Cambridge Pre-U

PHYSICS **9792/01**

Paper 1 Multiple Choice **October/November 2020**

1 hour 30 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

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INSTRUCTIONS

- There are **forty** 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 multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **16** pages. Blank pages are indicated.

Data

gravitational field strength close to Earth's surface	$g = 9.81\ \mathrm{N\,kg^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
speed of light in vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$
electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
molar gas constant	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$	change of state	$\Delta E = mL$
	$v^2 = u^2 + 2as$	refraction	$n = \dfrac{\sin\theta_1}{\sin\theta_2}$
	$s = \left(\dfrac{u+v}{2}\right)t$		$n = \dfrac{v_1}{v_2}$
heating	$\Delta E = mc\Delta\theta$		

diffraction

single slit, minima $n\lambda = b \sin\theta$

grating, maxima $n\lambda = d \sin\theta$

double slit interference $\lambda = \dfrac{ax}{D}$

Rayleigh criterion $\theta \approx \dfrac{\lambda}{b}$

photon energy $E = hf$

de Broglie wavelength $\lambda = \dfrac{h}{p}$

simple harmonic motion $x = A\cos\omega t$

$v = -A\omega \sin\omega t$

$a = -A\omega^2 \cos\omega t$

$F = -m\omega^2 x$

$E = \frac{1}{2}mA^2\omega^2$

energy stored in a capacitor $W = \frac{1}{2}QV$

capacitor discharge $Q = Q_0 e^{-\frac{t}{RC}}$

electric force $F = \dfrac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$

electrostatic potential energy $W = \dfrac{Q_1Q_2}{4\pi\varepsilon_0 r}$

gravitational force $F = -\dfrac{Gm_1m_2}{r^2}$

gravitational potential energy $E = -\dfrac{Gm_1m_2}{r}$

magnetic force $F = BIl\sin\theta$

$F = BQv\sin\theta$

electromagnetic induction $E = -\dfrac{\mathrm{d}(N\Phi)}{\mathrm{d}t}$

Hall effect $V = Bvd$

time dilation $t' = \dfrac{t}{\sqrt{1-\dfrac{v^2}{c^2}}}$

length contraction $l' = l\sqrt{1-\dfrac{v^2}{c^2}}$

kinetic theory $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$

work done on/by a gas $W = p\Delta V$

radioactive decay $\dfrac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$

$N = N_0 e^{-\lambda t}$

$t_{\frac{1}{2}} = \dfrac{\ln 2}{\lambda}$

attenuation losses $I = I_0 e^{-\mu x}$

mass-energy equivalence $\Delta E = c^2\Delta m$

hydrogen energy levels $E_n = \dfrac{-13.6\,\mathrm{eV}}{n^2}$

Heisenberg uncertainty principle $\Delta p\Delta x \geqslant \dfrac{h}{2\pi}$

Wien's displacement law $\lambda_{max} \propto \dfrac{1}{T}$

Stefan's law $L = 4\pi\sigma r^2 T^4$

electromagnetic radiation from a moving source $\dfrac{\Delta\lambda}{\lambda} \approx \dfrac{\Delta f}{f} \approx \dfrac{v}{c}$

1 Which pair of quantities are both scalars?

A force and area

B mass and weight

C velocity and displacement

D wavelength and frequency

2 The horizontal component of a force is F. The magnitude of the force is $1.8\,F$.

What is the vertical component of the force?

A $0.8\,F$ **B** $1.0\,F$ **C** $1.5\,F$ **D** $2.1\,F$

3 A space probe is due to be launched to one of the moons of Saturn. It is believed that the conditions on the moon are such that methane exists in liquid form and that lakes of methane may exist.

The probe is tested and it can be lowered to a depth of 64 m in a lake of water on Earth before the pressure is too high.

