HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 2

CANDIDATE NAME		**CT GROUP**	**23S**
CENTRE NUMBER		**INDEX NUMBER**	

PHYSICS

9749/01

Paper 1 Multiple Choice

17 September 2024

1 hour

Additional Materials: Optical Mark Sheet

INSTRUCTIONS TO CANDIDATES

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, CT, NRIC or FIN number on the optical mark sheet (OMS). Shade your NRIC or FIN in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate OMS.

Each correct answer will score one mark. A mark will **not** be deducted for a wrong answer.

Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space,
$c = 3.00 \times 10^8 \text{ m s}^{-1}$

permeability of free space,
$\mu_o = 4\pi \times 10^{-7} \text{ H m}^{-1}$

permittivity of free space,
$\varepsilon_o = 8.85 \times 10^{-12} \text{ F m}^{-1}$
$\approx (1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$

elementary charge,
$e = 1.60 \times 10^{-19} \text{ C}$

the Planck constant,
$h = 6.63 \times 10^{-34} \text{ J s}$

unified atomic mass constant,
$u = 1.66 \times 10^{-27} \text{ kg}$

rest mass of electron,
$m_e = 9.11 \times 10^{-31} \text{ kg}$

rest mass of proton,
$m_p = 1.67 \times 10^{-27} \text{ kg}$

molar gas constant,
$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

the Avogadro constant,
$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

the Boltzmann constant,
$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$

gravitational constant,
$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$

acceleration of free fall,
$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\,\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/\,^\circ\text{C} + 273.15$
pressure of an ideal gas	$P = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$ $= \pm \omega \sqrt{(x_o^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o n I$
radioactive decay	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

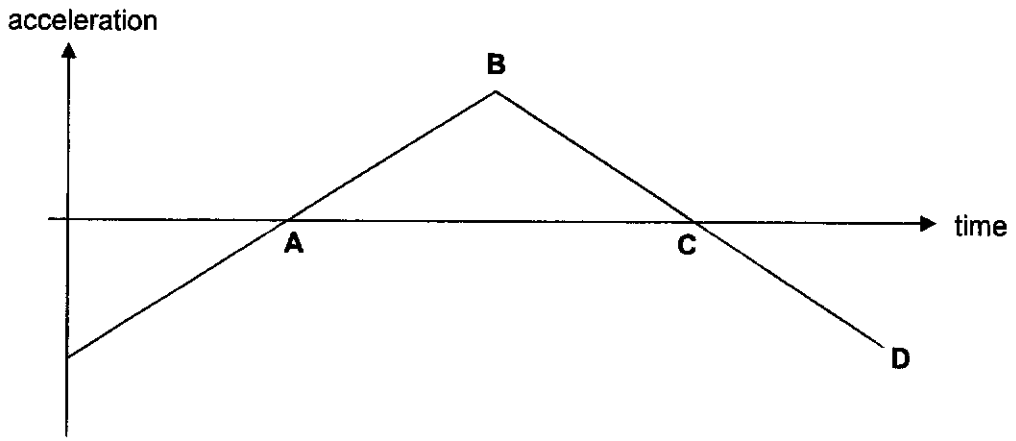
1 A thermometer can be read to an accuracy of ± 0.5 °C. This thermometer is used to measure a temperature rise from 20 °C to 80 °C.

What is the percentage uncertainty in the measurement of the temperature rise?

A 0.5 % **B** 0.8 % **C** 1.3 % **D** 1.7%

2 The acceleration–time graph of an object moving along a straight line is shown below. The object was initially at rest.

At which point on the graph is the object farthest from the starting point?



3 An elevator is moving downwards with a downward acceleration of 5.8 m s^{-2}. A ball, held 2.0 m above the floor of the elevator and at rest with respect to the elevator, is released.

How long does it take for the ball to reach the floor of the elevator?

A 0.51 s **B** 0.64 s **C** 0.83 s **D** 1.0 s

4 A man walking inside a shallow swimming pool managed to accelerate himself forward with a constant horizontal acceleration, a. Given the following information, which equation describes the horizontal motion of the man?

Mass of man: m

Upthrust: U

Drag force of water: f_D

Frictional force from the floor of the pool: f

Acceleration due to gravity: g

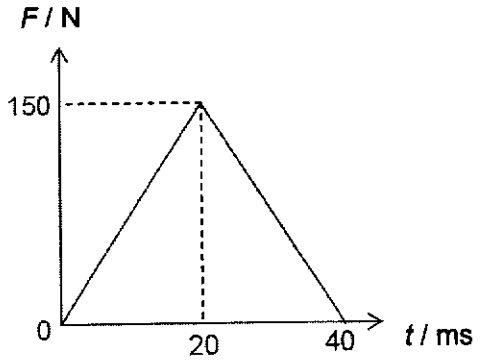
A $f - f_D = ma$

B $mg - U = ma$

C $f_D - f + mg - U = ma$

D $f - f_D + U = ma$

5 The graph shows the force delivered to an incoming ball by a tennis player. After the impact, the 60 g ball leaves the racket with a speed of 30 m s^{-1}.



What was the magnitude of the momentum, in N s, of the tennis ball before the player hit it?

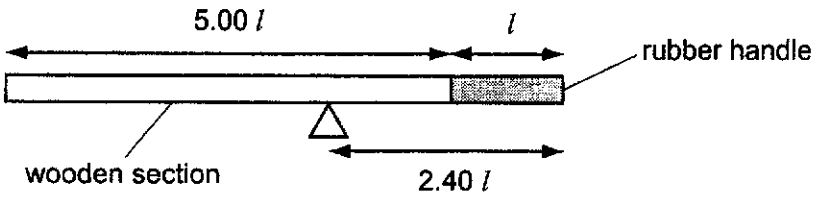
A 1.2 **B** 1.8 **C** 4.8 **D** 20

6 A thruster is used to launch a 500 kg rocket vertically upward from rest. This thruster ejects exhaust at a speed of 1000 m s^{-1}.

What should be the minimum rate, in kg s^{-1}, at which the exhaust leaves the thruster at the instant of launch?

