VICTORIA JUNIOR COLLEGE

2022 JC2 PRELIMINARY EXAMINATIONS

PHYSICS **9749/01**
Higher 2

2.30 pm- 3.30 pm

Paper 1 Multiple Choice **1 Hour**

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil (2B or softer).
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, CT group and shade your index number on the Answer Sheet provided.

HOW TO SHADE YOUR INDEX NUMBER:
Eg. If your class is 21S43, index number is 06, then shade 2140306.
Check that you have shaded correctly.

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 Answer Sheet.

Read the instructions on the Answer Sheet 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.

This document consists of **17** printed pages.

Data

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

temperature $T / K = T / {}^\circ C + 273.15$

pressure of an ideal gas $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

mean translational kinetic energy of an ideal gas molecule $E = \frac{3}{2}kT$

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, $V = Q/4\pi\varepsilon_o r$

alternating current/voltage, $x = x_o \sin \omega t$

Magnetic flux density due to a long straight wire $B = \frac{\mu_0 I}{2\pi d}$

Magnetic flux density due to a flat circular coil $B = \frac{\mu_0 NI}{2r}$

Magnetic flux density due to a long solenoid $B = \mu_0 nI$

radioactive decay, $x = x_o \exp(-\lambda t)$

decay constant, $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1. For electromagnetic induction, there is a physical quantity called self-induction, which is defined as

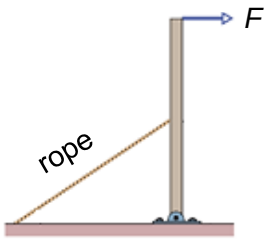
$$\text{self inductance} = \frac{\text{e.m.f. induced in coil by a changing current}}{\text{rate of change of current through coil}}$$

What are the base units of self-inductance?

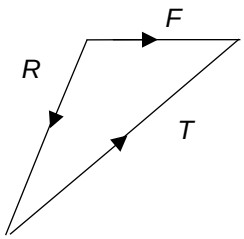
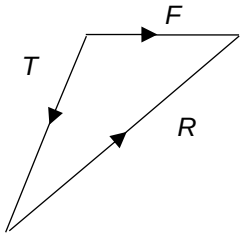
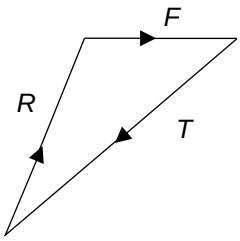
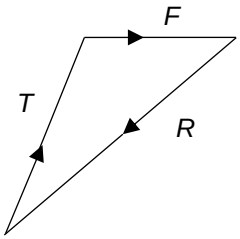
A H B kg m^2 A s^{-2}

C J s D kg m^2 s^{-2} A^{-2}

2. A light rod, hinged at its lower end, has a horizontal force *F* acting at its upper end and a reaction force *R* acting at its lower end. A tension *T* acts in the rope on the beam.



Which of the vector diagram below showing the forces acting on the beam is correct?

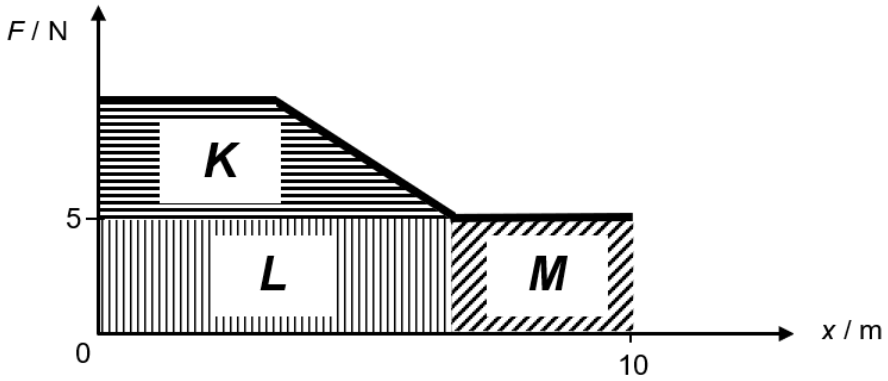
A		C	
B		D	

3. The diagram below shows two spheres undergoing a head-on elastic collision. Sphere A has mass $2M$ while sphere B has mass M. Both are moving with speed v towards each other.

Which of the following statements is incorrect?

A The two spheres cannot come to rest at the same time.
B The total kinetic energy of both spheres is conserved throughout the collision.
C The magnitude of the change in momentum for each sphere is the same after the collision.
D The force exerted by sphere A on B is equal and opposite to the force exerted by B on A during the collision.