What is the maximum depth the probe may be lowered to in a lake of methane on the moon of Saturn?

atmospheric pressure on Earth = 100 kPa

density of water in lake on Earth = $1000\,\text{kg}\,\text{m}^{-3}$

estimated atmospheric pressure on moon of Saturn = 35 kPa

estimated density of liquid methane on moon of Saturn = $740\,\text{kg}\,\text{m}^{-3}$

estimated gravitational field strength on moon of Saturn = $3.6\,\text{N}\,\text{kg}^{-1}$

A 220 m **B** 240 m **C** 260 m **D** 270 m

4 A small ice cube of mass 20 g is heated and changes from the solid to the liquid state. During this change in state the temperature of the substance does not change.

Which statement about this change in state is **not** correct?

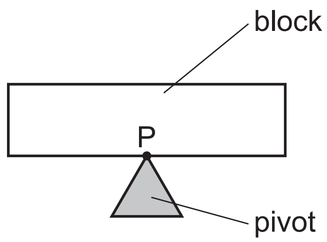
A The amount of energy the ice absorbs is equal to the specific latent heat of fusion.

B The average kinetic energy of the molecules remains unchanged.

C The average potential energy of the molecules increases.

D The total mass of ice and water remains constant throughout.

5 A thick block of wood balances horizontally on a pivot. The block and the pivot are in contact at point P.



Which statement about the block is always correct?

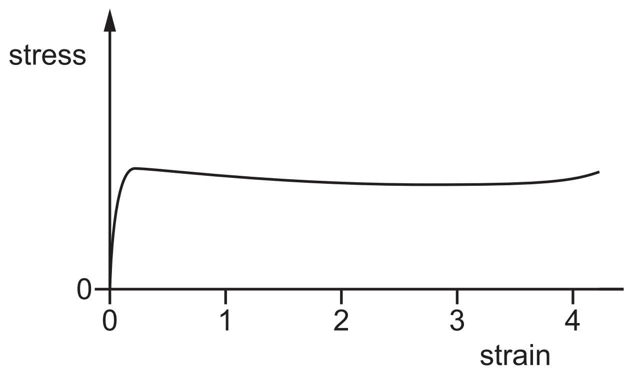
A In the position shown, all the weight of the block appears to act through point P.

B In the position shown, the centre of gravity of the block is located at point P.

C When the block is given a small displacement, the block will return to its horizontal position.

D When the block is given a small displacement, the moment of the weight of the block about point P is zero.

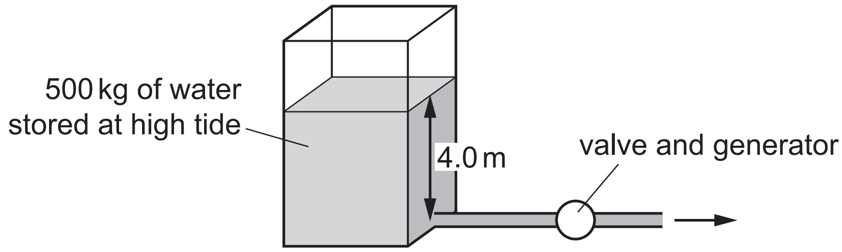
6 The graph shows the stress–strain relationship for polythene.



Which row shows which type of deformation the polythene has undergone and what type of material it is?

	deformation	material
A	elastic	brittle
B	elastic	ductile
C	plastic	brittle
D	plastic	ductile

7 A simple idea for generating electricity from the tides allows water stored in a container at high tide to flow away through a generator at low tide.



At high tide 500 kg of water is stored to a height of 4.0 m. When the valve is opened the container empties in 5.0 s and the generator operates with an efficiency of 40%.

What is the average electrical power generated during the period of water flow?

A 780 W **B** 1600 W **C** 2000 W **D** 3900 W

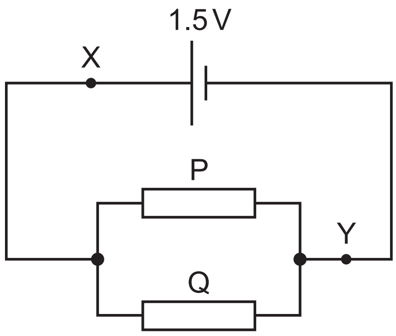
8 Two wires, X and Y, are made of different materials, but have the same resistance.

