H

NATIONAL JUNIOR COLLEGE
SENIOR HIGH 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS

9749/01

Paper 1 Multiple Choice

15 September 2023
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THE INSTRUCTION FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, subject class and registration number on the Optical Answer Sheet (OAS) 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 OAS.

Read the instructions on the OAS very carefully.

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.

<u>**Shading of OAS index number**</u>

OAS index number is in a 5-digit format.

The 5 digit format is as follows: **1st digit** and the **last four digits** of the Reg Number.
e.g. **2**00**501**1 becomes **25011**

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\mathrm{K} = T/°\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \dfrac{1}{3}\dfrac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \dfrac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm\, \omega \sqrt{x_0^{\,2} - x^2}$
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	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \dfrac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

1 Which definition is correct and uses only quantities rather than units?

A Density is mass per cubic metre.

B Potential difference is energy per unit current.

C Pressure is force per unit area.

D Speed is distance travelled per second.

Ans: C

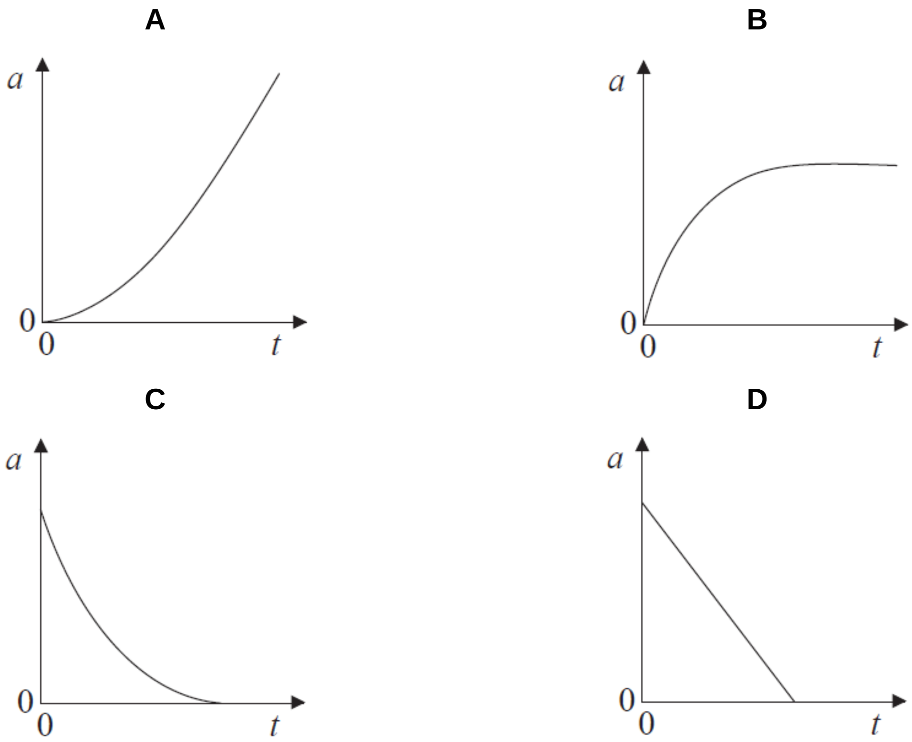
2 Which formula could be correct for the speed v of ocean waves in terms of density ρ of sea-water, the acceleration of free fall g, the height h of the wave and the wavelength λ?

A $v = \sqrt{\rho g h}$ **B** $v = \sqrt{\frac{g}{h}}$ **C** $v = \sqrt{g\lambda}$ **D** $v = \sqrt{\frac{g}{\rho}}$

2	**C**	unit of $\sqrt{g\lambda} = \sqrt{(\text{m s}^{-2})\ \text{m}} = \text{m s}^{-1}$

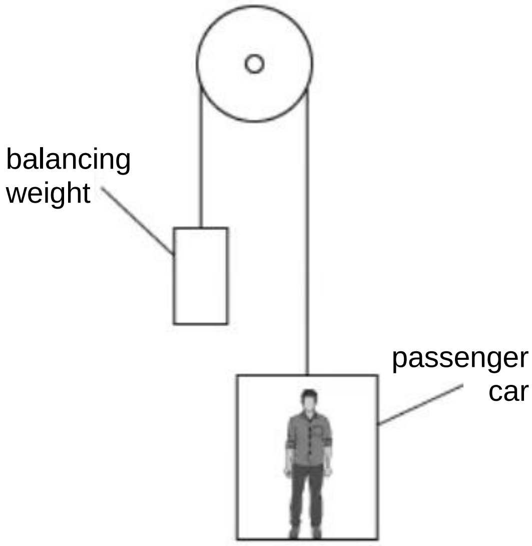
3 A ball, initially at rest, is dropped in the air from a great height. Air resistance is not negligible.

Which of the following graphs best shows the variation with time t of the acceleration a of the ball?



3	**C**	mg – kv =ma As time increases, a drops. Since v is not linear with time because acceleration is not constant therefore must be C

4 A lift consists of a passenger car supported by a cable which runs over a light, frictionless pulley to a balancing weight. The balancing weight falls as the passenger car rises.



(not drawn to scale)

The masses are shown in the table.

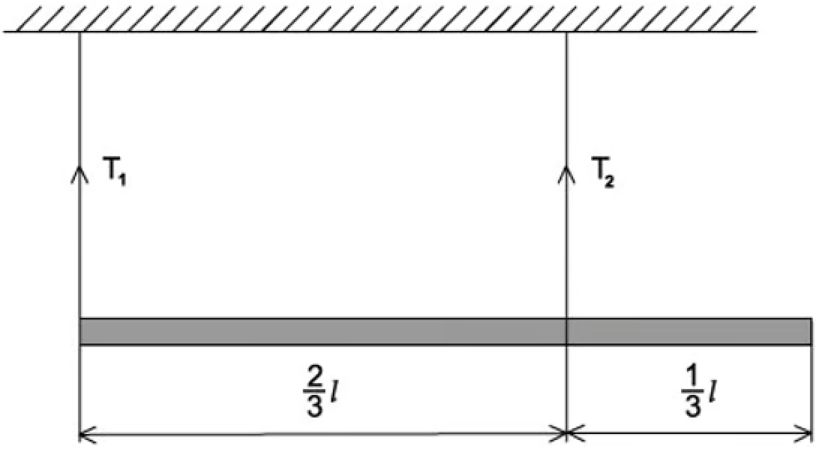
	mass / kg
passenger car	1200
balancing weight	1320
passenger	80

What is the magnitude of the force between the passenger and the passenger car when carrying just one passenger and when the pulley is free to rotate?

