Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

PHYSICS **9749/01**
Paper 1 Multiple Choice 15 September 2021
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and index number on the Answer Sheet provided.

There are **thirty** questions in this section. 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 Question Paper.
The use of an approved scientific calculator is expected, where appropriate.

This paper consists of 15 printed pages

DATA AND FORMULAE

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-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	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature	T/K	=	$T/°C + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translational kinetic energy of 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	=	$A n v q$
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,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 The table below shows some estimates of some physical quantities.

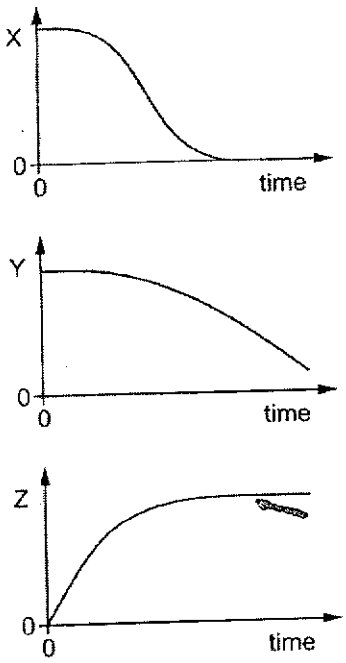
Which quantity is **not** a reasonable estimate?

	quantity	value
A	electric current in a heater	12 A
B	mass of an adult person	70 kg
C	maximum speed of an Olympic sprinter	10 m s^{-1}
D	water pressure at the bottom of a swimming pool	10^6 Pa

2 An object is dropped at time t = 0 s from a tall building. Air resistance is significant.

Three graphs are plotted against time:

- the height of the object above the ground
- the speed of the object
- the magnitude of the resultant force on the object.



What are the quantities X, Y and Z?

	height of the object above the ground	speed of the object	magnitude of the resultant force on the object
A	X	Y	Z
B	X	Z	Y
C	Y	Z	X
D	Z	Y	X

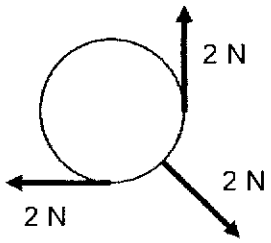
3 On a stationary ship, a golf ball is struck so that it flies off horizontally from the edge of the deck of the ship at a speed of 72 m s^{-1} and lands in the sea at a horizontal distance of 220 m.

Assuming air resistance to be negligible, what is the vertical height of the deck above the sea?

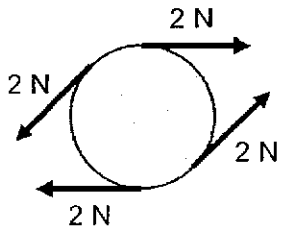
A 15 m
B 30 m
C 46 m
D 92 m

4 Which of the following diagrams shows a body in equilibrium?

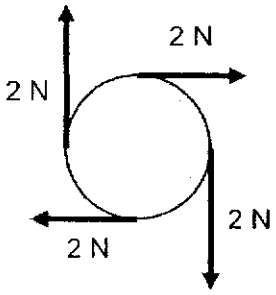
A



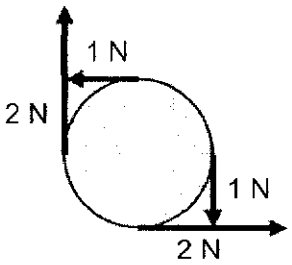
B



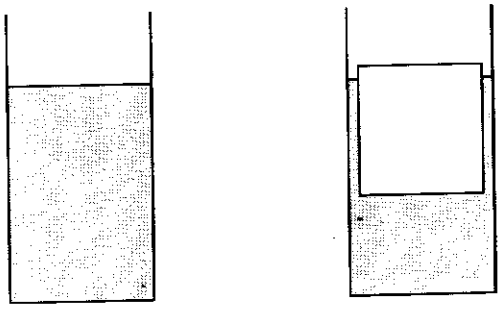
C



D



5 A cup contains 100 g of water. The pressure at the bottom of the cup is P.



before after

50 g of water is removed from the cup, frozen into ice, and added back to the cup, as shown above. 10% of the volume of the ice is above the surface of the water.

What is the new pressure at the bottom of the cup?