4. An object is pushed from rest in a straight line by a variable force F along a rough ground. The ground exerts a constant frictional force of 5 N throughout the motion of the object. The variation with displacement x of the force F is shown below.



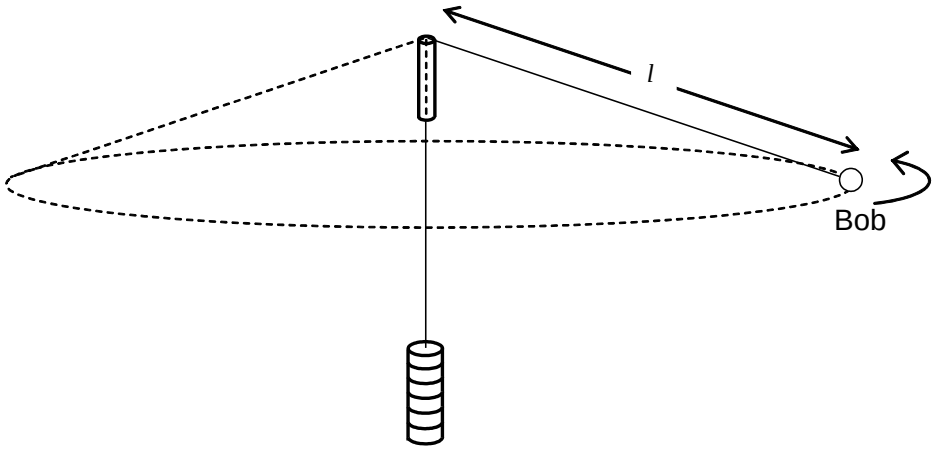
The magnitude of the kinetic energy of the object when it has travelled 10 m is the area

A K B $K + L$ C $K + L + M$ D $L + M$

5. A motor of power 10 W is used to lift a load of 20 N. The efficiency of the motor is 25 %. How long does it take to lift the load through a vertical distance of 0.50 m?

A 0.040 s B 0.25 s C 4.0 s D 39 s

6. A bob is tied using an inelastic string to a fixed set of brass weights. It is then made to execute circular motion in a horizontal plane, so that the string traces out a cone, as shown in the diagram below. The string is passed through a smooth vertical glass tube so that the length *l* of the string from the top of the glass tube to the bob can vary freely as the speed of the circular oscillation changes. What is the relationship between length *l* and the frequency *f* of the circular motion?



A $l \propto f^2$ B $l \propto f$

C $l \propto \frac{1}{f}$ D $l \propto \frac{1}{f^2}$

7. The table below gives the values for the gravitational potential at various points in the gravitational field of a celestial body.

Distance from surface of body / km	Potential / kJ kg^{-1}
0	−784.0
360	−649.6
370	−633.3
380	−617.0
Infinity	0

What is value of the gravitational acceleration at a height of 370 km of this celestial body?

A 9.83 m s^{-2} B 1.63 m s^{-2} C 19.73 m s^{-2} D 6.33 m s^{-2}

8. A satellite is shifted from a stable orbit to another orbit which is higher. Which one of the following quantities increases?