A 12 N **B** 773 N **C** 785 N **D** 797 N

4	**D**	for inextensible cable, the passenger, passenger car and balancing weight moves as one object with the upward motion of the balancing weight equivalent to the downward motion of the passenger and passenger car $1320 \times 9.81 - (1200+80) \times 9.81 = (1320+1200+80)\,a$ $a = 0.15092\ \text{m s}^{-2}$ resultant force on passenger = $80 \times 0.15092 = 12.074$ N upwards force by passenger car on passenger − weight of passenger = 12.074 N force by passenger car on passenger = $12.704 + 80 \times 9.81 = 797$ N

5 A heavy uniform beam of length *L* is supported by two vertical cords as shown.



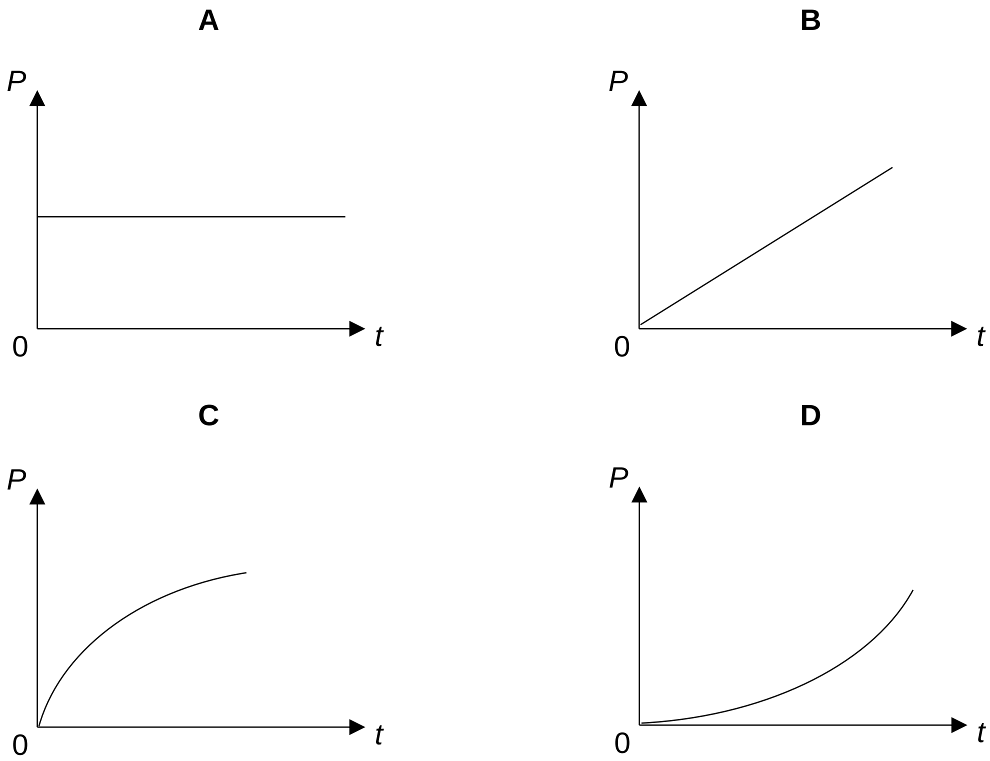
What is the ratio $\frac{T_1}{T_2}$ of the tensions in these cords?

A $\frac{1}{3}$ **B** $\frac{1}{2}$ **C** $\frac{2}{1}$ **D** $\frac{3}{1}$

5	**A**	Taking pivot about centre of gravity: $T_1 \times \frac{1}{2} l = T_2 \times 1/6\, l$ $T_1 / T_2 = 1/6\, l / \frac{1}{2} l = 1/3$

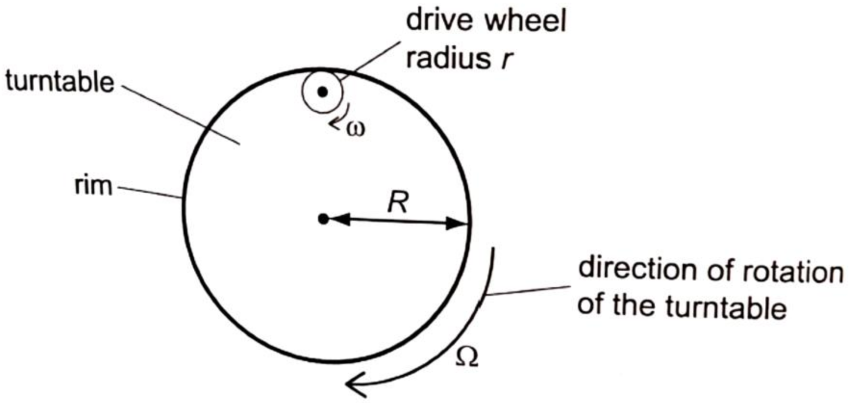
6 A constant force is applied to a body which is initially stationary but free to move in the direction of the force.

Assuming that the effects of friction are negligible, which of the following graphs best represents the variation with time *t* of the power supplied *P*?



6	**B**	As force is constant, acceleration on the body is constant, but velocity is increasing at a constant rate. ($v = u + at$), hence, the power = Fv is increasing at a constant rate.