A 0.5 **B** 2.0 **C** 4.9 **D** 20

7 A uniform rod has a wooden section and a solid rubber handle, as shown.

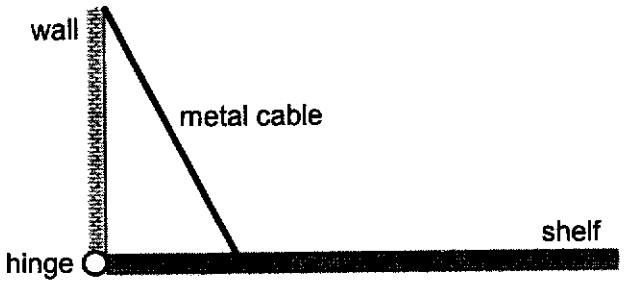


The length of the handle is l and the length of the wooden section is 5.00 l. The rod balances a distance 2.40 l from the rubber end.

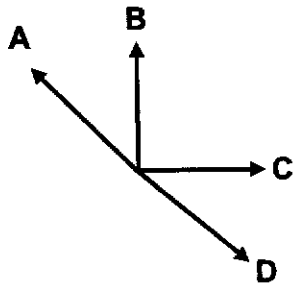
What is the ratio $\frac{\text{density of rubber}}{\text{density of wood}}$?

A 5.42 **B** 5.00 **C** 2.89 **D** 0.345

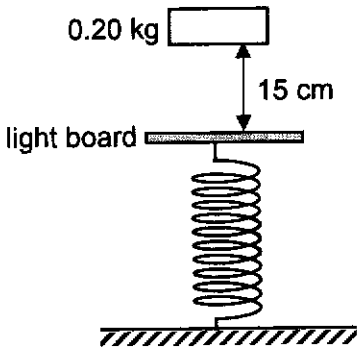
8 A shelf made of uniform material is held horizontally against a wall by a metal cable. The forces acting on the shelf are its weight, the force exerted by the metal cable, and the force exerted by the hinge.



Which arrow could represent the direction of the force the hinge exerts on the shelf?



9 A block of mass 0.20 kg is dropped from a height of 15 cm above a light spring of spring constant 85 N m^{-1}, as shown below. The block lands on a light board and compresses the spring.



Determine the maximum compression of the spring.

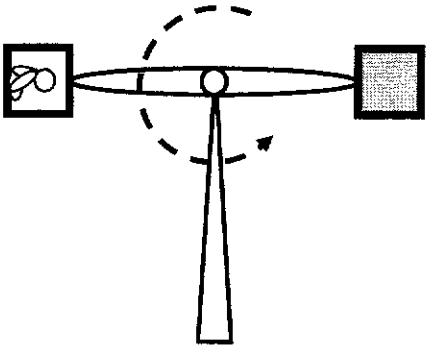
A 2.3 cm **B** 4.6 cm **C** 8.3 cm **D** 11 cm

10 A speed boat with two engines, each of power 32 kW, can travel at a maximum speed of 14 m s^{-1}. The total drag force on the boat is directly proportional to the speed of the boat.

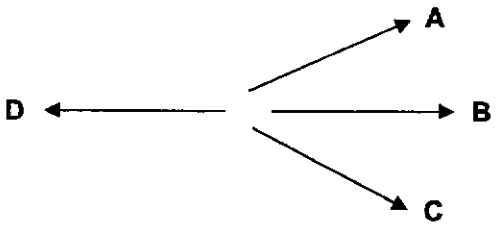
What is the maximum speed of the boat when only one engine is working?

A 3.5 m s^{-1} **B** 7.0 m s^{-1} **C** 9.9 m s^{-1} **D** 11 m s^{-1}

11 In an amusement park ride, a person sits in a cage which moves in a vertical circle at a constant speed. The person stays stationary with respect to the cage.

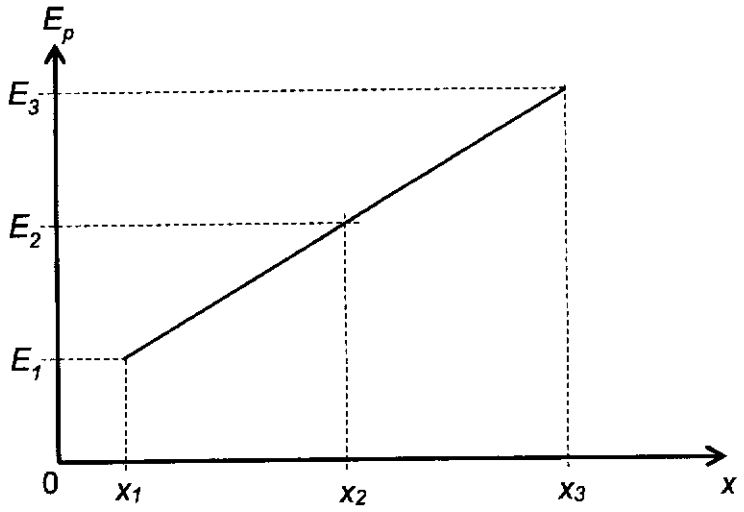


At the instant shown, what is the direction of the force exerted by the cage on the person?



12 An object of mass m is moving radially away from Earth of mass M.

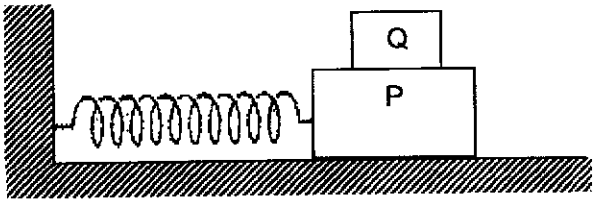
For a small distance x above the surface of the Earth, the variation with x of the stone's gravitational potential energy E_p is shown. At a point a distance x_2 from the surface of the Earth, the potential energy of the stone is E_2.



What is the magnitude of the force acting on the stone?