X is twice as long as Y but has half the diameter of Y.

What is the ratio $\dfrac{\text{resistivity of material from which wire X is made}}{\text{resistivity of material from which wire Y is made}}$?

A $\dfrac{1}{8}$ **B** $\dfrac{1}{4}$ **C** 4 **D** 8

9 The diagram shows an electrical circuit consisting of a chemical cell and two resistors P and Q.



The resistors have different values of resistance. The cell has an electromotive force of 1.5 V. It has negligible internal resistance.

Which statement about this circuit is correct?

A The cell transfers 1.5 J of electrical energy to chemical energy for each coulomb passing through it.

B The energy dissipated per unit charge is the same for P and Q.

C The potential difference across P and the potential difference across Q add up to 1.5 V.

D The rate of flow of charge at point X is greater than the rate of flow of charge at Y.

10 A beam of polarised light is shone through a polarising filter. The filter is positioned to give maximum brightness and is then rotated 60°.

What happens when the filter is rotated 60°?

A The amplitude falls by 13%.

B The amplitude falls by 50%.

C The intensity falls by 25%.

D The intensity falls by 50%.

11 When a person looks down into a swimming pool, it appears shallower than it actually is.

Which statement explains this effect?

A Light refracts towards the normal as it leaves the water surface.

B Light travels faster in air than water.

C Light undergoes total internal reflection at the water surface.

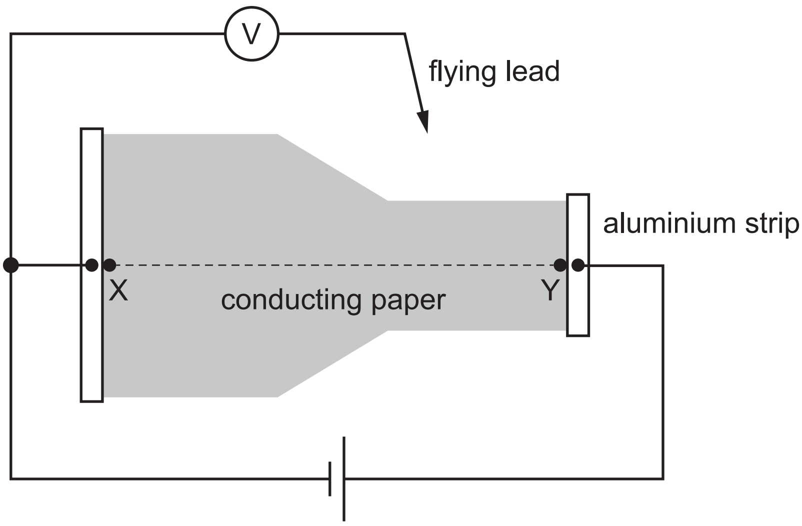
D Some light reflects from the water surface.

12 Two coherent light waves of equal frequency and intensity superpose at a point. The intensity of light at that point is twice the intensity of light due to either wave alone.

What is a possible phase difference between the two waves at that point?