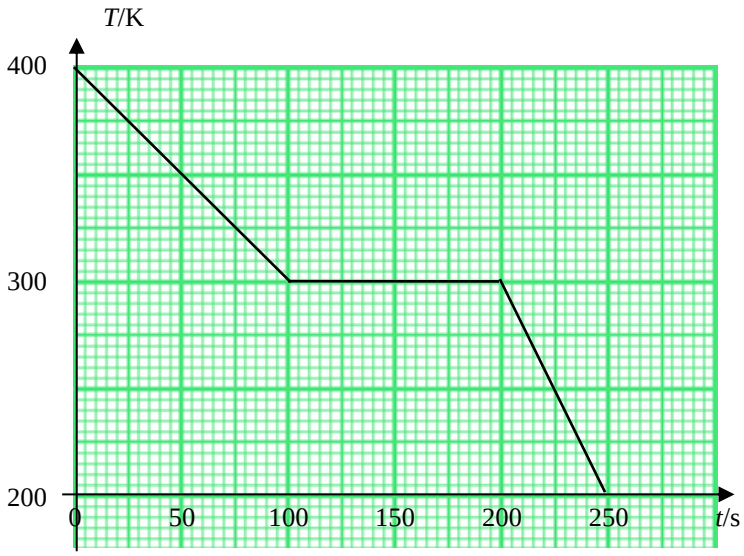
A Gravitational force

B Gravitational potential energy

C Linear speed

D Kinetic energy

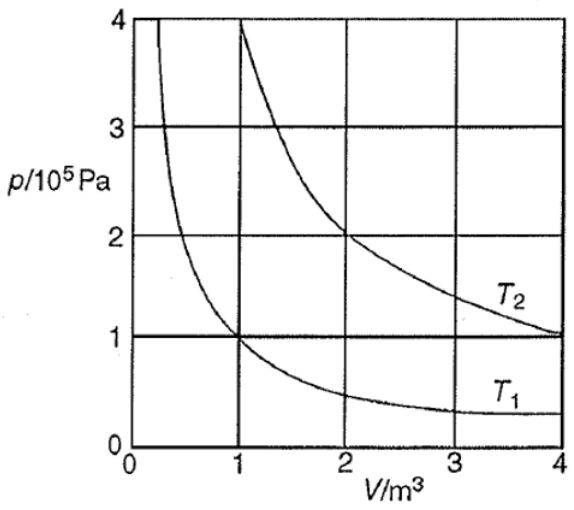
9. The graph shows the variation of temperature *T* against time *t* of a certain substance. Originally, it is in a liquid state at *t* = 0 s. Heat is removed from it at a constant rate until it becomes a solid.



Which of the following could be correct?

	specific heat capacity of liquid/J kg^{-1} K^{-1}	specific heat capacity of solid/J kg^{-1} K^{-1}
A	1500	3000
B	1800	900
C	2500	2500
D	4500	3000

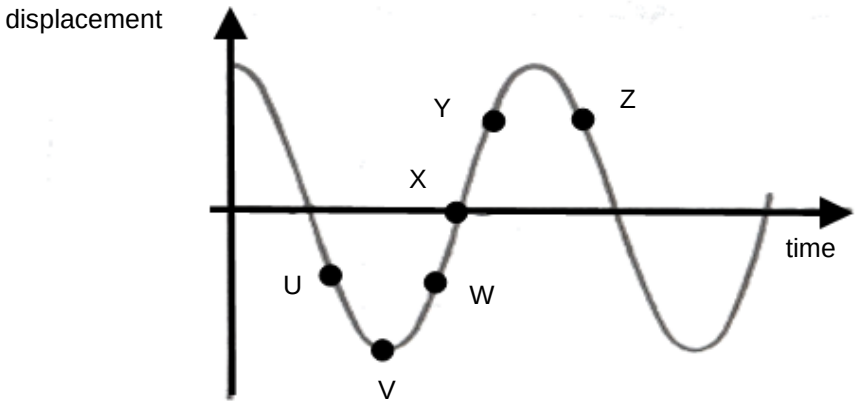
10. The two curves shown below are two different isothermal curves for a fixed mass of an ideal gas.



What is the ratio $\frac{\text{r.m.s. speed of the molecules at temperature } T_2}{\text{r.m.s. speed of the molecules at temperature } T_1}$?

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

11. The diagram below shows a displacement-time graph of a body performing simple harmonic motion.



At which points, U, V, W, X, Y or Z, are the body travelling *and* accelerating in the opposite direction?

A U and Y B V and X C U and Z D W and Z

12. A mass of 20 g is oscillating vertically in simple harmonic motion. The displacement of the mass is given by the equation

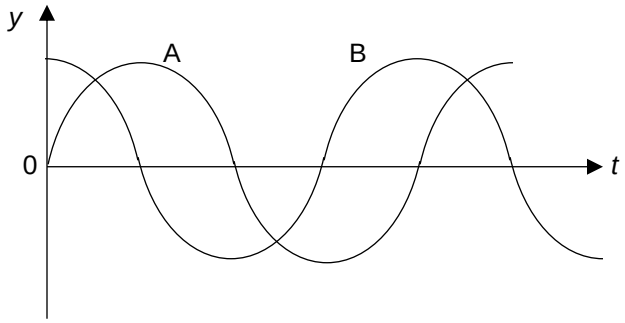
$$x = 6.0 \times 10^{-3} \sin (3\pi t)$$

where x is in metres and t in seconds.

What is the magnitude of the maximum force acting on the mass?

A 0.011 N B 0.50 N C 1.8 N D 11 N

13. Two wave particles A and B are on the same wave. The graph below shows how their displacements *y* vary with time *t*:



What can be said about A and B?