A $0.95P$ **B** P **C** $1.05P$ **D** $1.10P$

6 An aircraft, powered by a jet engine, is flying at a constant speed of 800 m s^{-1}. 20 kg of exhaust gas is ejected from the engine every second, with a velocity of 100 m s^{-1} in the opposite direction relative to the aircraft.

What is the magnitude of the resistive force experienced by the aircraft?

A 2 000 N

B 14 000 N

C 16 000 N

D 18 000 N

7 A man of 70 kg stands on a weighing scale in a lift. The lift begins to ascend with an acceleration of 0.80 m s^{2}, before slowing to a stop with a maximum deceleration of 0.30 m s^{-2}.

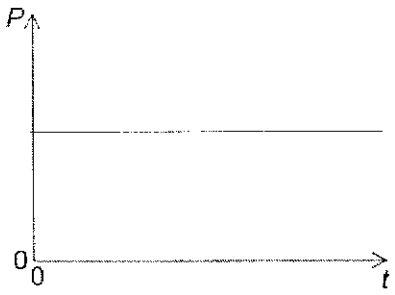
What is the difference between the maximum and minimum reading of his mass observed on the weighing scale?

A 2.1 kg **B** 3.6 kg **C** 5.7 kg **D** 7.8 kg

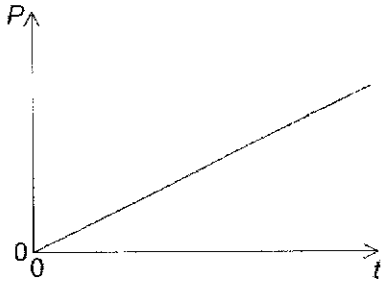
8 A train on a straight horizontal track moves from rest at constant acceleration. The horizontal forces on the train are the driving force exerted by the engine and a resistive force which increases with speed.

Which graph represents the variation with time t of the power P developed by the engine?

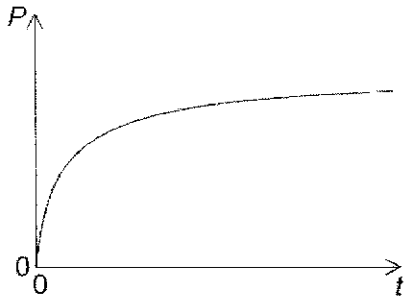
A



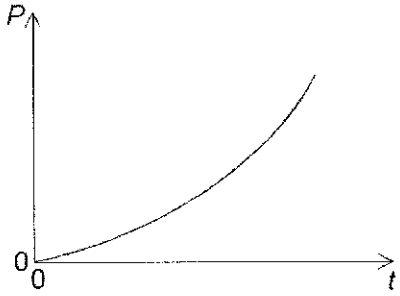
B



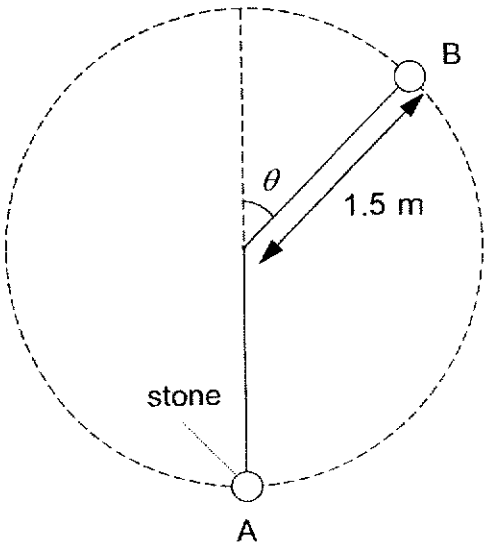
C



D



9 A stone attached to a light inextensible string at position A is given an initial push to the right. It subsequently moves in a vertical circle of radius 1.5 m and the string just slackens at position B when it makes an angle of θ to the vertical.



Given that the velocity of the stone at position B is 2.2 m s^{-1}, what is θ?

A 9° **B** 19° **C** 71° **D** 81°

10 A small mass m is placed in the gravitational field of a large mass M. Both masses experience a force F.

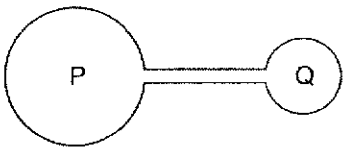
What is the gravitational field strength due to M at the position of m?