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

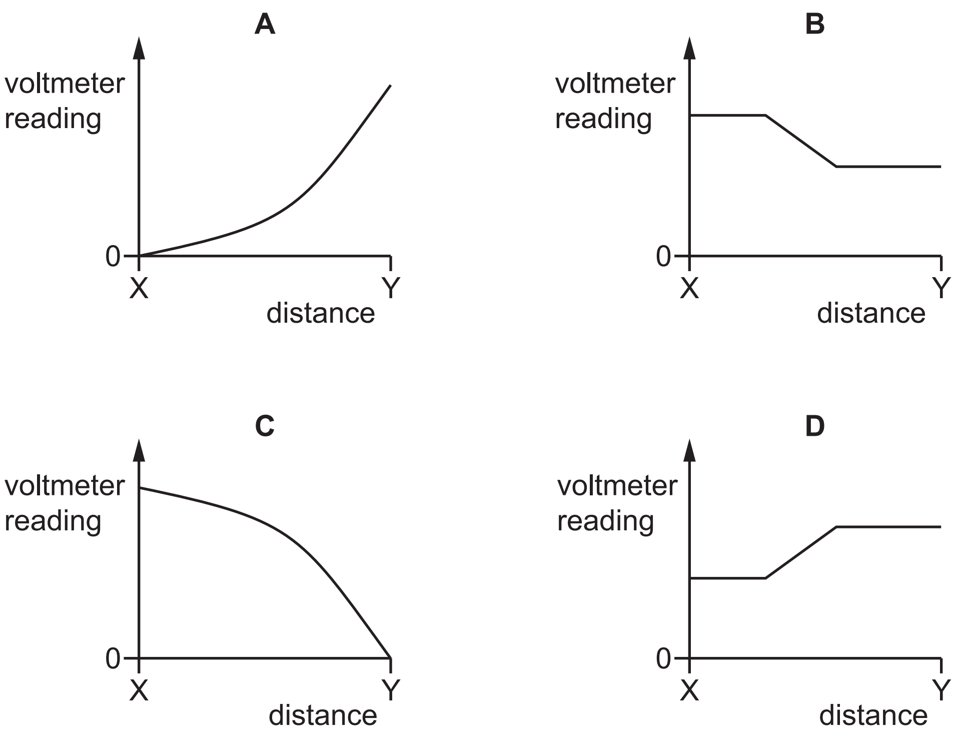
13 A sheet of conducting paper of uniform thickness is cut to the shape shown and a battery is connected to each end by aluminium strips. A high resistance voltmeter is also connected as shown.



The flying lead of the voltmeter is placed in contact with the conducting surface at X and the reading noted. This is repeated for a large number of points along the line XY, ending at point Y.

The readings are plotted on a graph of voltmeter reading against distance from X.

Which diagram shows the correct shape of the graph?



14 A sound is created by a vibrating guitar string.

The fundamental vibration of the string is a standing wave with the lowest possible frequency.

Which statement is correct?

A Adding one more node to the fundamental vibration of the string doubles the frequency of the sound.

B The fundamental vibration of the string has a node half way along the string.

C The sounds emitted by a vibrating guitar string are transverse waves.

D The wavelength of sound created by the fundamental vibration is equal to the length of the string.

15 A radioactive nucleus emits a β^- particle. The daughter nucleus formed then decays, emitting an α-particle. The daughter nucleus of this decay then emits a β^- particle.

How does the final nucleus compare with the original nucleus?

A It is a nucleus identical to the original nucleus.

B It is a nucleus of a different element of higher proton number.

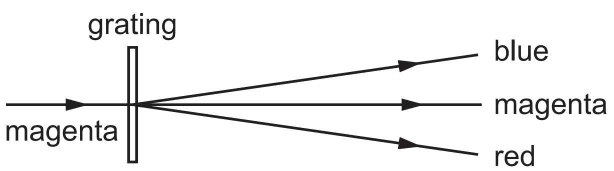
C It is a nucleus of a different element of lower proton number.

D It is a nucleus of an isotope of the original element.

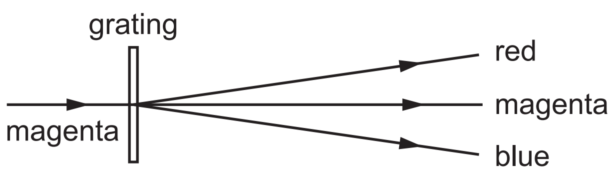
16 Magenta light consisting of a mixture of blue and red light is incident on a diffraction grating.

What is the expected arrangement of first orders about the central zero order?