7 A turntable has radius R. It is driven by a rubber drive wheel of radius r in contact with the inside of the rim of the turntable, as shown below.



plan view

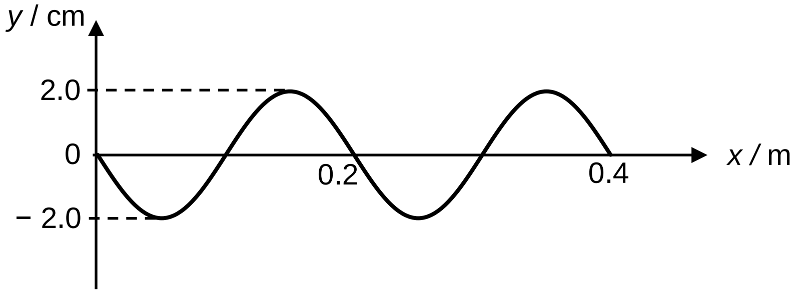
The turntable rotates with angular velocity Ω and the linear speed of a point on its rim is V. The drive wheel rotates with angular velocity ω and the linear speed of a point on its rim is v.

Which pair of equations show the relationship between the angular velocities and the linear speeds of the turntable and the wheel?

	angular velocities	linear speeds
A	$\Omega = \omega$	$V = v$
B	$\Omega = \omega$	$V = (\frac{r}{R})\, v$
C	$\Omega = (\frac{r}{R})\, \omega$	$V = v$
D	$\Omega = (\frac{R}{r})\, \omega$	$V = (\frac{r}{R})\, v$

7	**C**	Since no change in linear displacement, the 2 linear velocities are the same $R\,\Omega = r\ \omega$

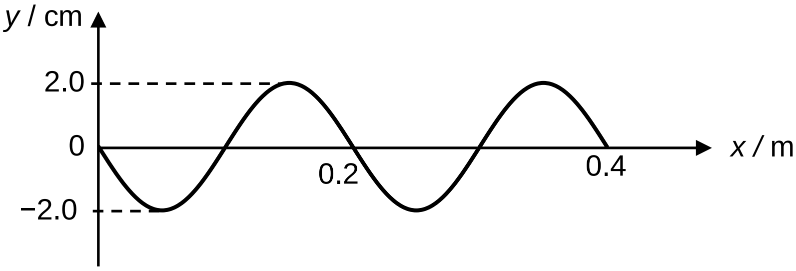
8 The graph below shows the variation with distance x of the displacement y of a transverse wave at a particular instance in time.



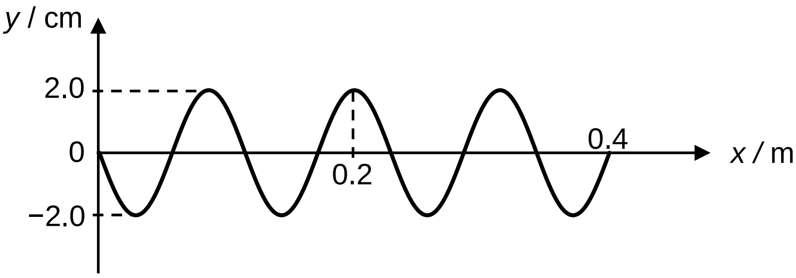
A second transverse wave has the same amplitude, twice the speed and twice the frequency.

For the second wave, which of the graphs below shows the variation with distance x of its displacement y?