A $\frac{F}{Mm}$ **B** $\frac{F}{M}$ **C** FMm **D** $\frac{F}{m}$

11 Which of the following satellites must be a geostationary satellite orbiting about Earth?

A Satellite A has a period of 12 hours.
B Satellite B orbits directly above the equator.
C Satellite C orbits from east to west.
D Satellite D always remains above the same point on the Earth.

12 Two flasks P and Q contain an ideal gas and are connected with a tube of negligible volume compared to that of the flasks. The volume of P is triple the volume of Q.



P is held at a temperature of 200 K and Q is held at a temperature of 600 K.

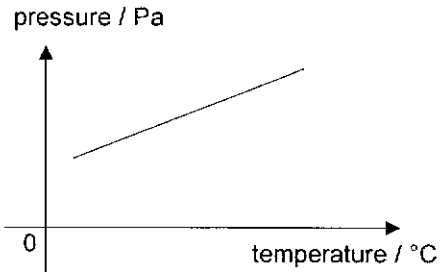
What is the $\frac{\text{mass of gas in P}}{\text{mass of gas in Q}}$?

A $\frac{1}{9}$ **B** $\frac{1}{3}$ **C** 3 **D** 9

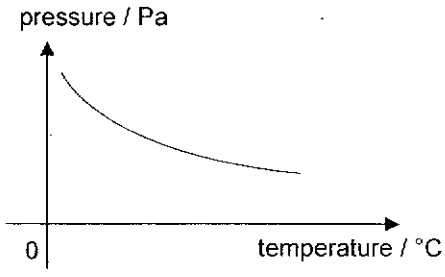
13 A fixed mass of an ideal gas is trapped in a cylinder of constant volume and its temperature is varied.

Which graph shows the variation of the pressure of the gas with temperature in degrees Celsius?

A



B



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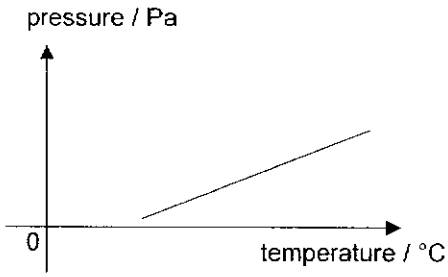

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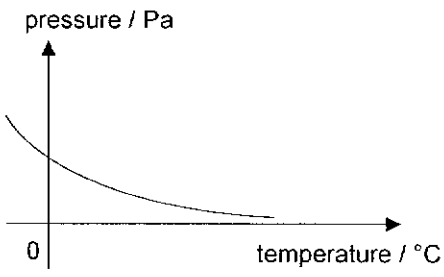


14 A block of iron of mass 15 kg and temperature 35 °C is in thermal contact with a block of iron of mass 30 kg and temperature 95 °C. Heat loss to the surroundings is negligible.

What will be the final temperature of both blocks?

A 60 °C **B** 65 °C **C** 70 °C **D** 75 °C

[Turn over

15 In a horizontal spring-mass system, a mass m oscillates with a frequency f and an amplitude x. The total energy of the oscillating system is E.

What is the total energy of a spring-mass system with a mass 0.50 m, frequency 3.0 f and amplitude 0.40 x?

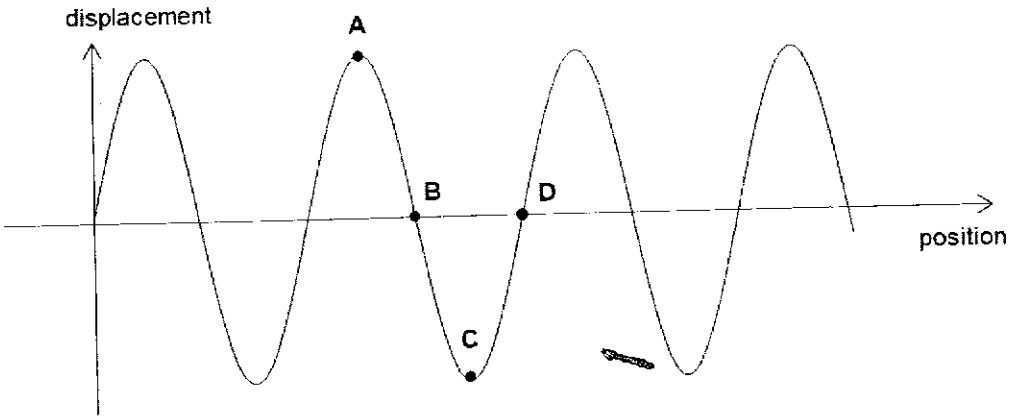
A $0.24E$ **B** $0.60E$ **C** $0.72E$ **D** $1.8E$