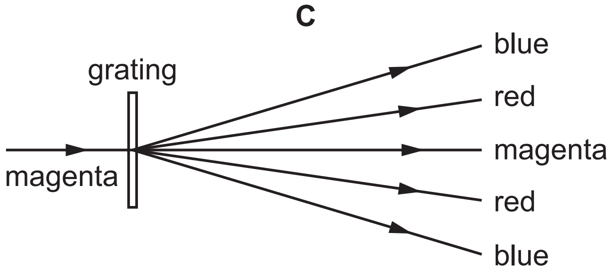
A



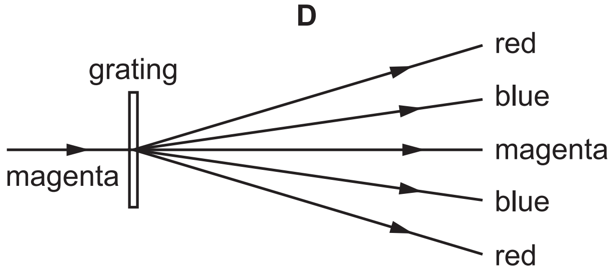
B



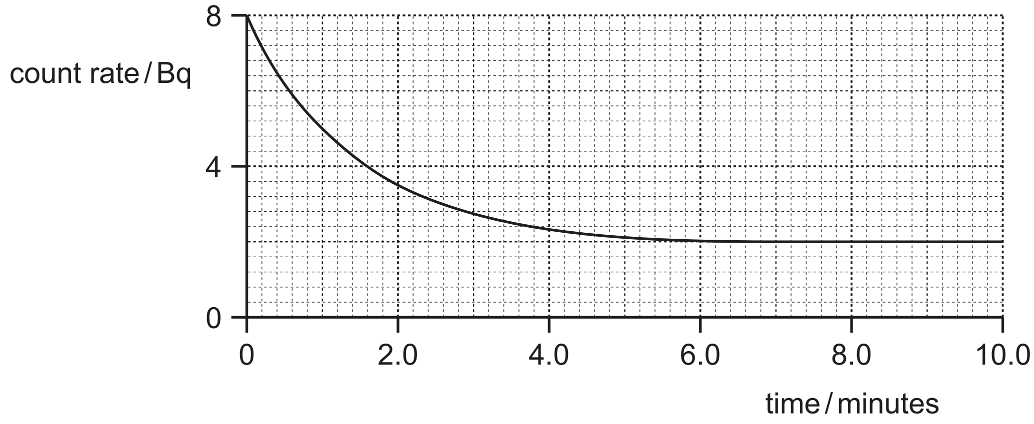
C



D



17 A sample of a radioactive isotope is placed close to a radiation detector in a laboratory and a datalogger produces the following graph of count rate against time.



What is the background count rate and the half-life of the radioactive sample?

	background count rate / Bq	half-life / minutes
A	2	1.0
B	2	1.6
C	6	1.0
D	6	1.6

18 A source of electromagnetic radiation emits photons. The intensity is measured at a fixed point near the source. The wavelength of the radiation is then gradually increased but the rate at which photons are emitted remains constant.

Which statement explains the effect this has on the measured intensity?

A Photon energy decreases so intensity decreases.

B Photon energy decreases so intensity increases.

C Photon energy increases so intensity decreases.

D Photon energy increases so intensity increases.

19 Electromagnetic radiation of wavelength 2.9×10^{-7} m is incident on the surface of a metal.

The energy of a single photon is three times greater than the work function of the metal.

What is the maximum speed of the ejected photoelectrons?