A $\frac{GMm}{(x_2)^2}$ **B** $\frac{E_2}{x_2}$ **C** $\frac{E_3 - E_1}{x_3 - x_1}$ **D** $\frac{(x_1 + x_2) \times (E_2 + E_1)}{4}$

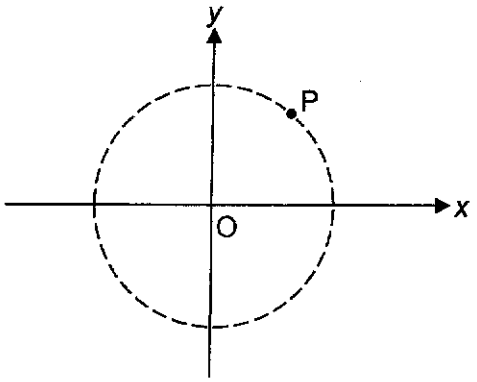
13 A system consisting of a large block P with a smaller block Q resting on it, oscillates on a frictionless surface with a frequency of 1.5 Hz. The maximum static friction *between* the two blocks is 5.0 N.



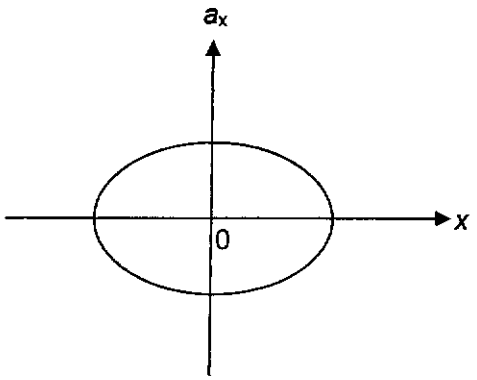
If the mass of P is 2.0 kg and the mass of Q is 0.20 kg, what is the maximum amplitude of oscillation of the system in order that block Q does not slip?

A 0.026 m **B** 0.028 m **C** 0.056 m **D** 0.28 m

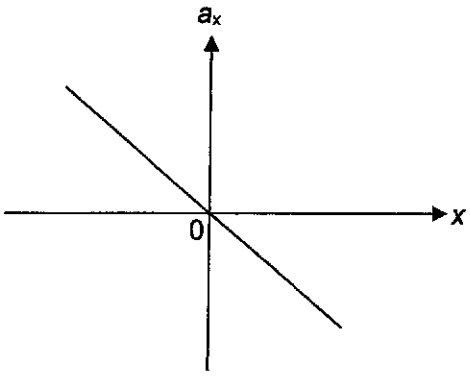
14 A particle P performs uniform circular motion about the origin O in the *x*-*y* plane as shown below.



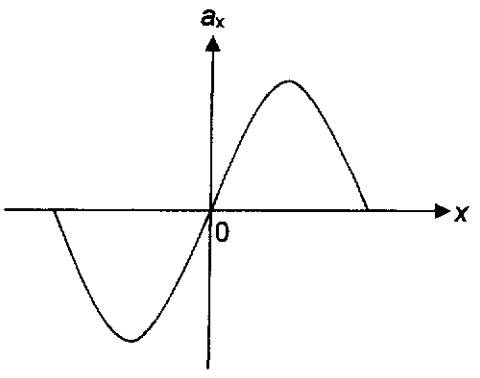
Which of the following graphs shows the relationship between the *x*-component of the acceleration a_x and the displacement in the *x*-direction?



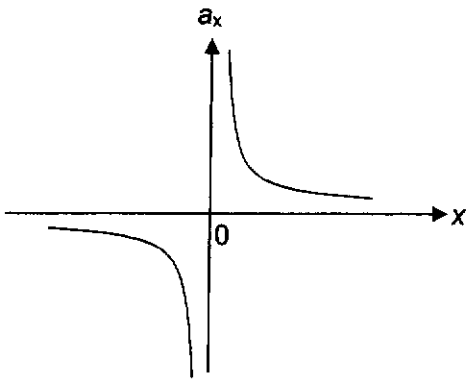
A



B

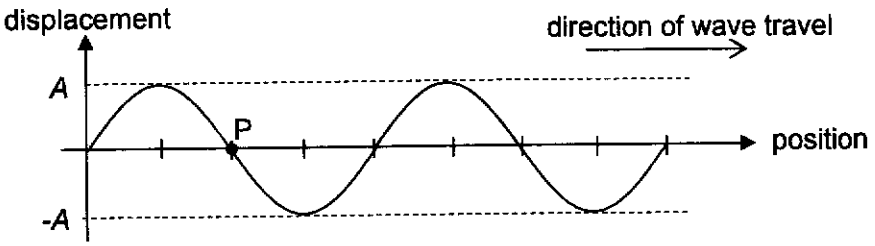


C



D

15 The displacement-position graph of a progressive wave is shown below. Particle P is a point along the wave.



Which of the following statements is **true** about particle P at the instant shown in the graph?

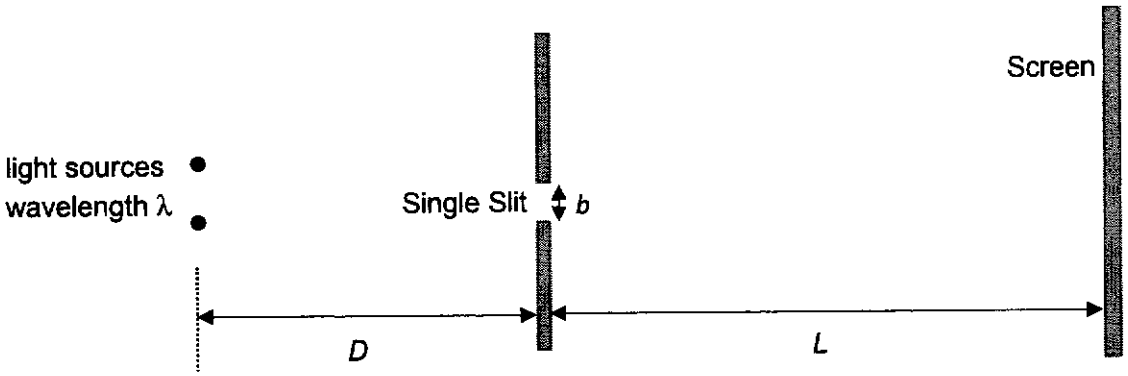
A It is moving towards the negative direction.

B It has zero velocity.

C It has an amplitude of *A*.

D It is experiencing the largest acceleration.

16 Two monochromatic light sources of wavelength λ are separated by a fixed distance. Light from the sources pass through a single slit of width *b* at a distance of *D*. The image of the light sources is projected on a screen at a distance *L* from the single slit.