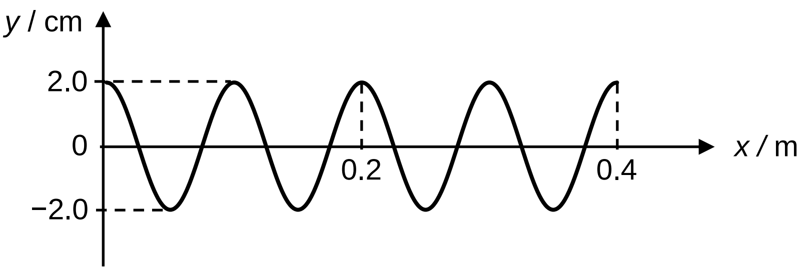
A



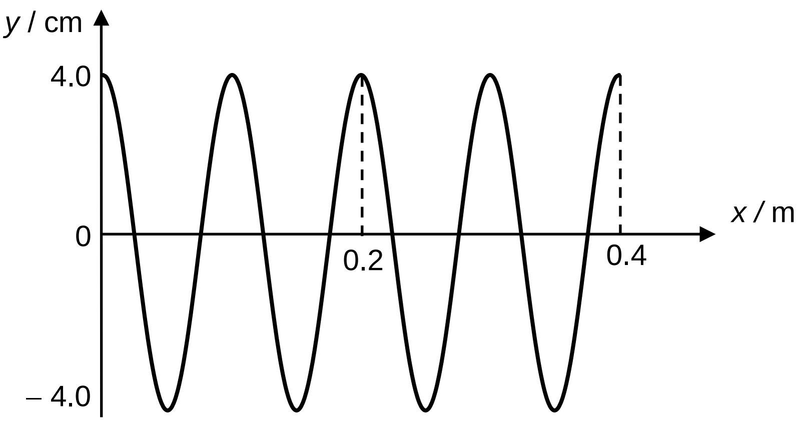
B



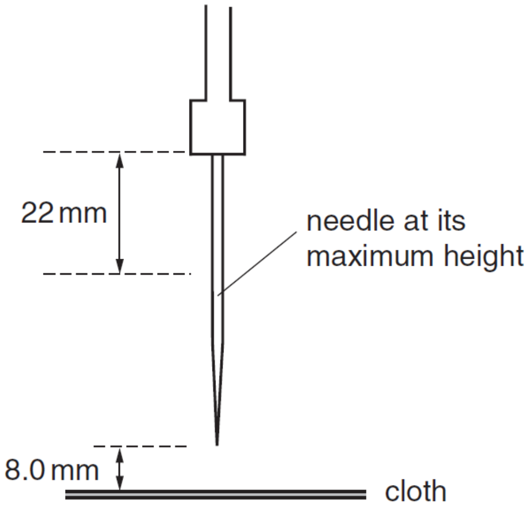
C



D



9 The needle of a sewing machine is made to oscillate vertically through a total distance of 22 mm, as shown below.



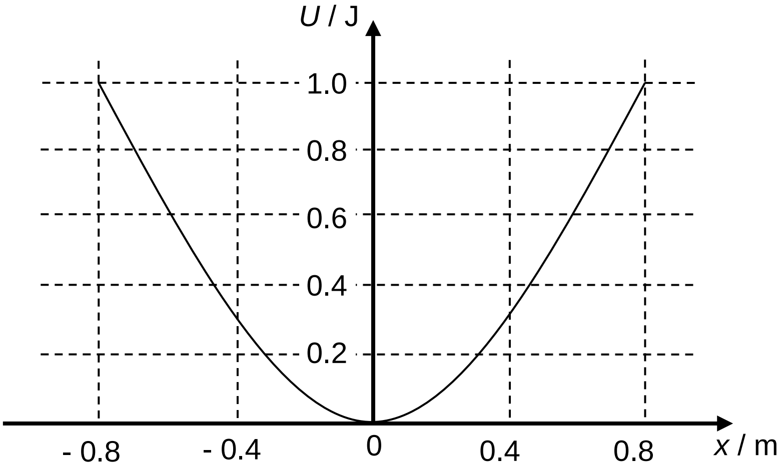
The oscillation is simple harmonic with a frequency of 4.5 Hz. The cloth that is being sewn is positioned 8.0 mm below the point of the needle when the needle is at its maximum height.

What is the speed of the needle as its tip touches the cloth?

A 0.00317 m s^{-1} **B** 0.0848 m s^{-1} **C** 0.226 m s^{-1} **D** 0.299 m s^{-1}

9	**D**	Amplitude, x_0 = 22/2 = 11 mm When the tip of the touches the cloth, the displacement of needle from the equilibrium position is 3 mm. $v = \omega\sqrt{x_o^2 - x^2}$ = $(2\pi\ (4.5))(\sqrt{(11 \times 10^{-3})^2 - (3 \times 10^{-3})^2}$ = 0.299 m s^{-1}

10 A particle of mass 5.0 kg moves with simple harmonic motion and the variation with position *x* of its potential energy *U* is shown below.



What is the period of oscillation of the mass?

A 7.9 s **B** 8.8 s **C** 11 s **D** 20 s

10	**A**	$KE_{max} = U_{max} = 1.0$ $\frac{1}{2} m v_{max}^2 = 1.0$ $v_{max} = 0.632$ $v_{max} = \omega x_o = x_o$ $T = \frac{2\eth x 0.8}{0.632} = 7.9$ s

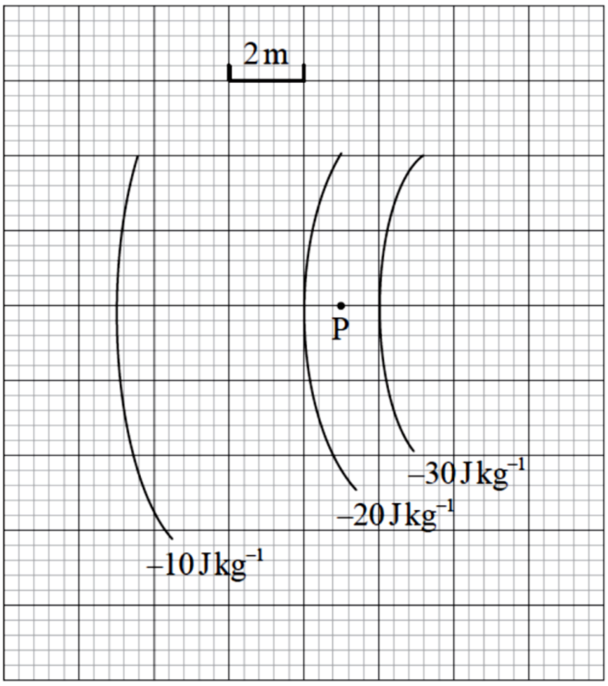
11 A double star system is at a distance of 1.9×10^{17} m from the Earth. A telescope with a diameter of 3.0 m is used to view the stars.

What is the approximate minimum separation between the two stars of the double star system such that both stars can be detected by the telescope?

A 5.0×10^{8} m **B** 1.0×10^{9} m **C** 3.0×10^{10} m **D** 3.0×10^{11} m

11	**C**	$\theta \approx \frac{\lambda}{3} \approx \frac{x}{1.9 \times 10^{17}}$ If violet light: $x \approx \frac{400 \times 10^{-9}}{3} \times 1.9 \times 10^{17} = 2.5 \times 10^{10}$ m If red light: $x \approx \frac{700 \times 10^{-9}}{3} \times 1.9 \times 10^{17} = 4.4 \times 10^{10}$ m Since wavelength of visible light must be between wavelength of violet light and wavelength of red light, answer must be between 2.5 and 4.4 $\times 10^{10}$ m

12 The diagram below represents equipotential lines of a gravitational field.



Which of the following is the direction and strength of the field at point P?

	direction	strength
A	→	5.0 N kg^{-1}
B	←	5.0 N kg^{-1}
C	→	13 N kg^{-1}
D	←	13 N kg^{-1}

12	**A**	Use $E = -\Delta V / \Delta r = (-20 - (-30)) / 2 = 5.0$ N kg^{-1}

13 A pair of twins of equal masses travels on separate express trains that run along the Earth's equator. Edison is on the train travelling eastwards while Wilson is on the train travelling westwards.

Assuming both trains are moving at equal speed (relative to the Earth's surface), which of the following statements about their measured weight is correct?

A Edison weighs more as his motion is in the same direction to the Earth's rotational motion about its axis.

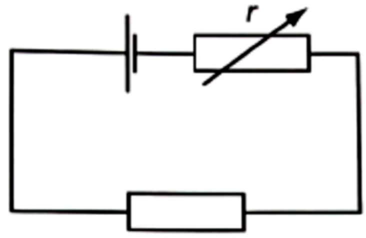
B Wilson weighs more as his motion is counter to the Earth's rotational motion about its axis.

C Both weigh more than when the train is stationary since kinetic energy is converted to an increase in mass.

D Both weigh the same since motion along the Earth's equator does not affect their measured weights.

13	**B**	Earth rotates to the east, so Edison will have higher angular velocity while Wilson will have lower angular velocity. $mg - N = mr\omega^2$ N will give the balance reading. $N = mg - mr\omega^2$ So Wilson will have higher reading.