A $1.0 \times 10^{6}\,\mathrm{m\,s^{-1}}$

B $1.2 \times 10^{6}\,\mathrm{m\,s^{-1}}$

C $2.1 \times 10^{6}\,\mathrm{m\,s^{-1}}$

D $2.5 \times 10^{6}\,\mathrm{m\,s^{-1}}$

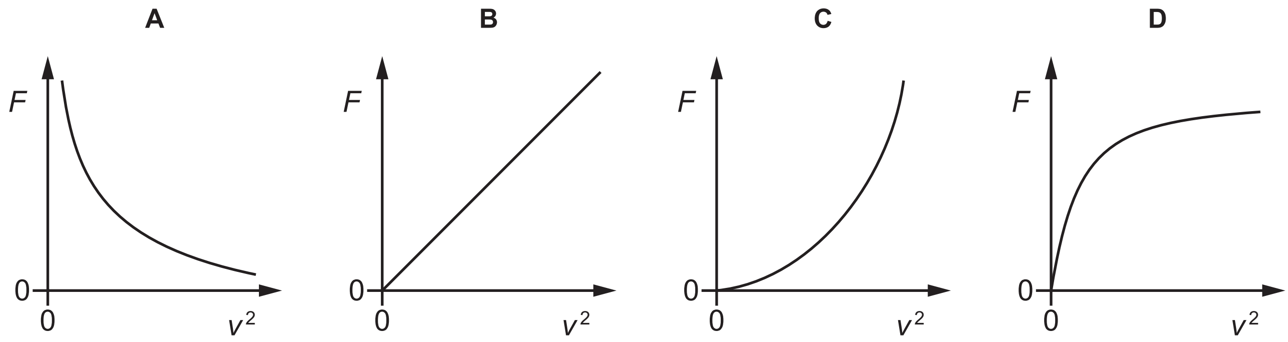
20 Crystal structure may be examined using electrons that have been accelerated through a potential difference of about 5.0 kV.

What is the de Broglie wavelength of these electrons?

A 1.7×10^{-11} m **B** 2.4×10^{-11} m **C** 5.5×10^{-10} m **D** 1.5×10^{-7} m

21 A body of mass *m* undergoes uniform circular motion with speed *v*.

Which graph represents the relationship between the force *F* acting on the body and v^2?



22 The drum of a washing machine has a diameter of 60 cm. The manufacturer states that the machine has a maximum spin rate of 1500 revolutions per minute.

Assume that, during the spin, the clothes are pressed against the edge of the drum.

What is the maximum centripetal acceleration experienced by the clothes in the machine?

A $7400\,\mathrm{m\,s^{-2}}$

B $14\,800\,\mathrm{m\,s^{-2}}$

C $675\,000\,\mathrm{m\,s^{-2}}$

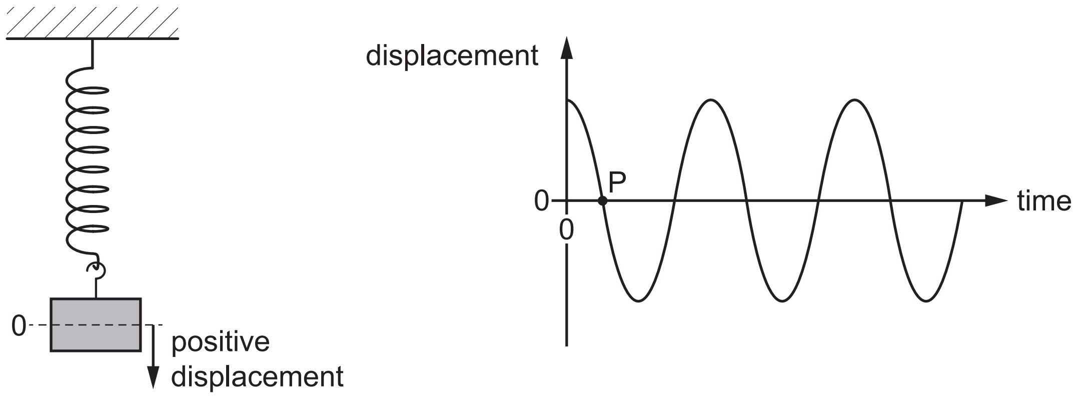
D $1\,350\,000\,\mathrm{m\,s^{-2}}$

23 Body X executes simple harmonic motion. Body Y, which has twice the mass of body X, executes simple harmonic motion with the same frequency as body X but with only half of the amplitude.

What is the ratio $\dfrac{\text{total energy of body Y}}{\text{total energy of body X}}$?

A 0.25 **B** 0.50 **C** 1.0 **D** 2.0

24 A body undergoes simple harmonic motion. The graph shows the variation of the displacement of the body with time.



Which description of the velocity of the body at point P is correct?