One is just able to distinguish that there are two light sources from the image captured on the screen.

For the image captured on screen, which of the following changes will make it easier to distinguish that there are two light sources?

A λ is increased.

B *D* is reduced.

C *b* is decreased.

D *L* is increased.

17 White light (400 - 700 nm) is directed perpendicularly towards a diffraction grating. The diffraction grating has 300 lines per mm and the resulting image is projected on a screen.

What is the highest order of diffraction whereby a complete spectrum (red to violet) which does not overlap with the next order is clearly visible?

A 1st order **B** 2nd order **C** 3rd order **D** 4th order

18 In deriving the equation $p = \frac{1}{3}\rho\langle c^2\rangle$ using the kinetic theory of gases, which of the following is **not** a valid assumption?

A The volume of the molecules is negligible compared with the volume of the gas.

B The duration of a collision is negligible compared with the time between collisions.

C The molecules experience negligible change of momentum on collision with the walls of the container.

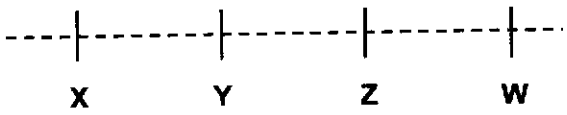
D Collisions with the walls of the container and with other molecules cause no change in the average kinetic energy of the molecules.

19 N molecules of a monatomic ideal gas are contained in a rigid box at pressure p and temperature T. An additional N molecules of the same gas are added to the box in such a way that the internal energy is kept constant at its original value.

Which of the following indicates the values of the temperature and pressure of the gas after the addition?

	temperature	pressure
A	$\frac{1}{2}T$	p
B	$\frac{1}{2}T$	$\frac{1}{2}p$
C	T	$2p$
D	T	p

20 X, Y, Z and W are four points on a straight line as shown below. The points are equally spaced apart.



A point charge +Q is fixed at X. When another point charge -Q is moved from Y to Z, which of the following statements is **false**?

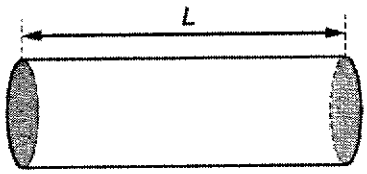
A The electric potential energy of the system of charges will increase.

B The magnitude of the electric field strength at point W will increase.

C The electric potential at point W will increase.

D The electric potential at point Y will become zero.

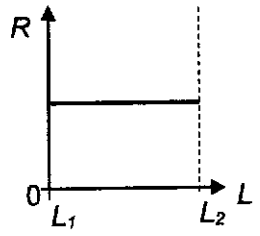
21 A piece of conducting modelling clay of constant resistivity is formed into a cylindrical shape. The resistance *R* between its flat ends (shaded) is measured.



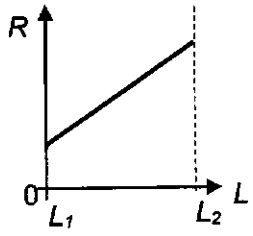
The same volume of modelling clay is re-formed into cylinders of different lengths *L* in the range of L_1 to L_2 and the resistance *R* between the flat ends is measured for each value of *L*.

Which graph best shows the variation of *R* with *L*?

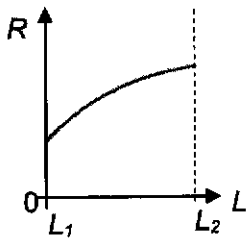
A



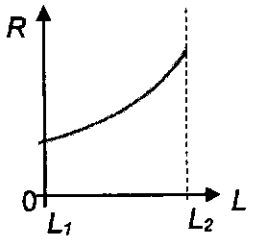
B



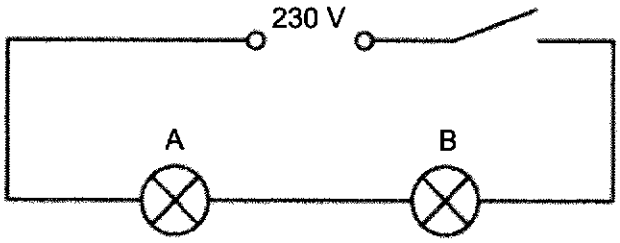
C



D



22 In the circuit shown, lamp A is rated 230 V, 10 W and lamp B is rated 230 V, 40 W. The two lamps are connected in series to a 230 V power supply.



Assume that the resistance of each lamp remains constant at all temperatures.

Which statement most accurately describes what happens when the switch is closed?

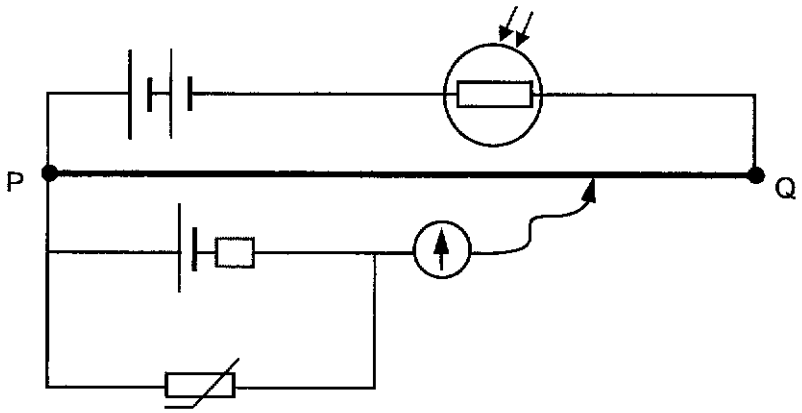
A Lamp A emits twice as much power as lamp B.

B Lamp A emits four times as much power as lamp B.

C Lamp B emits twice as much power as lamp A.

D Lamp B emits four times as much power as lamp A.

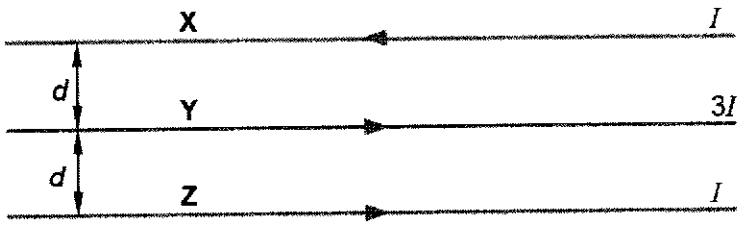
23 A NTC thermistor and a light-dependent resistor are connected in a potentiometer circuit. PQ is a resistance wire.