16 Which statement is true of a lightly-damped system?

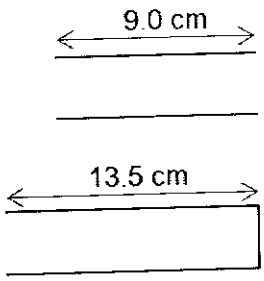
A Increased damping will decrease the frequency of the system.
B Increased damping will not affect the period of the system.
C The amplitude of the system remains constant over time.
D The period of the system increases over time.

17 A sound wave is propagating in air. The graph below shows the displacement to the right from the equilibrium of the air molecules against position along the path of propagation.

At which point will there be a rarefaction in the air?



18 Two tubes of different length are used for an experiment. The 9.0 cm tube has both ends open while the 13.5 cm tube has one end open and one end closed as shown.



Sound is projected into both tubes. Assuming sound travels at 330 m s^{-1}, at which frequency will resonance occur in both tubes?

A 5.50 kHz **B** 7.33 kHz **C** 7.94 kHz **D** 11.0 kHz

19 Monochromatic light of wavelength λ is incident on a diffraction grating of x lines per millimetre.

Which row will produce the largest number of maxima emerging from the grating?

	λ / nm	x
A	400	200
B	400	500
C	650	200
D	650	500

20 Two horizontal metal plates A and B are situated a distance d apart in a vacuum.

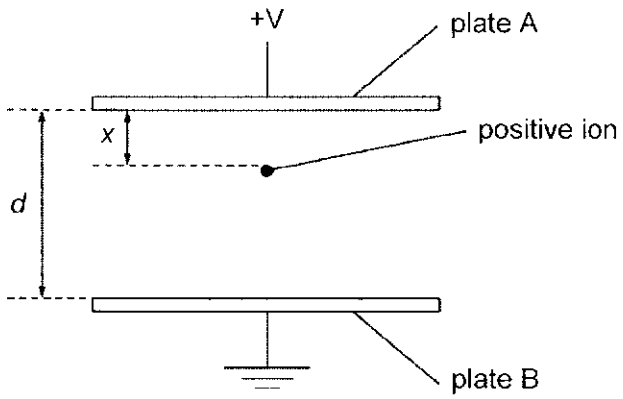


Plate A is at a potential of +V and plate B is earthed. A positive ion is initially placed at rest in the region of the uniform electric field where its distance x from plate A is zero.

Any change in gravitational potential energy of the positive ion is negligible compared with any change in electric potential energy.

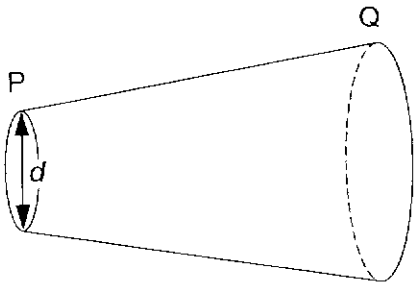
Which of the following statements is correct as it moves from $x = \frac{d}{4}$ to $x = \frac{3d}{4}$?

A The energy gained by the positive ion is directly proportional to d.
B The energy gained by the positive ion is directly proportional to d^2.
C The energy gained by the positive ion is independent of d.
D The energy gained by the positive ion is inversely proportional to d.

21 Which statement is true of an electric field strength and gravitational field strength of a point source?

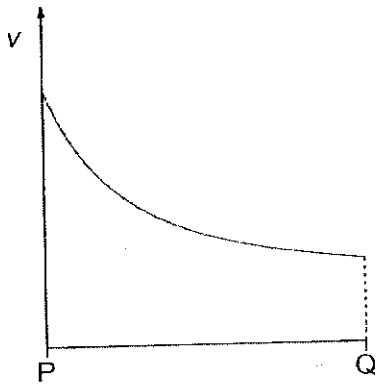
A Both are always directed towards the source.
B Both are inversely proportional to the distance from the source.
C Both are inversely proportional to the square of the distance from the source.
D Both can be directed towards or away from the source.