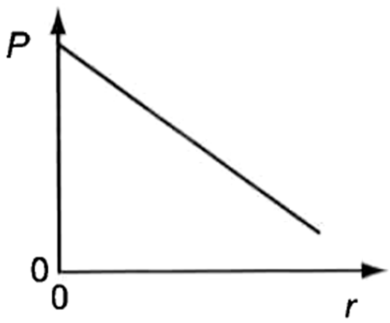
14 The circuit shown contains a cell of negligible internal resistance, a variable resistor of resistance *r* and a fixed resistor.



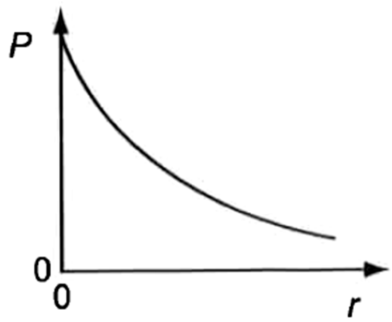
The resistance *r* is varied.

Which graph shows the variation of the power *P* dissipated in the fixed resistor as the resistance *r* of the variable resistor is changed?

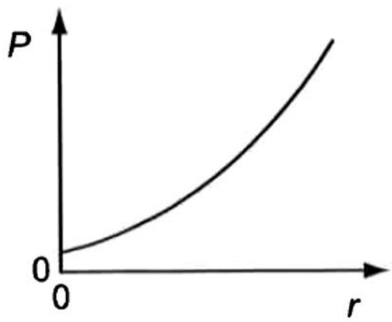
A



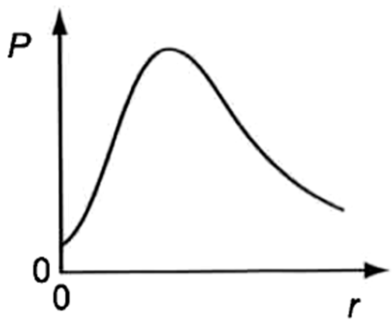
B



C

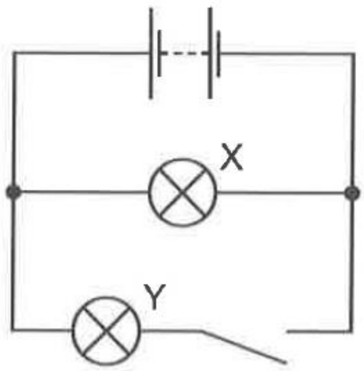


D



14	**B**	$P = I^2R = E^2R/(R+r)^2$ As r increase, I (current) in the circuit decreases, hence P decreases. The equation shows this is not a linear relation

15 A battery is connected to two lamps X and Y as shown.



With the switch open, lamp X has normal brightness.

The switch is now closed and lamp Y lights up. Lamp X is seen to be dimmer than before the switch was closed.

Why does lamp X become dimmer?

A Some current in X originally is used to supply Y.

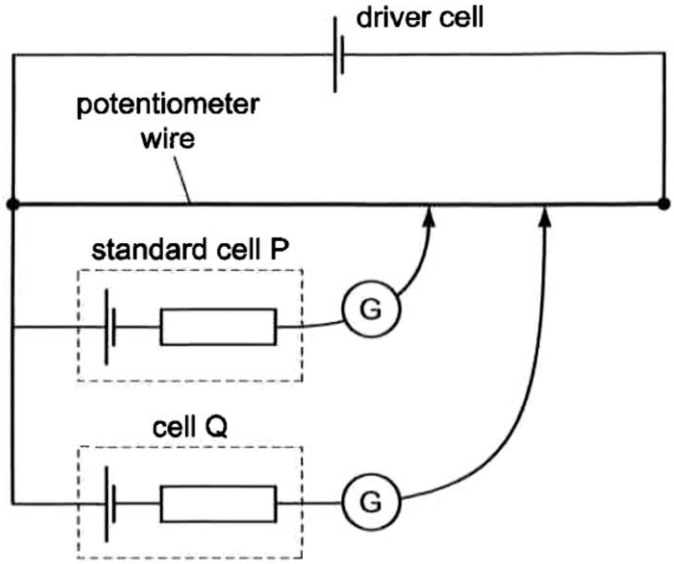
B The internal resistance of the battery increases.

C The terminal potential difference of the battery decreases.

D The working voltage of lamp Y is greater than that of lamp X.

15	**C**	The effective resistance drops as the switch is closed and because the battery has internal resistance, the terminal pd is reduced.

16 A potentiometer circuit is set up in which there is a standard cell P and a cell Q whose e.m.f. is to be determined. The two cells are used simultaneously, as shown below.



Is the value of the e.m.f. of Q, obtained by taking the two readings simultaneously, accurate and why?

A No, because cells P and Q will affect each other.

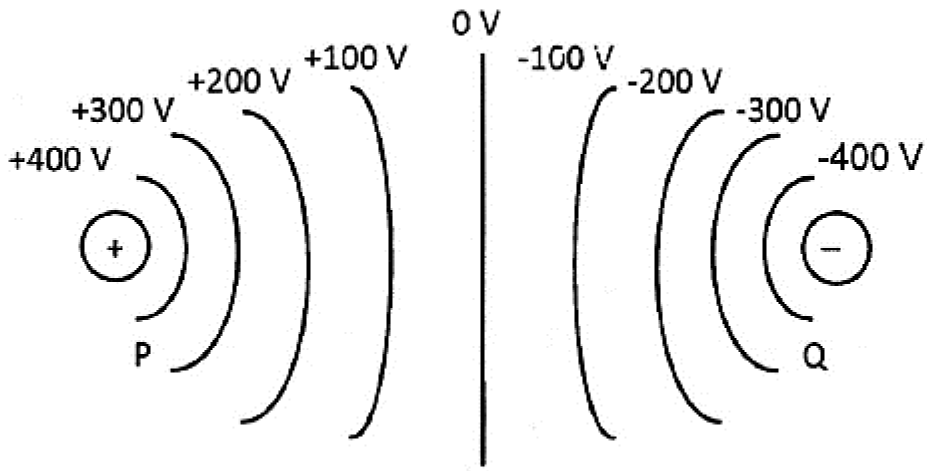
B No, because the internal resistances of P and Q will be different.