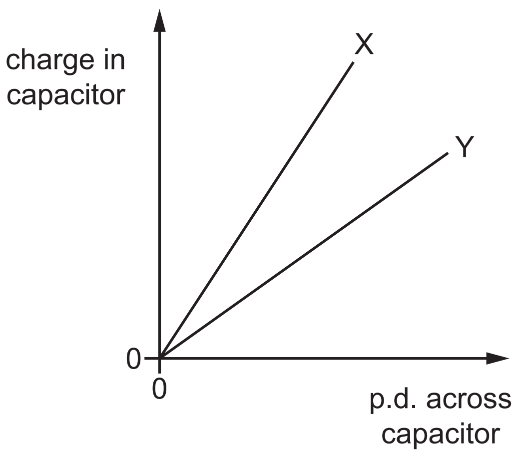
A maximum velocity, moving downwards

B maximum velocity, moving upwards

C zero velocity, accelerating downwards

D zero velocity, accelerating upwards

25 The charge stored by two capacitors, X and Y, depends on the potential difference (p.d.) across them as shown in the graph.



Which statement is correct?

A The capacitance of both X and Y increases with increasing voltage.

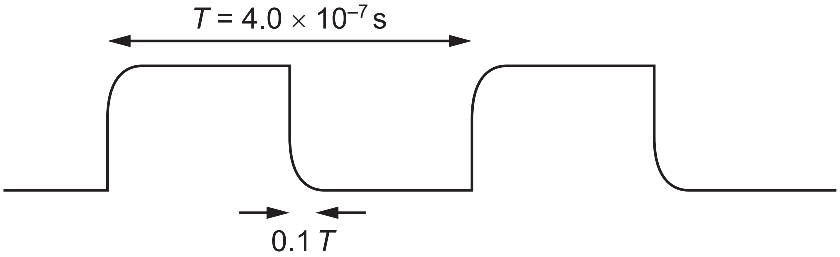
B The capacitance of Y is greater than the capacitance of X.

C The p.d. across each capacitor is directly proportional to its capacitance.

D There is more charge per unit p.d. in X than Y.

26 A square wave of time period $T = 4.0 \times 10^{-7}$ s is obtained by charging and discharging a capacitor of capacitance 63 pF.

To obtain a good square wave shape, the fall of charge on the capacitor from full charge to $(0.01 \times$ full charge) must take place in less than a tenth of the time period, as shown.



What is the maximum value of the resistance in the circuit for this to happen?

A 138 Ω **B** 276 Ω **C** 1380 Ω **D** 6350 Ω

27 A metal disc of radius r is spinning with an angular velocity ω about an axis through its centre and perpendicular to its plane. The disc is in a uniform magnetic field B which is perpendicular to the plane of the disc.

What is the electromotive force induced between the centre of the disc and its edge?

A $\pi r^2 \omega B$ **B** $\pi r \omega^2 B$ **C** $\dfrac{\omega r^2 B}{2}$ **D** $\omega r^2 B$

28 Planet X has a diameter half that of the Earth and a mass that is a quarter that of the Earth. The gravitational field strength on the surface of the Earth is g.

What is the gravitational strength on the surface of planet X?

A $0.25g$ **B** $0.5g$ **C** g **D** $2g$

29 An electron in a hydrogen atom is at a distance of 1.0×10^{-10} m from the proton at the centre.

What is the electric field strength experienced by the electron?

A 2.3×10^{-18} N C^{-1}

B 2.3×10^{-8} N C^{-1}

C 1.4×10^{1} N C^{-1}

D 1.4×10^{11} N C^{-1}

30 The planet Jupiter has satellites called Io and Europa which have different orbital radii and different orbital time periods. The table shows the orbital radii for Io and Europa and the orbital time period of Io.

	orbital radius / km	orbital time period / days
Io	4.22×10^5	1.77
Europa	6.71×10^5	T_E

What is the orbital time period T_E of Europa?