Which combination of temperature and lighting condition maximises the balance length?

	temperature	lighting
A	low	dark
B	low	bright
C	high	dark
D	high	bright

24 The diagram below shows three long, parallel, straight wires X, Y and Z placed in the same plane in a vacuum. Wires X and Z each carries a current of I, and wire Y carries a current of $3I$. Wire Y is halfway between wire X and wire Z.

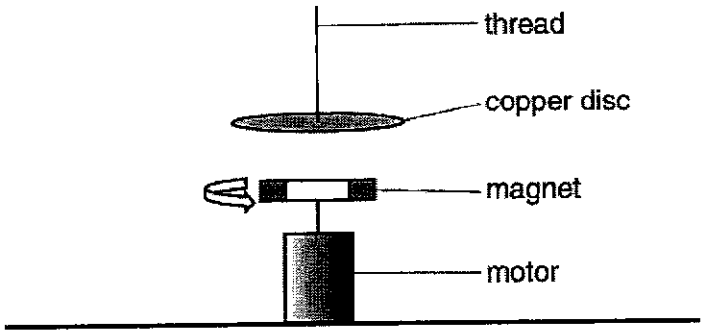


The magnitude of the force per unit length acting between X and Z is F.

What is the direction and magnitude of the net force per unit length acting on Z?

	Direction	Magnitude
A	Towards Y	F
B	Towards Y	$5F$
C	Away from Y	$5F$
D	Away from Y	$7F$

25 A magnet is attached to a motor and rotates below a freely-suspended copper disc as shown below.



Which of the following statements is correct?

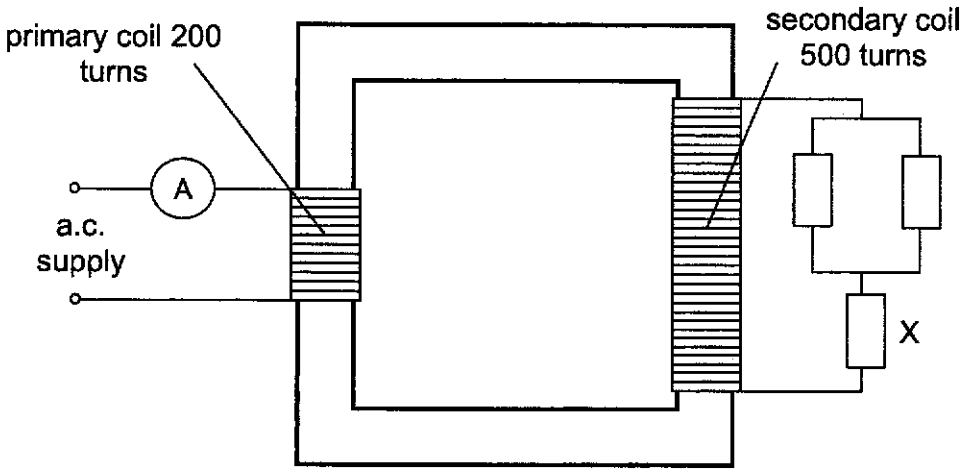
A The disc remains stationary as copper is not magnetic.

B The disc rotates in the same direction as the magnet as copper is magnetic.

C The disc rotates in the same direction as the magnet as eddy currents are induced in the disc.

D The disc rotates in the opposite direction as the magnet as eddy currents are induced in the disc.

26 A 100% efficient transformer is connected to a sinusoidal a.c. supply as shown below. The secondary coil is connected to 3 identical resistors, each of resistance 1000 Ω. The potential difference across resistor X is 80 V.



What is the reading on the ammeter?

A 0.080 A **B** 0.20 A **C** 0.40 A **D** 2.3 A

27 Which of the following statements is **true** when the photoelectric effect occurs?

A The maximum speed of emitted electron is proportional to the intensity of the incident light.

B The maximum energy of the emitted electrons increases with the wavelength of the incident light.

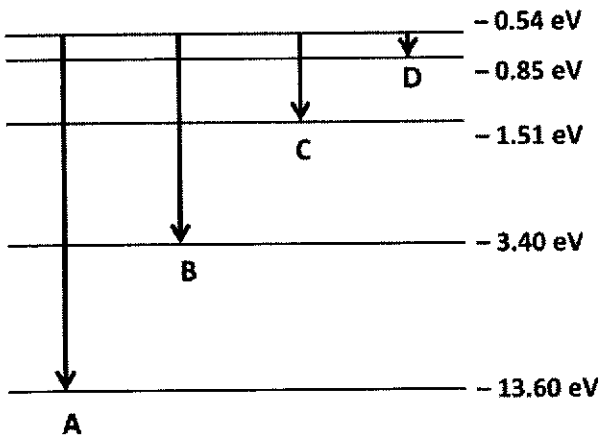
C The number of electrons emitted per unit time is proportional to the intensity of the incident light.

D The wavelength of the incident light must be greater than a certain threshold value.

28 The energy level diagram represents the five lowest energy levels of hydrogen.

A spectral line of wavelength 435 nm corresponds to one of the lines in the spectrum of hydrogen.

Which of the transitions gives this particular spectral line?



29 Two deuterium nuclei undergo a fusion reaction to form a helium nucleus as represented by

$$^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He + \text{energy}$$

The binding energy per nucleon of helium is 2.54 MeV.
The minimum amount of energy released in this reaction is 3.26 MeV.

What is the binding energy per nucleon of deuterium?

A 1.45 MeV **B** 1.73 MeV **C** 3.36 MeV **D** 3.45 MeV

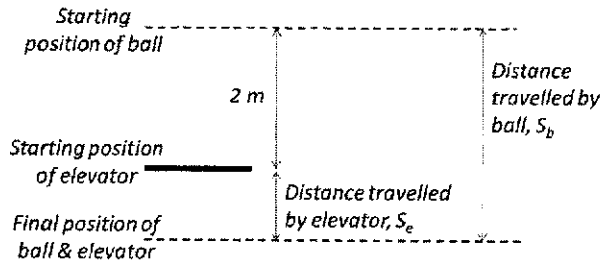
30 A detector detects an average count-rate of 600 counts min^{-1}. Two half-lives later, the count-rate drops to 180 counts min^{-1}.