C Yes, because the e.m.f. of the driver cell is less than the e.m.f. of cell P or cell Q.

D Yes, because when readings are taken there is no current in either cell P or cell Q.

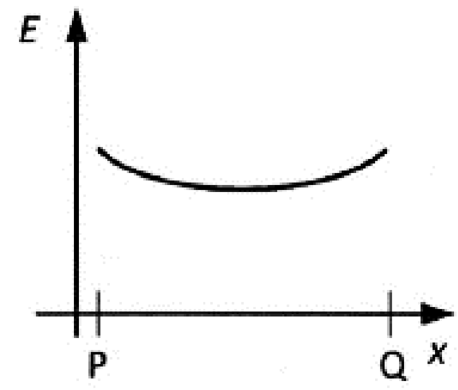
16	**D**	This is the working principle of potentiometer, i.e., both are at balanced lengths.

17 A positive charge is placed at P and a negative charge is placed at Q. The electric potential at different points between these two charges is shown in the figure below.

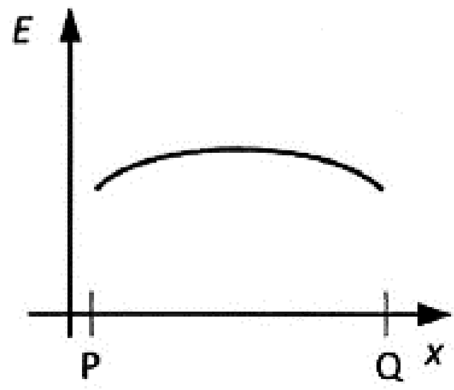


Which of the following graphs correctly shows the variation of the electric field strength E with distance x along line PQ?

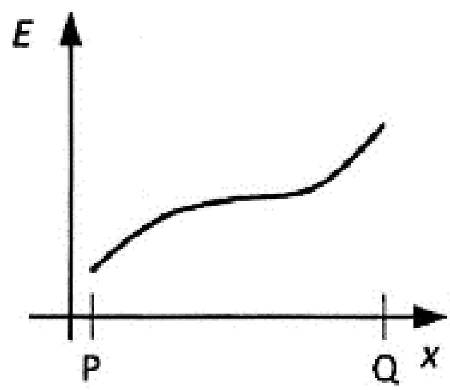
A



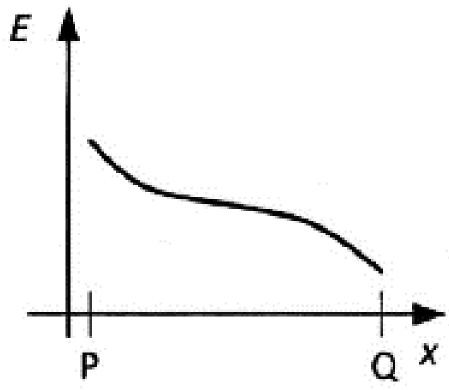
B



C

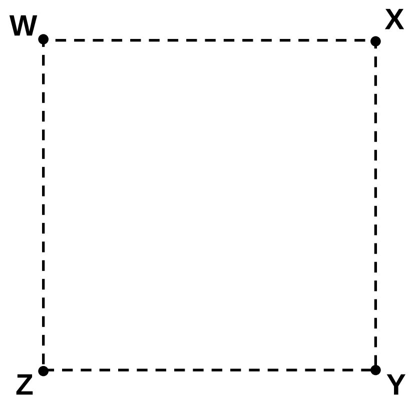


D



17	**A**	Field strength E of the field at a point is numerically equal to the potential gradient at that point. As the equipotential lines are closer at the two ends, the potential gradient is steeper at these regions, i.e. a stronger E field.

18 W, X, Y and Z are four points on a square as shown.



A point charge +Q is fixed at W. Another point charge –Q is moved from X to Y.

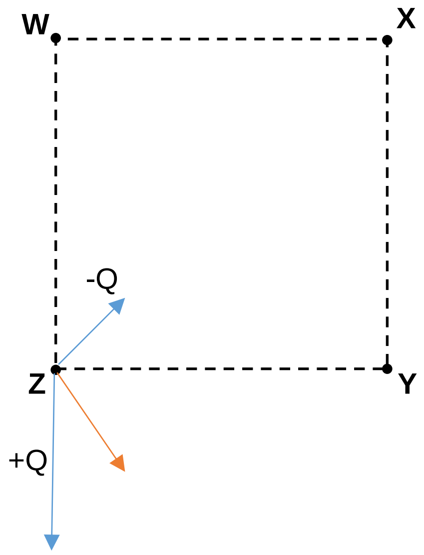
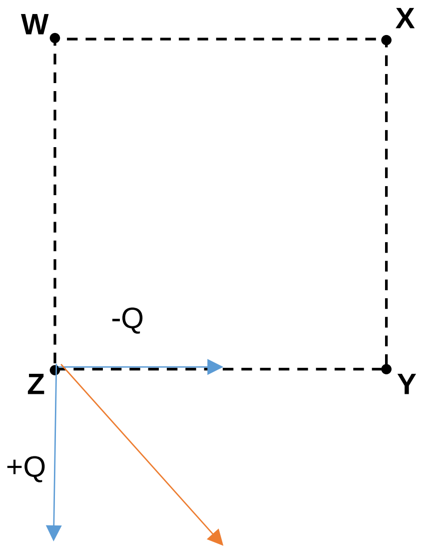
Which of the following statements is true?

A The electric potential at **Z** will increase.

B The electric potential energy of the system will decrease.

C The attractive force between the two charges will increase.

D The magnitude of the electric field strength at **Z** will increase.

18	**D**	A: When a negative charge is moved from X to Y, the negative charge will contribute a more negative potential, so electric potential will drop B: The unlike charges are attractive. By placing them further apart, work needs to be done on the system, thereby increasing the potential energy of the system C: Distance increases so attractive force will decrease. D: Original  After 

19 Thermometers M_1 and M_2 are placed inside an evacuated enclosure with walls maintained at temperature T. The thermometers are identical except that the bulb of M_1 is blackened.

