}\ J$

2.3 B

× A The colour of the monochromatic light depends on the frequency of the light.
The higher the frequency, the greater is the energy of the incident photons.
By $E = \phi + K_{max}$, the maximum kinetic energy of the photoelectrons increases.

× B The intensity of the monochromatic light only affect the number of incident photons,
but not the energy of the photons.

× C The material of the cathode metal affects the work function,
thus affect the maximum kinetic energy of the photoelectrons emitted.

× D When the photoelectrons are emitted from the cathode,
they would accelerate to the anode if the anode is positive,
or decelerate to the anode if the anode is negative,
thus the final kinetic energy reaching the anode would be affected.

2.4 A

De Broglie wavelength : $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_k}} = \frac{h}{\sqrt{2mqV}} \propto \frac{1}{\sqrt{mq}}$

$\frac{\lambda'}{\lambda} = \sqrt{\frac{m}{4m}} \times \sqrt{\frac{q}{2q}} \quad \therefore \lambda' = 0.35\lambda$

2.5 B

Since intensity is proportional to the power of radiation for the same area, the power remains unchanged.

By $P = \frac{N}{t}hf$, frequency f is inversely proportional to the number of photons per second.

Since saturation current : $I = \frac{n}{t}e$ and $\frac{n}{t} \propto \frac{N}{t}$, thus the frequency f is inversely proportional to the saturation current.

$\frac{I'}{I} = \frac{f}{1.2f} \quad \therefore I' = 0.83I$

2.6 C

Angular separation of the two objects : $\theta = \frac{a}{L} = \frac{(0.04)}{(5\times10^3)} = 8\times10^{-6}$ rad

By Rayleigh criterion, resolving power $\theta = 1.22\frac{\lambda}{d}$

$\therefore (8\times10^{-6}) = 1.22\times\frac{(550\times10^{-9})}{d}$

$\therefore d = 0.084\ m = 8.4\ cm$

2.7 B

× (1) Since the bumps are of nanoscale,
the resolving power of optical microscope is not high enough to observe

✓ (2) Since the leave surface is highly hydrophobic, water forms spherical droplets that can roll off easily

× (3) There may be dirt on the surface of the leave.
Only when there is rain water falling onto the leave surface,
water droplets can carries away the dirt to make it clean

2.8 A

✓ (1) This is exactly the working principle of a TEM.

× (2) De Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_k}} = \frac{h}{\sqrt{2mqV}} \propto \frac{1}{\sqrt{V}}$

The higher the voltage, the smaller the de Broglie wavelength.
By Rayleigh criterion, resolving power : $\theta = 1.22\frac{\lambda}{d}$
The smaller the wavelength, the smaller the angle θ, thus the higher the resolving power.

(3) After passing through the sample,
the electron beam is focused and projected by objective lens and projection lens, not condensing lens.

Q2 (a) The electron inside the atom is bounded to the atom. (OR attracted by the nucleus) [1]

(b) (i) $E = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34})(3\times10^{8})}{(4.875\times10^{-7})} = 4.08\times10^{-19}\ J = 2.55\ eV$ [1]

(ii) $E_n - (-3.4) = 2.55 \quad \therefore E_n = -0.85\ eV$ [1]

The transition is from E_4 to E_2 [1]

(c) (i) Momentum of the electron :

$p = \sqrt{2mE_k} = \sqrt{2(9.11\times10^{-31})(13.6\times1.6\times10^{-19})} = 1.99\times10^{-24}\ N\,s$ [1]

De Broghe wavelength :

$\lambda = \frac{h}{p} = \frac{(6.63\times10^{-34})}{(1.99\times10^{-24})} = 3.33\times10^{-10}\ m$ [1]

(ii) By $mvr = n\frac{h}{2\pi}$

$(1.99\times10^{-24})r_1 = (1)\frac{(6.63\times10^{-34})}{2\pi}$ [1]

$\therefore r_1 = 5.30\times10^{-11}\ m$ [1]

(d) The discrete lines of the emission spectrum of hydrogen by a gas discharge tube give evidence. [1]

Each discrete line corresponds to a photon of certain energy equal to the difference of two energy levels, thus energy levels must be discrete. [1]

Section C : Energy and Use of Energy

31 B

Power of the air-conditioner

$E = Pt$

$(1620\ kW\,h) = P(1200\ h) \quad \therefore P = 1.35\ kW$

$COP = \frac{Q_c/t}{P} = \frac{3.78}{1.35} = 2.8$

Rate of heat rejected to environment :

$\frac{Q_H}{t} = \frac{Q_c}{t} + \frac{W}{t} = 3.78 + 1.35 = 5.13\ kW$

32 C

$XP = \sqrt{3^2+2^2} = 3.606\ m \quad \theta = \tan^{-1}(\frac{2}{3}) = 33.7°$

Illuminance at P due to lamp X $E = \frac{\Phi}{4\pi r^2}\cos\theta = \frac{500}{4\pi(3.606)^2}\cos33.7° = 2.546\ lux$

Illuminance at P due to lamp Y: $E = \frac{\Phi}{4\pi r^2}\cos\theta = \frac{500}{4\pi(3)^2}\cos0° = 4.421\ lux$

Total illuminance at P = 2.546 + 4.421 = 7.0 lux

33 A

A. The bottom of the cookware and the cooker should be in close contact without air gap so that the magnetic field can effectively be guided to the cookware.