A A leads B by 45°
B A lags B by 45°
C A leads B by 90°
D A lags B by 90°

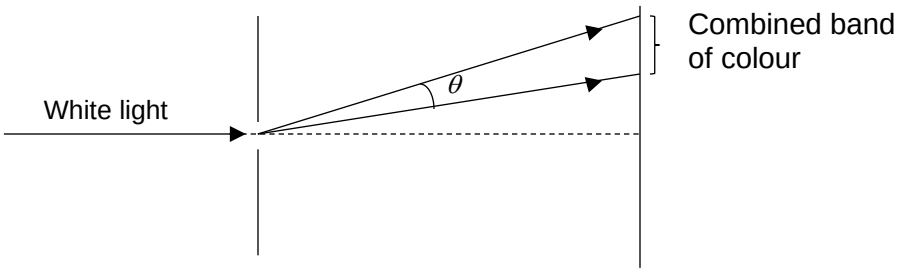
14. A wave has an amplitude of 3.0 cm, wavelength of 15 cm and speed of 4.0 m s^{-1}. What is the maximum speed of a particle on the wave?

A 7.1×10^{-3} m s^{-1} B 3.0×10^{-2} m s^{-1}
C 4.0 m s^{-1} D 5.0 m s^{-1}

15. Images viewed through a single slit may or may not be well resolved. Which of the following will improve the resolving power of the slit?

A Making the slit narrower
B Making the slit wider
C Decreasing the distances between the images and the slit
D Increasing the distances between the images and the slit

16. White light is shone through a diffraction grating that contains 300 lines per mm. It is observed that the second and third order spectra overlap, forming a combined band of colour in the region of overlap on a screen with an angular width θ, as shown:



What is the value of θ?
[Range of visible light wavelengths: 400 nm to 700 nm]

A 3.7° B 11° C 18° D 25°

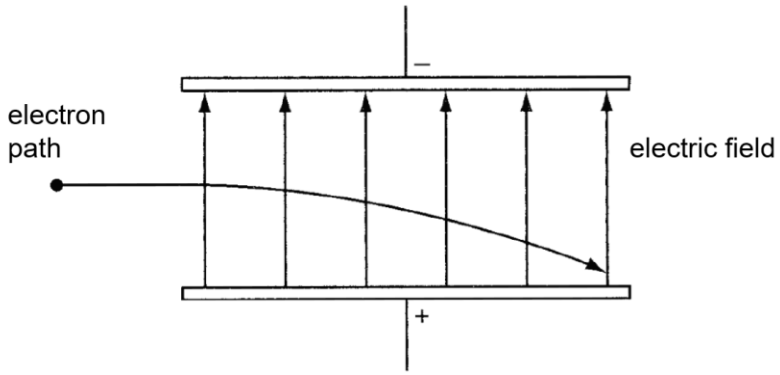
17. A positive charge of 2.6×10^{-8} C is in a uniform electric field of field strength 3.0×10^{5} N C^{-1}.

How much work must be done on the charge in order to slowly move it a distance of 4.0 mm in the opposite direction to the direction of the field?

A -3.1×10^{-2} J B -3.1×10^{-5} J

C 3.1×10^{-5} J D 3.1×10^{-2} J

18. An electron is projected horizontally into the vertical electric field in the space between two horizontal charged plates. The electron follows a curved path as shown.

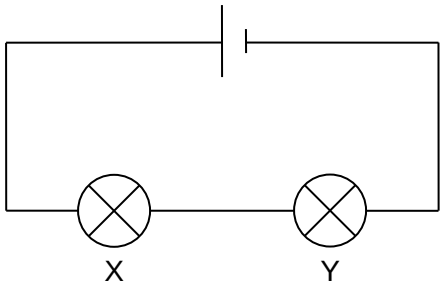


There are changes to the electron's electric potential energy and to its gravitational potential energy.

Which row correctly identifies these changes?

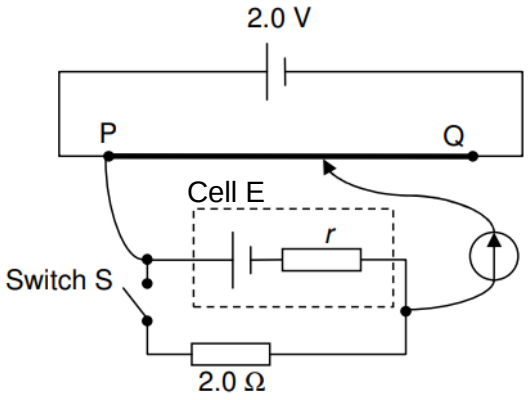
	electric potential energy	gravitational potential energy
A	Decreases	Decreases
B	Decreases	Increases
C	Increases	Decreases
D	Increases	Increases

19. The circuit below contains a cell and 2 identical lamps X and Y. What will happen to the brightness of the 2 lamps if an additional identical lamp is added in parallel to X?