22 The diameter d of a wire PQ increases linearly with distance along the wire from end P to end Q. There is current I in the wire.

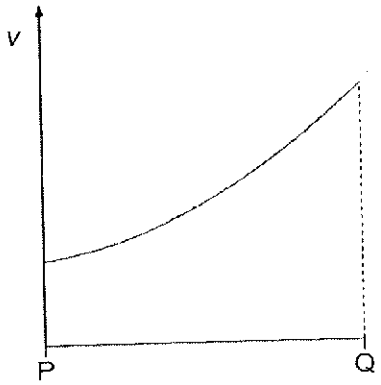


Which graph shows the variation of the average drift speed v with position along the wire between P and Q?

A



B



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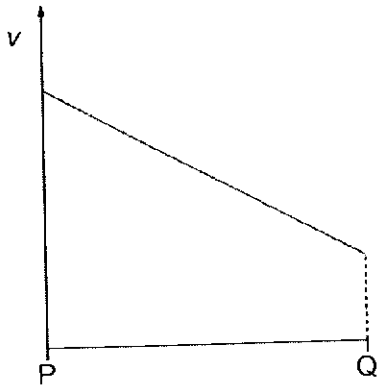
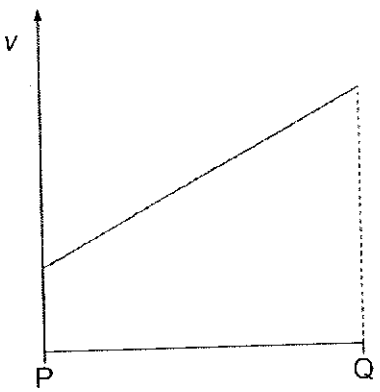


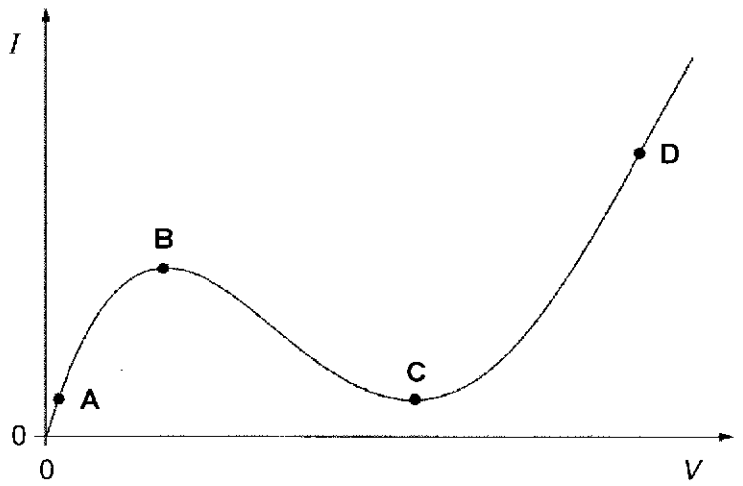
D



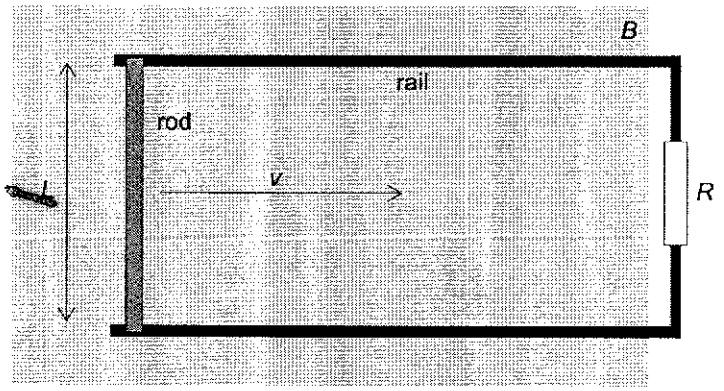
23 The current I through an electrical component is measured when a potential difference V is applied across it.

The graph shows the variation of I with V.

At which point is the resistance the greatest?