* B. There is no eddy current induced at the cooker. The eddy current is induced in the cookware

* C. The solenoid inside the cooker produces high frequency varying magnetic field, not steady. Only varying magnetic field can induce eddy current in the cookware.

* D. The surface of an induction cooker may be made of non-ferrous material, such as glass. However, the bottom of the cookware should be made of ferrous material so that the magnetic field produced by the solenoid can be increased and effectively guided to the cookware for inducing eddy current.

34 C

Total area of the four walls and the ceiling = $9\times4\times2 + 3\times4\times2 + 9\times3 = 123\ m^2$

Rate of heat flow into the house from surrounding = $30\times123 = 3690\ W$

Total rate of heat gain in the house = 3690 + 1500 + 300 = 5490 W

The minimum cooling capacity of the air-conditioning system should be 5490 W

By $COP = \frac{Q_c/t}{P}$

$P = \frac{5490}{2.25} = 2440\ W$

3.5 B

Let the temperature of the interface be θ.

By $\frac{Q}{t} = k\frac{A(T_H - T_C)}{d}$

Since the rate of heat flow through the two materials must be the same,

$\therefore k\frac{A(T_H - T_C)}{d}$ = constant

$\therefore (1.2)\frac{(40 - \theta)}{(15)} = (1.5)\frac{(\theta - 20)}{(10)}$

$\therefore \theta = 27\ ^\circ C$

3.6 B

By $(220)(15)(5 \times 3600) \times 65\% = 180 \times 10^3 \times d$

$\therefore d = 215$ km

3.7 A

(1) In the p-n junction, positive holes move to the n-layer and negative electrons move to the p-layer. Thus, an electric field is created pointing from n-layer to p-layer across the junction.

(2) Light photons knock out electrons to give free holes and free electrons

(3) The electrons move against the direction of the electric field to the n-layer, then flow out via the load to the p-layer and rejoin the holes there.

3.8 D

$P_{out} = \frac{1}{2}\rho A v^3 \times \eta$

$(250 \times 10^3) = \frac{1}{2}(1.2)(\pi r^2)(12)^3 \times 35\%$

$\therefore r = 14.8$ m

Diameter : $d = 2r = 29.6$ m

Q3 (a) Mass defect = 235.044 − 143.912 − 89.902 − 1.0087 = 0.2213 u [1]

Nuclear energy release in each fission = $0.2213 \times 931 \times 10^3 \times 1.6 \times 10^{-19} = 3.30 \times 10^{-11}$ J [1]

OR

Nuclear energy release in each fission = $(0.2213 \times 1.661 \times 10^{-27}) \times (3 \times 10^8)^2 = 3.31 \times 10^{-11}$ J [1]

(b) $\frac{M}{0.235} \times 6.02 \times 10^{23} \times 3.30 \times 10^{-11} \times 35\% = (500 \times 10^6) \times (24 \times 3600)$ [1]

$M = 1.46$ kg [1]

(c) ① The pressurized water acts as coolant.

It gains energy from the reactor to produce steam that drive the generator to produce electricity [1]

② The pressurized water acts as moderator.

It slows down the fission neutrons to increase the chance of capture by U-235 [1]

(d) $Pt \times \eta = \frac{m}{t} g h$

$(500 - 350) \times 10^6 \times 72\% = \frac{m}{t}(9.81) \times (250)$ [1]

$\frac{m}{t} = 44000$ kg s^{-1} [1]

(e) Any TWO of the followings : [1×1]

* The fission reactor is enclosed in thick concrete walls.
* The reactor can be shut down by inserting all the control rods into the core of the reactor
* The coolant which is radioactive is enclosed in the reactor to avoid leakage of radiation.