Which of the following equations is true if T_1 and T_2 are the temperatures indicated by M_1 and M_2 respectively after thermal equilibrium has been established?

A $T_1 > T_2 > T$ **B** $T_1 = T_2 = T$ **C** $T_2 > T_1 = T$ **D** $T_1 > T_2 = T$

19	**B**	At thermal equilibrium, the temperature is the same for the thermometers and the walls.

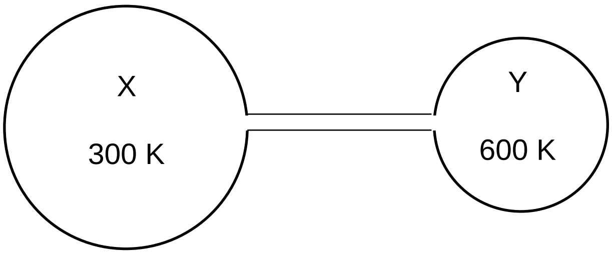
20 A fixed mass of ideal gas at constant pressure occupies a volume V. The gas undergoes a rise in temperature so that the root mean square velocity of its molecules is doubled.

What is the new volume?

A V **B** $\sqrt{2}V$ **C** $2V$ **D** $4V$

20	**D**	Internal energy = kinetic energy = $\frac{3}{2}pV = \frac{1}{2}m < c^2 >$ When rms velocity doubles, internal energy increases by 4 times. Since pressure is constant, V increases by 4 times. (internal energy for ideal gas is 3/2 pV)

21 In the diagram, the volume of bulb X is twice that of bulb Y. The system is filled with an ideal gas and a steady state is established with the bulbs held at 300 K and 600 K.



There is a total of n moles of gas in the bulbs.

How many moles of gas are in bulb X?

A $\frac{1}{3}n$ **B** $\frac{1}{2}n$ **C** $\frac{2}{3}n$ **D** $\frac{4}{5}n$

21	**D**	$n = \frac{pV}{RT}$ So total number of moles in the bulbs $n = \frac{p(2V)}{R(300)}(\text{bulb X}) + \frac{pV}{R(600)}(\text{bulb Y})$ note that the pressure is the same in both bulbs $n = \frac{pV}{R}\left(\frac{1}{150} + \frac{1}{600}\right) = \frac{1}{120}\frac{pV}{R}$ $p = \frac{120nR}{V}$ So the number of moles in X $= \frac{p(2V)}{R(300)} = \frac{120nR}{V} \times \frac{2V}{300R} = 0.8\,n$

22 In a constant flow determination of the specific heat capacity of a liquid, it is important to allow for any heat losses.

What conditions are required when repeating the experiment?

A same temperature, heat input and flow rate

B same temperature but different heat inputs and flow rates

C same temperature and flow rate but different heat inputs

D same flow rate but different temperatures and heat inputs

22	**B**	Only same temperatures are required to ensure rate of heat loss is the same

23 When a frictionless and well-insulated bicycle pump is used to pump up a tyre, the air in the tyre becomes hotter than the surrounding air.

Which of the following statements best explains this observation?

A After compression, the air molecules collide more frequently with the walls of the tyre.

B Work is done on the air and the internal energy remains unchanged.

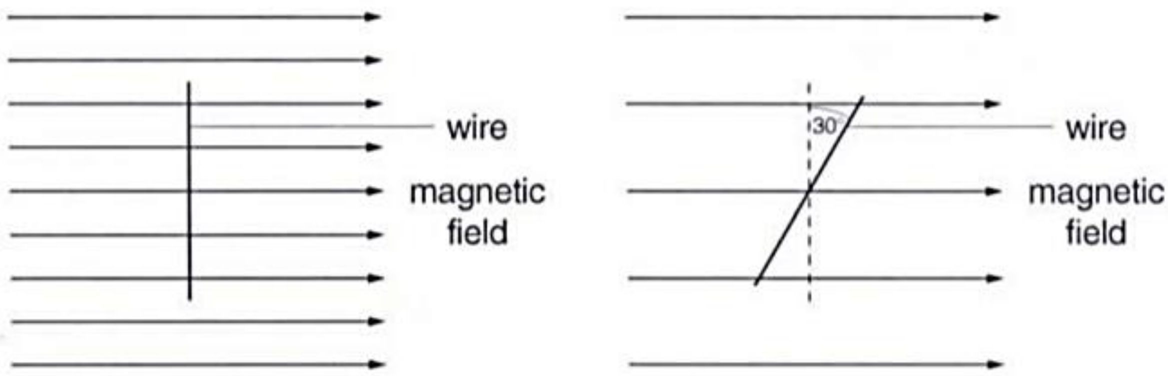
C Work is done on the air and since little thermal energy escapes, the internal energy increases.

D The internal energy increases because thermal energy is supplied and work is done on the air.

23	**C**	Work is done on the air via pumping action. However, there is no heat supplied to the air. Hence by the 1st law of thermodynamics, the internal energy increases.

24 A straight, horizontal, current-carrying wire lies at right angles to a horizontal magnetic field. The field exerts a vertical force of 8.0 mN on the wire.

The wire is rotated, in its horizontal plane, through 30° as shown. The flux density of the magnetic field is halved.



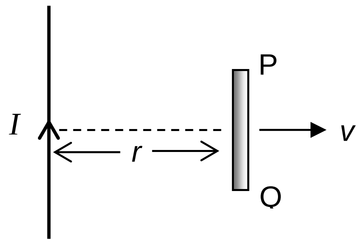
What is the vertical force on the wire?

A 2.0 mN **B** 3.5 mN **C** 4.6 mN **D** 8.0 mN

24	**B**	Diagram on the left: $F = BIL\sin 90°$ hence $BIL = 8.0$ mN Diagram on the right: B is halved hence $F = \frac{1}{2}B\,IL\sin\theta = \frac{1}{2}\,8.0\sin 60° = 3.5$ mN

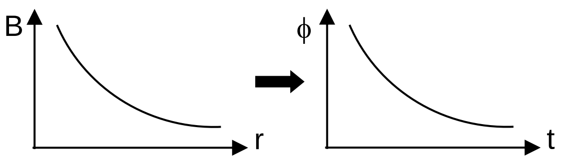
25 The diagram below shows a long wire carrying a current I.