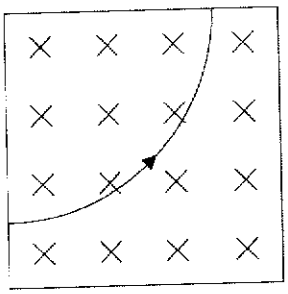
24 A conducting rod of length L is moved in a region of uniform magnetic field of flux density B. The field is directed at right angles to the plane of the paper. The rod slides on conducting rails at a constant speed v. A resistor of resistance R connects the rails as shown in the figure below.



Which statement is true?

A The magnetic force on the rod is directly proportional to B.
B The magnetic force is independent of R.
C Increasing the length of the rod will increase the induced current in the rod.
D The power required to move the rod is proportional to the square of the velocity

25 A particle is in a region of uniform magnetic field. The field is directed into the plane of the page. The path of this particle is shown in the figure below.



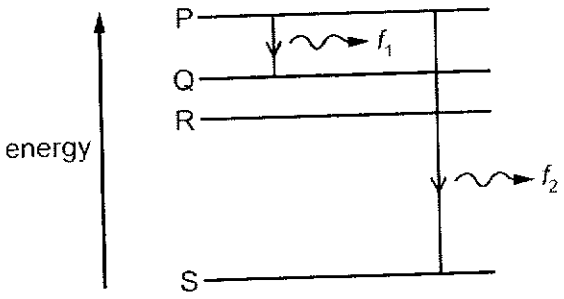
What is this particle and what is the direction of the electric field for it to pass through with no deflection?

	This particle is	Direction of electric field is
A	a positive ion	upwards
B	a positive ion	downwards
C	an electron	upwards
D	an electron	downwards

26 Which of the following minimises the energy loss in a transformer core due to eddy currents?

A Use of a steel core.
B Use of a higher frequency primary voltage.
C Use of a laminated core.
D Use of a primary coil with smaller resistivity.

27 The energy level diagram shows four energy levels for the electrons.



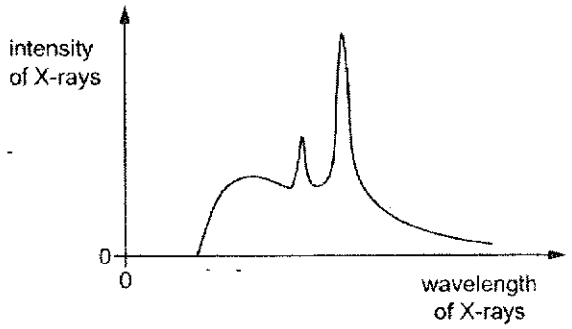
Two electron transitions are also shown together with the frequencies f_1 and f_2 of the emitted photons.

Which statement is **not** correct?

A All the emitted photons have the same speed.
B The frequency of the photon emitted is $f_2 - f_1$ for the transition Q to S.
C The longest wavelength is for the transition Q to R.
D There are five possible spectral lines for these four energy levels.

28 X-rays are produced when high speed electrons collide with a metal target. To attain the high speed, electrons are accelerated over a potential difference.

The graph illustrates how the intensity of X-rays varies with their wavelength when the target is tungsten.



The electrons are subsequently accelerated across a higher potential difference.

Which statement is correct?

A The minimum wavelength will decrease.
B The minimum wavelength will increase.
C The number of peaks will increase.
D The position of the peaks will move towards shorter wavelengths.

29 Nucleus P undergoes a series of nuclear reactions to form nucleus Q. It is found that Q has the same nucleon number as P, but a larger mass.

Which statement is true?

A P is less stable than Q.
B P requires more energy than Q to be separated into its individual nucleons.
C The binding energy of P is smaller than the binding energy of Q.
D There has been a net release of energy through the series of nuclear reactions.

30 Which combination of successive emissions produces a final nucleus with the same proton number as the starting nucleus?