A Both X and Y are less bright.
B X is less bright, Y is brighter.
C X is brighter, Y is less bright.
D Both X and Y are brighter.

20. The diagram below shows a simple potentiometer circuit used to determine the internal resistance *r* of a cell E. The driver cell has an e.m.f. of 2.0 V with negligible internal resistance and the resistance wire PQ is 1.0 m long. Cell E is connected in parallel with a resistor of 2.0 Ω. When the switch is open, the balance length is 0.70 m and when the switch is closed, the balance length is 0.50 m.



What is the internal resistance *r* of cell E?

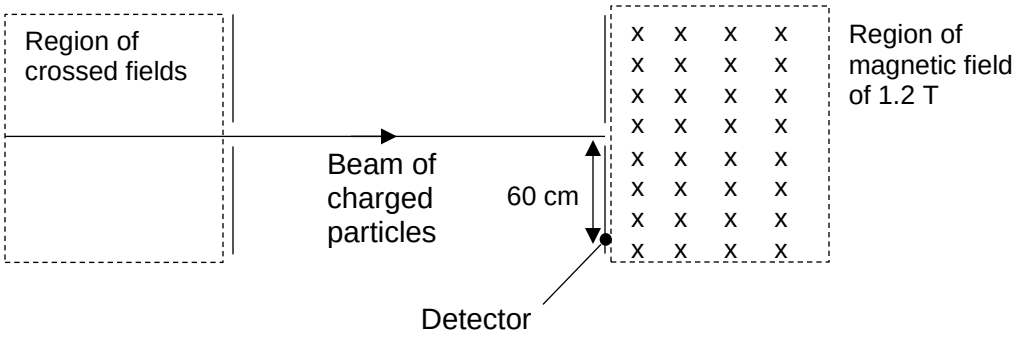
A. 0.15 Ω B. 0.40 Ω C. 0.50 Ω D. 0.80 Ω

21. A compass placed horizontally points north due to the horizontal component of the Earth's magnetic field, which is 3.5×10^{-5} T. A vertical wire is placed 9.0 mm due south of the compass. When a current of 3.0 A flows downwards through the wire, the compass needle deflects.

What is the angle and direction of the deflection?

A 28^{o} east of north
B 28^{o} west of north
C 62^{o} east of north
D 62^{o} west of north

22. A horizontal beam of doubly-charged particles passes through a crossed field, consisting of an electric field of 6.0×10^{2} N C^{-1} and a magnetic field of 2.0×10^{-5} T. Particles which emerge from the crossed field undeflected are allowed to pass through a small hole. This beam is then directed at another small hole, beyond which a uniform field of 1.2 T is applied. This field is horizontal, but perpendicular to the original direction of motion of the beam. The beam then impacts a detector placed 60 cm beside the second hole, as shown below:



What is the mass of each particle?

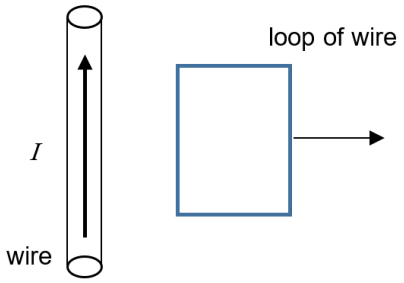
A 3.8×10^{-27} kg B 7.7×10^{-27} kg
C 3.5×10^{-12} kg D 7.0×10^{-12} kg

23. A flat circular coil of 120 turns, each of diameter 30 cm, is placed with its axis parallel to a uniform magnetic field. The ends of the coil are not connected to form a closed circuit (as shown below).

The flux density of the magnetic field is changed steadily from 80 mT to 20 mT over a period of 4.0 s. What is the e.m.f. induced in the coil during this time?

A 0 B 1.1 mV C 130 mV D 510 mV

24. A rectangular loop of wire is held close to a long vertical wire carrying a current I. The loop is then pulled to the right as shown.