Determine the average background count-rate, in counts min^{-1}.

A 15 **B** 40 **C** 60 **D** 120

END OF PAPER

Solutions to Paper 1

1	**D**	Temperature difference = $\theta_f - \theta_i = 80 - 20 = 60\ ^\circ C$ Absolute uncertainty, = $\Delta\theta_f + \Delta\theta_i = 0.5 + 0.5 = 1\ ^\circ C$ Percentage uncertainty = $\frac{1^\circ C}{60^\circ C} \times 100\% = 1.7\%$
2	**B**	The object starts from rest and moves along a straight line. Area under the acceleration-time graph represents <u>change</u> in velocity. The triangle below the time axis shows that the change in velocity is in the negative direction. Since the <u>initial velocity is zero</u>, that triangle represents the increasing velocity (in – ve direction). This happens up to the time at A. Beyond A, the acceleration changes direction (from – ve to + ve dir). However, the velocity still points in the – ve direction after A i.e. object continues to travel in the same direction (still getting further away from the starting point), except that since the acceleration and velocity point in opposite directions, the object is slowing down. At point B the object comes to a momentary stop and it is also the furthest from the starting point. Between B and C, the object changes its velocity direction and starts to speed up back towards the starting point. At C, the object possesses maximum speed as it moves towards the starting point. Beyond C, the object slows down but it is still moving towards the starting point. At D, the object is back at the starting point.
3	**D**	 $S_b - S_e = 2$ $2.0 = [ut + (0.5)(9.81)\,t^2] - [ut + (0.5)(5.8)\,t^2]$ t = 1.00 s Or recognise that the effective acceleration = 9.81 – 5.8 = 4.01 m s^{-2}. Using $s = ut + \frac{1}{2}at^2$, $2.0 = \frac{1}{2}(4.01)t^2$, giving t = 1.00 s.
4	**A**	The question asks for the HORIZONTAL forces only. The horizontal force the propels the man forward is the frictional force of pool's floor on his feet. The horizontal resistive force on his motion comes from the drag due to water. Using Newton's second law along the horizontal direction: Net force on man = (mass of man)(acceleration of man) i.e. $f - f_D = ma$

5 **A**

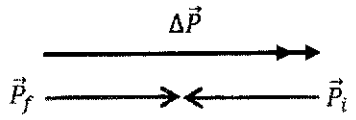
Magnitude of the change in momentum ΔP = area under graph = $\frac{1}{2}(150)(40 \times 10^{-3})$ = $3\ Ns$. This change in momentum takes place in the direction of the force, i.e. opposite to the initial momentum. In the vector diagram below, the ball is approaching the racket from right to left.

$\vec{P}_f - \vec{P}_i = \Delta\vec{P}$

$P_f + P_i = \Delta P$

$(0.060)(30) + P_i = 3$

$P_i = 1.2\ Ns$



6 **C**

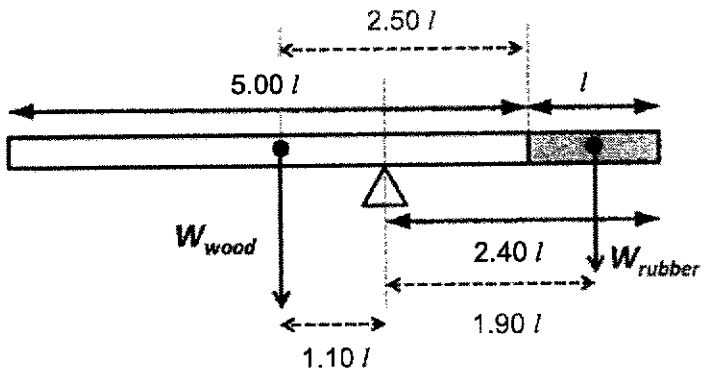
The thrust must provide an upward force to propel the rocket upward. This force must be least at equal to its weight.

Thrust = $v\left(\frac{dm}{dt}\right)$

$v\left(\frac{dm}{dt}\right) = Mg$

$\frac{dm}{dt} = \frac{Mg}{v} = \frac{(500)(9.81)}{1000} = 4.9\ kg\ s^{-1}$

7 **C**



Taking moments about the CG (pivot) and letting A be the x-sectional area,

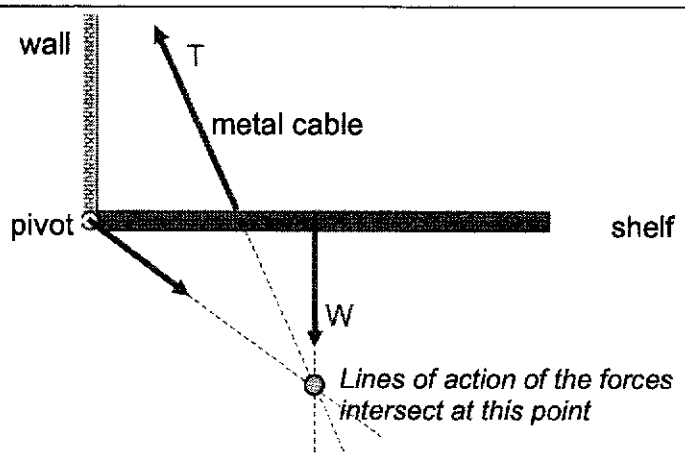
W_{wood} (distance of center-of-mass of wood from pivot) = W_{rubber} (distance of center-of-mass of rubber from pivot)

$A(5.00\ l)\rho_{wood}\, g(1.10\ l) = A(l)\rho_{rubber}\, g(1.90\ l)$

$5.00\ \rho_{wood}(1.10) = \rho_{rubber}(1.90)$

$\frac{\rho_{rubber}}{\rho_{wood}} = \frac{5.50}{1.90} = 2.89$

8 **D**



Lines of action of the three co-planar non-parallel forces intersecting at a point is necessary if the object is in rotational equilibrium.

Vector sum of all forces add to zero is necessary if the object is in translational equilibrium. Hence the answer cannot be A.