A straight conductor PQ is placed on the same vertical plane as the wire and is moved at constant speed v away from the wire.

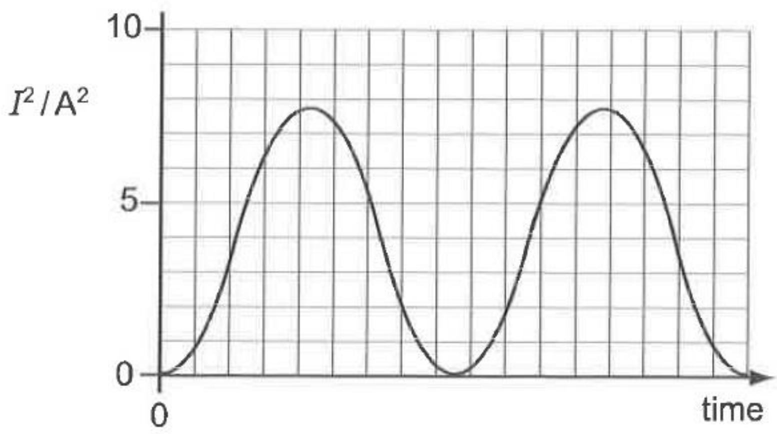


How does the magnitude of the induced e.m.f. in PQ vary and which end is at a higher potential?

	magnitude of induced e.m.f.	end at higher potential
A	decreases	P
B	decreases	Q
C	increases	P
D	increases	Q

25	**A**	Since rod is moving at constant v, graph of B vs r will be similar to graph of ϕ vs t  Since gradient drops as t increases, decreases as conductor PQ moves away →magnitude of induced emf decreases. Using FRHR, induced current is from Q to P, therefore P is at higher potential

26 The alternating current from an a.c. mains supply varies sinusoidally. The graph below shows how the square of the current I in a given resistor varies with time.



Which direct current in the same resistor would generate the same average power as that from the alternating current?

A 2.0 A **B** 2.8 A **C** 3.9 A **D** 5.5 A

26	**A**	Peak current roughly equals $\sqrt{7.8}$ Rms current for sinusoidal $= \frac{\sqrt{7.8}}{\sqrt{2}} = 1.97$ A

27 In the photoelectric effect, light falling on a metal surface causes electrons to be ejected from the surface.

Which statement is correct?

A Electrons are ejected only if the wavelength of the incident light is greater than some minimum value.

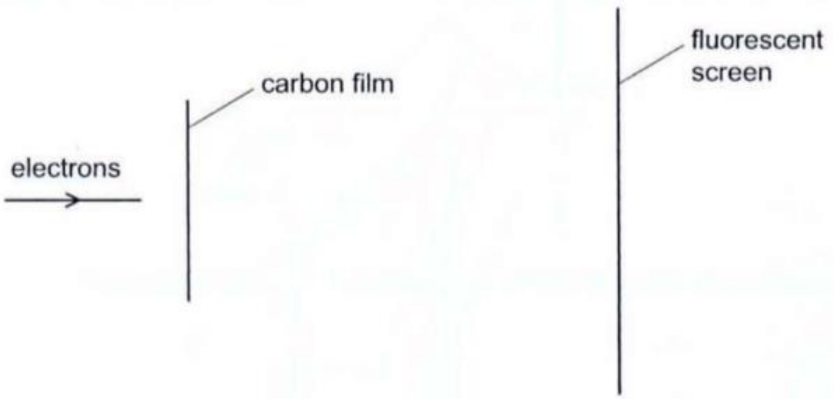
B The maximum energy of the electrons is independent of the intensity of the incident light.

C The maximum energy of the electrons is independent of the type of metal.

D The waves associated with the ejected electrons have the same wavelength as the incident light.

27	**B**	A: maximum wavelength / minimum frequency rather than minimum wavelength C: $hf = E_{kmax} + \Phi$ and Φ depends on type of metal D: the electrons do not have the same energy as the incident photons, even then you need to use De Broglie's equation.

28 Electrons with velocity v travel through a vacuum and are incident on a thin carbon film, as shown.



The electrons produce a pattern of concentric circles on the fluorescent screen.

What causes the pattern and which change to the pattern occurs when the velocity v is increased?

	cause	change to pattern
A	diffraction	diameters of circles increase
B	diffraction	diameters of circles decrease
C	refraction	diameters of circles increase
D	refraction	diameters of circles decrease

28	**B**	v increases → p increases and by $\lambda = h/p$, λ decreases by $d \sin\theta = n\lambda$, θ decreases and hence diameter of rings decreases

29 The rest mass of the deuterium, ${}^{2}_{1}H$ is equivalent to an energy of 1876 MeV. The rest mass of a proton is equivalent to 939 MeV and that of a neutron to 940 MeV.

How may a deuterium disintegrate into a proton and a neutron?

A by capturing a γ-ray photon of energy 2 MeV

B by emitting a γ-ray photon of energy 2 MeV

C by capturing a γ-ray photon of energy 3 MeV

D by emitting a γ-ray photon of energy 3 MeV

29	**C**	Mass defect in terms of energy $= 939 + 940 - 1876 = 3\ \text{MeV}$ 3 MeV needs to be supplied to break up the nucleus

30 Samples of two radioactive nuclides, X and Y, each have equal activity A_0 at time $t = 0$. X has a half-life of 24 years and Y a half-life of 16 years.

The samples are mixed together.

What will be the total activity of the mixture at t = 48 years?

A $\frac{1}{12}A_0$ **B** $\frac{3}{16}A_0$ **C** $\frac{1}{4}A_0$ **D** $\frac{3}{8}A_0$

30	**D**	X undergoes 2 half-lives so its activity is $\frac{A_0}{4}$ Y undergoes 3 half-lives so its activity is $\frac{A_0}{8}$ Total activity = $\frac{3A_0}{8}$

END OF PAPER