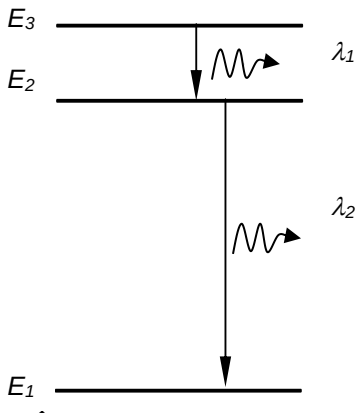
What are the directions of the induced current in the loop and the net magnetic force on the loop as it is being pulled?

	induced current	**net magnetic force**
A	anticlockwise	to the left
B	clockwise	to the left
C	anticlockwise	to the right
D	clockwise	to the right

25. When a sinusoidal e.m.f of peak value V is connected across a resistor R, a current of peak value I flows through it.
What is the mean power dissipated in the resistor?

A I^2R B $\frac{IV}{\sqrt{2}}$ C $\frac{I^2R}{\sqrt{2}}$ D $\frac{V^2}{2R}$

26. The diagram below shows a simplified representation of the three electron energy levels in an atom.



Cool vapour of this element at low pressure is bombarded with electrons accelerated from rest across a potential difference *V*. Two possible transitions which result in the emission of photons of wavelengths $\lambda_1 = 6.22 \times 10^{-7}$ m and $\lambda_2 = 1.78 \times 10^{-7}$ m are observed.

What is the minimum value of *V* for the above transitions to occur?

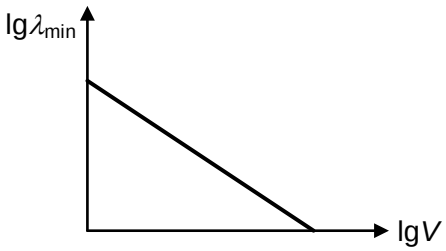
A 1.56 V B 2.80 V C 7.00 V D 9.00 V

27. The position of a subatomic particle with a momentum of 2×10^{-22} N s is measured to within an uncertainty of $\pm 1 \times 10^{-10}$ m. What is the minimum percentage uncertainty in the kinetic energy of the particle?

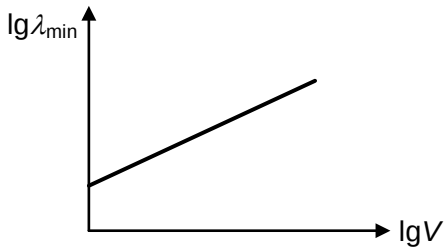
A 0.03% B 0.07% C 3% D 7%

28. Electrons accelerated from rest by a potential difference V are directed to hit a metallic target to produce X-rays. It produces continuous as well as characteristic X-rays. If λ_{min} is the shortest possible wavelength of X-ray in the spectrum, which of the following shows the variation with $\lg V$ of $\lg \lambda_{min}$?

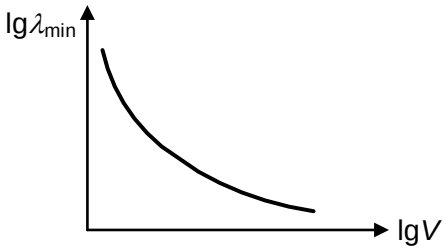
A



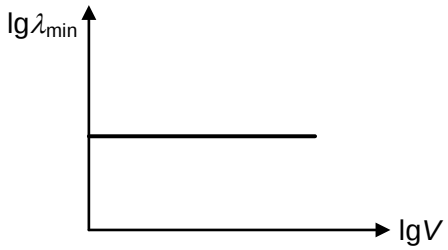
B



C



D



29. The nuclear reaction P + Q ⟶ X + Y proceeds with a release of energy. Which of the following statement must be correct?

A Mass of X and Y is larger than mass of P and Q.
B Momentum of X and Y is larger than momentum of P and Q.
C Total binding energy of X and Y is larger than total binding energy of P and Q.
D Binding energy per nucleon of both X and Y are larger than binding energy per nucleon of P or Q.

30. A radioactive sample of half-life of 10 minutes is placed 40.0 cm away from a radiation detector. The detector gives an average count-rate of 39.0 s^{-1}. In the absence of the radioactive sample, the detector records an average count-rate of 5.0 s^{-1}.

After 20 minutes, the detector, which is still facing the radioactive sample, is moved 20.0 cm nearer the radioactive sample. The sample can be regarded as a point source of radiation.

What is the average count rate on the detector?

A 8.5 s^{-1} B 13.5 s^{-1} C 34.0 s^{-1} D 39.0 s^{-1}

End of paper