9 **D**

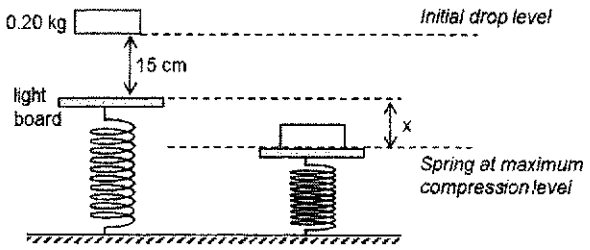
No kinetic energy at the initial drop level as well at at the final maximum compression of spring.
Comparing the total energy at the initial and final positions,
gain in elastic potential energy = total loss in gravitational potential energy

$$\frac{1}{2}kx^2 = mg(0.15+x)$$

$$\frac{1}{2}(85)x^2 = (0.20\times 9.81)(0.15+x)$$

$$42.5x^2 - 1.962x - 0.2943 = 0$$

$$x = 0.109 \text{ m}$$



10 **C**

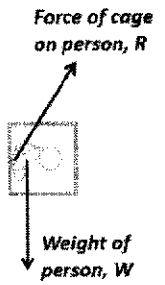
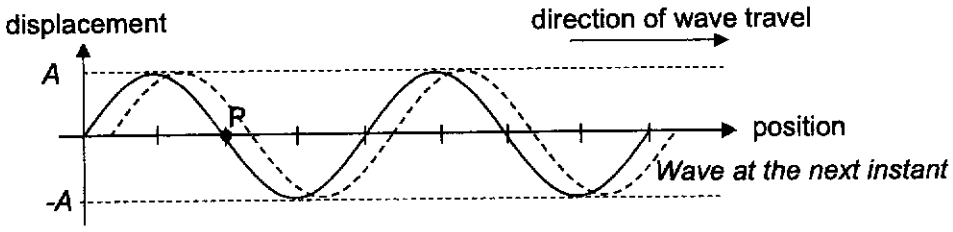
At maximum speed, engine force = drag force of kv.

Power of boat, P = (engine force) v = kv^2

Hence, $\frac{P_{\text{one engine}}}{P_{\text{two engines}}} = \left(\frac{v_{\text{one engine}}}{v_{\text{two engines}}}\right)^2$

$$\frac{32}{64} = \left(\frac{v_{\text{one engine}}}{14}\right)^2$$

$v_{\text{one engine}}$ = 9.9 m s^{-1}

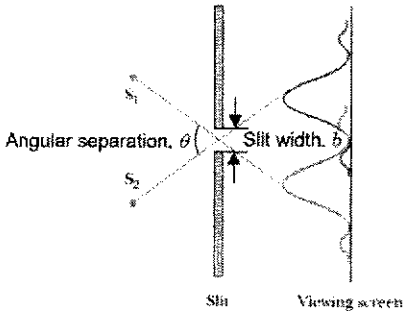
11	**A**	There are only two forces acting on the person, force of cage on him, ***R*** and his weight, ***W***. Since the man is in uniform (i.e. constant speed) circular motion, the net force on him is directed toward the centre of the circle, i.e. toward the right. The vector sum of ***R*** and ***W*** must point toward the right. Vertical component of ***R*** must balance the weight. Horizontal component of ***R*** provides the centripetal force (which is also the net force). 
12	**C**	Option A: The variable x is denoted as the distance *above the surface of the earth*. It is not defined from the centre of the Earth. Option B: $F_g = -\frac{dE_p}{dx}$. The force is the gradient of the $E_p - x$ graph, not ratio of E to x. [whereas the resistance is the ratio V to I, and not the gradient as given by dV/dI.] Option C: $F_g = -\frac{dE_p}{dx}$. Take note, for small distances above the Planet's surface, the gravitational field strength is approximately constant. Hence, the gradient of the graph is the same. Option D: The equation does not adhere to $F_g = -\frac{dE_p}{dx}$.
13	**D**	Frictional force by P on Q is the restoring force for Q. Without friction, Q will not move as P slides underneath it. Net force on Q is provided for by the frictional force by P on Q. friction = $ma = m\omega^2 x$ $5.0 = 0.2\{(2\pi)(1.5)\}^2 A$ A = 0.28 m
14	**B**	The components of the particle's motion in the horizontal x-direction is simple harmonic. Hence $a \propto -x$. This holds true for the motion in the y-axis as well.
15	**C**	 When the wave profile is drawn in the next instant (dotted line), one can tell that Particle P will be moving upwards in the positive direction, hence option A is incorrect. As the particle P is undergoing a simple harmonic oscillation, at this instance it is at the equilibrium position, it should have the maximum velocity, zero acceleration. So, options B and D are incorrect. As the displacement-position graph does not show a decreasing amplitude, all particles along the wave (including Particle P) have an amplitude of A. This is one of the distinguishing features between a progressive wave and a stationary wave. For the latter, the amplitude varies from maximum at the antinode and zero at the node.

16 **B**

Resolution or Rayleigh questions necessarily involve small angles.

$\theta_{min} = \frac{\lambda}{b}$

If angle of θ subtended at the opening by the two sources is greater than θ_{min}, the two images will be resolved (distinguished on the screen). This means that in order to make the separation of the images clearer, we can either increase θ or reduce θ_{min}.



Options A and C actually increases θ_{min} while keeping θ constant. This would make the images less resolved.

Option D does not affect either θ_{min} or θ so it should have no effect on the resolution of the images.

For option B, by reducing D. the angular separation θ increases for the same θ_{min}, thus the images are better resolved.

17 **A**

Using $d \sin\theta = n\lambda$,

Where there is an overlap between a lower order - longer wavelength and higher order-shorter wavelength, θ is the same. Since the same diffraction grating is used, d is the same.
Hence, $n\,\lambda_{longer} = (n + 1)\,\lambda_{shorter}$

Systematically working out,
When n = 1 and λ_{longer} = 700 nm, (n+1) = 2 and $\lambda_{shorter}$ = 350 nm. Since 350 nm is outside the range of 400 to 700 nm, there is no overlap between the first order's 700 nm and the second order's 400 nm.