A $\alpha\,\alpha\,\beta$
B $\alpha\,\beta\,\beta$
C $\alpha\,\beta\,\gamma$
D $\beta\,\gamma\,\beta$

End of Paper

1	**D**	Depth of swimming pool = 2m Pressure at the bottom of the pool = $p_o + \rho gh = 10^5 + (10^3)(10)2 = 10^7$ Pa
2	**C**	
3	**C**	$s_x = u_x t$ $220 = (72)t$ $t = 3.06$ s $s_y = u_y t + \frac{1}{2}at^2$ $= 0 + \frac{1}{2}(9.81)(3.06)^2$ $= 46$ m
4	**B**	
5	**B**	
6	**A**	$F_{\text{resistive}} = -\text{thrust}$ $= -v_{rel}\frac{dm}{dt}$ $= -(-100)(20)$ $= 2\,000$ N
7	**D**	$\Delta a = 0.80 - (-0.30) = 1.10$ m s^{-2} $\Delta F = m\Delta a = (70)(1.10) = 77$ N Apparent difference in mass $= \frac{77}{9.81} = 7.8$ kg
8	**D**	

9	C	When the string just slackens, the tension in the string is zero. The component of the weight acting in the radial direction provides for the centripetal force. $mg\cos\theta = \frac{mv_B^2}{r}$ $g\cos\theta = \frac{v_B^2}{r}$ $\theta = \cos^{-1}\left(\frac{v_B^2}{rg}\right) = \cos^{-1}\left[\frac{2.2^2}{(1.5)(9.81)}\right]$ $= 71°$
10	D	
11	D	
12	D	At steady state, pressure in both flasks are the same. Applying ideal gas law $P_P = P_Q$ $\frac{n_P R T_P}{V_P} = \frac{n_Q R T_Q}{V_Q}$ $\frac{M_P}{M_Q} = \frac{T_Q}{T_P}\frac{V_P}{V_Q} = 9$
13	A	$pV = nRT$ $pV = nR(t + 273.15)$ $p = \frac{nR}{V}(t + 273.15)$
14	D	Heat loss by block of higher temp = Heat gained by block of lower temp $Q = mc\Delta T$ $15c(T_f - 35) = 30c(95 - T_f)$ $T_f - 35 = 190 - 2T_f$ $T_f = 75$
15	C	$E = \frac{1}{2}m(2\pi f)^2 x^2$ $\frac{1}{2}(0.5m)(2\pi)^2(3.0f)^2(0.40x)^2 = (0.72)\left(\frac{1}{2}m(2\pi f)^2 x^2\right)$ $= 0.72E$
16	A	
17	D	
18	A	

Freq / Hz	wavelength / m	9.0 cm tube	13.5 cm tube
5500	0.060	1.50	2.25
7330	0.045	2.00	3.00
7940	0.042	2.17	3.25
11000	0.030	3.00	4.50

19 **A**

	λ / nm	x	n
A	400	200	12.5
B	400	500	5.0
C	650	200	7.7
D	650	500	3.1

20 **C**

gain in kinetic energy = loss in electric potential energy

$$= qV_{\text{initial}} - qV_{\text{final}}$$

$$= qE\left(d - \frac{\mathrm{d}}{4}\right) - qE\left(d - \frac{3\mathrm{d}}{4}\right)$$

$$= \frac{1}{2}qEd$$

$$= \frac{1}{2}q\left(\frac{V}{d}\right)d$$

$$= \frac{1}{2}qV$$

The gain in kinetic energy of the positive ion is independent of *d*.

21 **C**

22	**A**	$I = nevA$ $v = \frac{I}{neA}$ $= \frac{I}{ne\pi\left(\frac{d}{2}\right)^2}$ $v \propto \frac{1}{d^2}$ If d increases linearly with position x, $d \propto x$. $v \propto \frac{1}{x^2}$ When x increases, v decreases at a decreasing rate.
23	**C**	
24	**D**	$I = \frac{\varepsilon}{R} = \frac{BLv}{R}$ $F = BIL = B(\frac{BLv}{R})L$ $F = \frac{B^2L^2v}{R}$ $P = Fv = \frac{B^2L^2v^2}{R}$ L is the length of the rod in contact with the rail.
25	**B**	Centripetal force when entering is upwards hence magnetic force is upwards. Using Fleming's right hand rule, current is in the same direction as the path so it must be positively charged. If direction of magnetic force is upwards, electric force must be downwards so electric field must also be downwards.
26	**C**	Laminating the iron core in a transformer narrows the eddy current paths which reduces the induced e.m.f. and hence the eddy currents.
27	**D**	For a 4-level system, the number of possible transitions is ${}^4C_2 = 6$
28	**A**	Higher p.d. → higher KE → max energy of photon is higher → λ_{min} is smaller
29	**B**	
30	**B**	