Section D : Medical Physics

4.1 A

By $L_2 - L_1 = 10\log\frac{I_2}{I}$

$(55) - (70) = 10\log\frac{I_2}{I_1}$ $\quad \frac{I_2}{I_1} = 0.0316$

By $\frac{I_2}{I_1} = (\frac{d_1}{d_2})^2$

$\therefore (0.0316) = (\frac{2}{d_2})^2$ $\quad d_2 = 11.2$ m

4.2 B

By $d = \frac{1}{2}c\Delta t$

$\therefore \frac{d_1}{d_2} = \frac{c_1}{c_2}\cdot\frac{t_1}{t_2}$

$\frac{(2.4)}{(d)} = \frac{(1460)}{(1550)}\cdot\frac{(2)}{(3)}$

$d = 3.82$ cm

4.3 B

Acoustic impedance of fat : $Z_1 = 1450 \times 952 = 1.38$ MRayl

Acoustic impedance of liver : $Z_2 = 1620 \times 1032 = 1.67$ MRayl

Intensity reflection coefficient from fat to liver :

$\alpha = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2} = \frac{(1.67 - 1.38)^2}{(1.67 + 1.38)^2} = 9.04 \times 10^{-3}$

Intensity of ultrasound reflected from the interface :

$I_r = \alpha I_o = (9.04 \times 10^{-3}) \times (22.5) = 0.20$ mW cm^{-2}

4.4 B

By $I = I_o e^{-\mu x}$ $\quad \frac{I}{I_o} = e^{-\mu x}$

For the first tissue with thickness x and attenuation coefficient μ

$\frac{I}{I_o} = e^{-\mu x} = 40\%$

For the second tissue with thickness $1.5x$ and attenuation coefficient 0.8μ :

$\frac{I'}{I_o} = e^{-0.8\mu(1.5x)} = (e^{-\mu x})^{1.2} = (40\%)^{1.2} = 33.3\%$

The percentage of intensity that can be transmitted through the second tissue is 33.3%

4.5 D

By $\sin c = \frac{n_{shell}}{n_{core}} = \frac{(1.38)}{(1.64)}$ $\quad c = 57.3°$

Angle of refraction at air-core interface :

$\theta_{core} = 90° - 57.3° = 32.7°$

By $n_{air}\sin\theta_{air} = n_{core}\sin\theta_{core}$

$\therefore (1)\sin\theta_{max} = (1.64)\sin 32.7°$

$\therefore \theta_{max} = 62.4°$

4.6 A

✓ (1) Since CT scan records multiple X-ray projections that are used for back projection to reconstruct the attenuation coefficients of different body tissues, even very small difference of tissue contrast can be distinguished.

✓ (2) Since CT scan can show the transaxial anatomy, it can overcome the problem of superimposition of different tissues.

× (3) Since CT scan takes multiple projections, the radiation dosage is much higher than X-ray radiographic imaging.

4.7 C

By $\frac{1}{T_t} = \frac{1}{T_s} + \frac{1}{T_p}$

$\frac{1}{T_t} = \frac{1}{(2\times 24)} + \frac{1}{(6)}$

$T_t = 5.33$ hours

By $A = A_o(\frac{1}{2})^{t/T_t}$

$\therefore A = (1250)(\frac{1}{2})^{3.0/5.33} = 846$ Bq

4.8 B

× (1) Since penetration power of γ radiation is very high, there is no attenuation in the human body.

× (2) RNI gives worse resolution of image, thus it cannot show clearly the structure of the organ.

✓ (3) RNI image is used for study of organ function.
Cold spot means that it cannot function normally.
Hot spot means that there is abnormal metabolism that may be due to tumour.

Q4. (a) Cones, used for colour vision. [1]

Rods, used for black and white vision in dim light. [1]

(b) (i) By Rayleigh criterion, resolving power :

$$\theta = 1.22\frac{\lambda}{d} = 1.22 \times \frac{625\times10^{-9}}{3.5\times10^{-3}} = 2.18\times10^{-4}\text{ rad}$$ [1]

By $\theta = \frac{a}{L}$

$$\therefore (2.18\times10^{-4}) = \frac{(2.4\times10^{-3})}{L} \quad \therefore L = 11.0\text{ m}$$ [1]

(ii) In dim environment, size of pupil increases, resolving power increases ($\theta\downarrow$), thus L increases. [1]

(c) (i) By $P = \frac{1}{u} + \frac{1}{v}$

$$\therefore (-1.36) = \frac{1}{(\infty)} + \frac{1}{v}$$ [1]

$\therefore v = -0.735$ m

$\therefore$ His far-point distance without spectacles is 0.735 m (**OR** 73.5 cm) [1]

(ii) $P = \frac{1}{u} + \frac{1}{v} = \frac{1}{0.735} + \frac{1}{0.026} = +39.8$ D [1]

(iii) By $P = \frac{1}{u} + \frac{1}{v}$

$$\therefore (-1.36) = \frac{1}{u} + \frac{1}{(-0.25)}$$ [1]

$\therefore u = 0.379$ m

After wearing spectacles, his near point distance becomes 0.379 m (**OR** 37.9 cm) [1]