When n = 2 and λ_{longer} = 700 nm, (n+1) = 3 and $\lambda_{shorter}$ = 467 nm. Since 467 nm is within the range of 400 to 700 nm, there is an overlap between the second and third orders.

The highest order of diffraction where there is no overlap is n = 1, the 1st order.

Alternatively

Using $d \sin\theta = n\lambda$, work out the angle of deviation θ for 400 nm light and 700 nm for each order n.

Order, n	θ for 400 nm	θ for 700 nm
1	6.9°	12.1°
2	13.9°	24.8°
3	21.1° (inside 2nd order)	

18 **C**

Statements A, B, D are correct assumptions while statement C is incorrect. The molecules are assumed to undergo elastic collisions with the walls of the container i.e. after the collisions the molecules move off in the opposite direction while having the same speed. Hence the change in momentum of the molecules Δp as shown below is not negligible.

$\Delta p = mv - m(-v) = 2mv$

19 **A**

From the ideal gas equation: $pV = NkT$ .....(1)

and total internal energy of the gas molecules in the box, $U = \frac{3}{2}NkT$

Introducing additional N molecules of the same gas into the box $\Rightarrow$ $p'V = (2N)kT'$ .....(2)

and total internal energy of the gas molecules, $U' = \frac{3}{2}(2N)kT'$, where p' & T' are the new pressure and temperature, and U' is the new internal energy of the gas in the box.

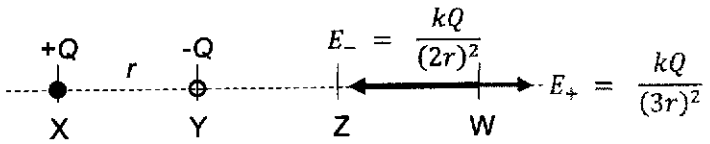
$U = U' \rightarrow \frac{3}{2}NkT = \frac{3}{2}(2N)kT'$, resulting in $T' = \frac{1}{2}T$

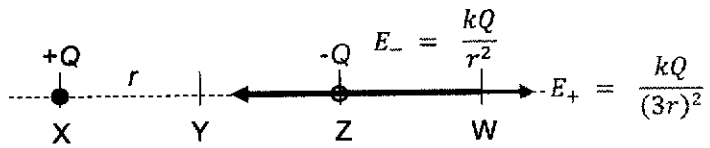
(2) ÷ (1) $\rightarrow p' = p$

20 **C**

A: $U = k\frac{Q_1Q_2}{r_{12}}$. When r increases, U becomes less negative, i.e. the potential energy increases.

B:





C: $V_W = k\frac{Q_1}{r_{1W}} + k\frac{Q_2}{r_{2W}}$. When -Q is moved to Z, which is closer to W, V_W becomes more negative, i.e. the potential at W decreases.

D: +Q and -Q are at the same distance from Y. Based on the formula above, the potential at Y is zero.

21 **D**

Volume V is constant, express cross-sectional area A in terms of V and L: $AL = V \Rightarrow A = V/L$

Hence, the resistance variation with L is given by : $R = \frac{\rho L}{A} = \frac{\rho L^2}{V} \propto L^2$

22 **B**

Resistance of each of the lamp : $R = \frac{V^2_{rating}}{P_{rating}}$

since, both of them have the same voltage rating: $\frac{R_A}{R_B} = \frac{P_{rating,B}}{P_{rating,A}} = \frac{40}{10} = \frac{4}{1}$

Since, both lamps are connected in series, the same current passes both lamps and power emitted by each lamp : $P_{emitted} = I^2R$.

$\frac{P_{emitted,A}}{P_{emitted,B}} = \frac{R_A}{R_B} = \frac{4}{1} \Rightarrow P_A = 4P_B$

23	**A**	Consider the secondary circuit: when temperature is low the resistance of the thermistor is high. This means that the terminal p.d. across the secondary cell is larger. (note that if the secondary cell has no internal resistance it would not matter what the resistance of the thermistor was, as the terminal p.d. would always simply be the secondary cell's e.m.f.) Consider the driver circuit: when it is dark the resistance of the LDR increases. This means that less of the driver cell e.m.f. drops across wire PQ. With a smaller p.d. per unit length of PQ, a longer balance length is needed.
24	**B**	The force per unit length acting on Z by X, $\frac{F_{XZ}}{l_Z} = B_X l_Z = \frac{\mu_o I^2}{2\pi(2d)} = F$ The force per unit length acting on Z by Y, $\frac{F_{YZ}}{l_Z} = B_Y l_Y = \frac{3\mu_o I^2}{2\pi d} = 6F$ Currents in Y and Z are in the same direction: Y attracts Z. Currents in X and Z are in opposite direction: X repels Z. Hence, the net force of 5*F* towards Y.
25	**C**	The copper disc "sees" the magnet rotating. The portion of the disc either "sees" an approaching pole or a pole moving away. By Lenz's law, in order to "oppose" the change (which again, is the rotation of the magnet), the disc will tend to rotate in the same direction as the magnet so that the magnet will appear "stationary" from the disc's perspective.
26	**B**	Using the potential divider principle, potential difference across the secondary coil = $80 \times \left(\frac{1500}{1000}\right) = 120V$ Current passing through the secondary coil = $I = \frac{V}{R} = \frac{80}{1000} = 0.080A$ Power dissipated by secondary coil = $IV = 0.080 \times 120 = 9.60W$ Potential difference across the primary coil = $120 \times \frac{200}{500} = 48.0V$ Power dissipated by primary coil = $V_p I_p = 9.60 \rightarrow I_p = \frac{9.60}{48.0} = 0.20A$
27	**C**	
28	**B**	Energy of photon = $\frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{(435 \times 10^{-9})} = 4.57 \times 10^{-19} J = 2.86\ eV$ Transition B, the difference in energy level = $(-0.54) - (-3.40) = 2.86\ eV$
29	**B**	Energy released = BE of helium – BE on reactants 3.26 = 2.54 × 4 – 4 × BE/nucleon of deuterium BE/nucleon of deuterium = 1.725 MeV
30	**B**	Let the background count-rate be C_B. $\frac{1}{4}(600 - C_B) = 180 - C_B$ $0.75C_B = 30$ C_B = 40 counts min^{-1}