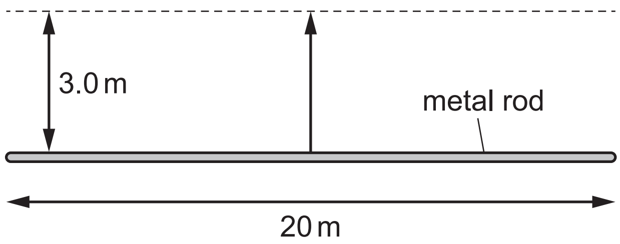
A 0.88 days **B** 2.4 days **C** 2.8 days **D** 3.5 days

31 A cylinder of fixed volume contains 15 moles of an ideal gas at a pressure of 500 kPa and a temperature of 17 °C.

What is the volume of the cylinder?

A $4.2 \times 10^{-3}\,m^3$ **B** $7.2 \times 10^{-2}\,m^3$ **C** $4.2\,m^3$ **D** $72\,m^3$

32 A horizontal straight metal rod is raised vertically at a constant velocity of $15\,m\,s^{-1}$. The length of the rod is 20 m.



The horizontal component of the Earth's magnetic flux density acting perpendicular to the rod is $2.0 \times 10^{-5}\,T$.

What is the induced voltage across the ends of the rod as it is raised through 3.0 m?

A zero **B** 0.24 mV **C** 1.2 mV **D** 6.0 mV

33 A gas is heated very gradually. This causes it to expand slowly. During this entire process, the temperature of the gas remains constant.

Which statement is correct?

A As the heat is applied, the internal energy of the gas increases.

B The gas does no work in expanding.

C The rate of heating and the rate of the gas doing work are equal at all times.

D The root-mean-square speed of the gas molecules increases as the heat is applied.

34 A cycle of four strokes in a heat engine are shown in which the final internal energy of the engine is the same as the initial internal energy of the engine.

thermal energy supplied / J	work done on the system / J	increase in internal energy / J
2000	0	2000
0	500	500
0	–1300	–1300
–1200	0	–1200

What is the efficiency of the engine?

A 40% **B** 42% **C** 62% **D** 100%

35 What is the quark composition of an antineutron and an antiproton?

	antineutron	antiproton
A	$\bar{d}\bar{d}\bar{d}$	$\bar{u}\bar{u}\bar{u}$
B	$\bar{u}\bar{d}\bar{d}$	$\bar{u}\bar{u}\bar{d}$
C	$\bar{u}\bar{u}\bar{d}$	$\bar{u}\bar{d}\bar{d}$
D	$\bar{u}\bar{u}\bar{u}$	$\bar{d}\bar{d}\bar{d}$

36 The half-life of carbon-14 is 5700 years.

A sample of pure carbon-14 has an activity of 6.2 MBq.

How many atoms of carbon-14 does the sample contain?

A 5.1×10^{4} **B** 5.1×10^{10} **C** 1.6×10^{12} **D** 1.6×10^{18}

37 A source of gamma rays has an intensity of 88 kW m^{-2}.

Lead is placed in front of the source. The lead has a linear absorption coefficient of 1.6 cm^{-1}.

Which thickness of lead is required to reduce the intensity of the gamma rays to 56 μW m^{-2}?

A 0.40 cm **B** 5.7 cm **C** 8.9 cm **D** 13 cm

38 The energy levels in a hydrogen atom are shown.

energy level *n*	energy / eV
1	−13.6
2	−3.4
3	−1.5
4	−0.9
5	−0.5

A red spectral line known as the hydrogen alpha line has been of great value to astronomers. Its wavelength is 656.28 nm.

Which level change gives rise to the hydrogen alpha line?

A 2 to 1 **B** 3 to 1 **C** 3 to 2 **D** 5 to 2

39 A star has a radius of 7.00×10^{8} m and an average surface temperature of 6000 °C.

How much electromagnetic energy is emitted by the star in an hour?

A 4.52×10^{26} J

B 5.41×10^{26} J

C 1.63×10^{30} J

D 1.95×10^{30} J

40 Star X has twice the surface temperature of star Y, but the same luminosity as star Y.

What is the ratio $\dfrac{\text{radius of star X}}{\text{radius of star Y}}$?

A 0.25 **B** 0.50 **C** 2.0 **D** 4.0