VICTORIA JUNIOR COLLEGE
2024 JC2 PRELIMINARY EXAMINATION
Higher 2

PHYSICS 9749/01

Paper 1 Multiple Choice **20 September 2024**

FRIDAY

Additional Materials: Multiple Choice Answer Sheet **2.30 pm to 3.30 pm (1 hour)**

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and Civics Group on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE ON ANY BARCODES.

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.

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	$s = ut + (½)\,at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{GM}{r}$
temperature	$T\ /\mathrm{K} = T\ /^{\circ}\mathrm{C} + 273.15$
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.	$v = v_0 \cos \omega t$ $= \pm\omega\sqrt{x_0^{\,2} - x^2}$
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	$V = \frac{Q}{4\pi\epsilon_0 r}$
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	$\lambda = \frac{\ln 2}{t_{1/2}}$

1. Which one of the following estimates is unrealistic?

A The potential energy of a man at the top of Bukit Timah Hill is 100 kJ.
B The volume of air in a classroom is 150 m^3.
C The mass of an apple is 100 g
D The average temperature of fire is 300 K.

2. The velocity- time graph of a particle moving in a straight line is shown in Fig. 2:

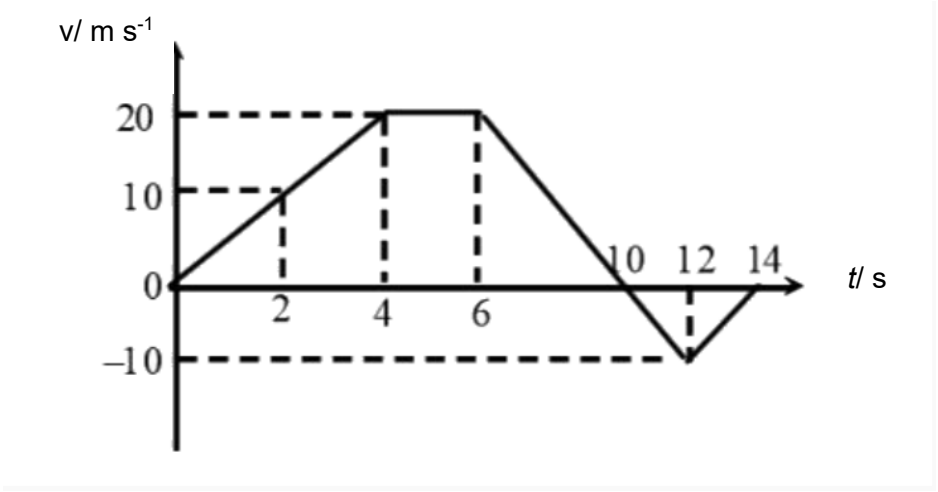
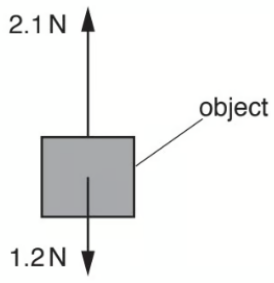


Fig. 2

What are the average speed and velocity of the particle between time t = 0 and t = 14 s?

	Average speed / m s^{-1}	Average velocity / m s^{-1}
A	7.1	7.1
B	7.1	10
C	10	7.1
D	10	10

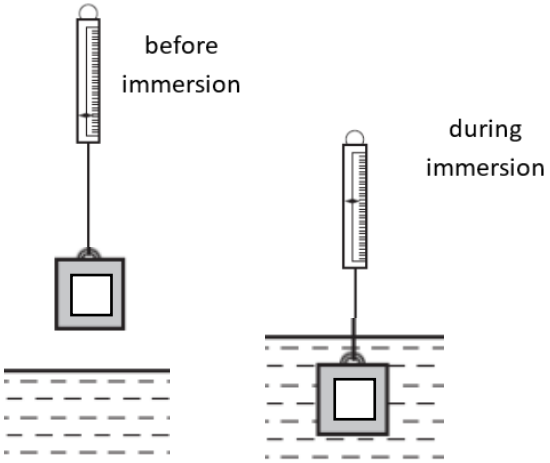
3. The diagram shows two opposite vertical forces of magnitude 1.2 N and 2.1 N acting on an object.



Which of the following statements is wrong?

A The magnitude of the resultant force is 0.9 N.
B The object is accelerating and moving up.
C The object is decelerating and moving up.
D The object is decelerating and moving down.

4. The diagrams show a hollow metal cube, with a sealed opening, is suspended from a spring balance before and during immersion in water. A reduction in the balance reading occurs because of the immersion.



Water is then allowed to enter the metal cube, through the opening, to fill up the empty space in the cube.

Which of the following statements is correct?

A Upthrust of the water on the cube increases, hence the balance reading will be further reduced.

B The balance reading during immersion corresponds to the upthrust of the water on the cube.

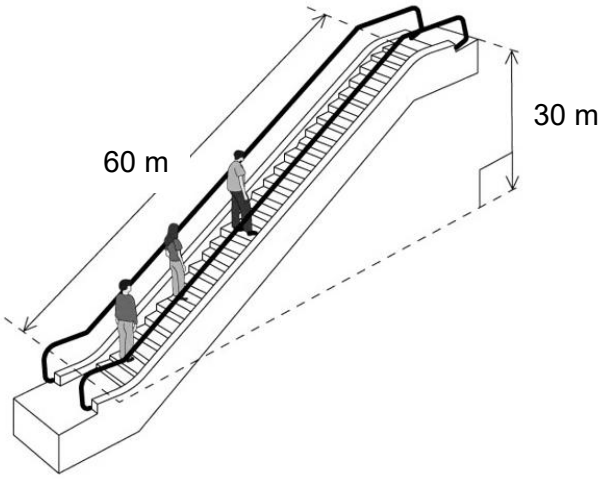
C The balance reading stays the same as the increase in weight of water in the cube is offset by the increase in upthrust of the water on the cube.

D The balance reading increases due to the increase of gravitational pull on the cube.

5. Which row in the table gives the gravitational potential energy, the elastic potential energy and the kinetic energy of a bungee jumper during the first fall? Air resistance is negligible.

		Gravitational potential energy/ kJ	Elastic potential energy/ kJ	Kinetic energy/kJ
A	top middle bottom	120 60 0	0 10 120	0 50 0
B	top middle bottom	120 60 0	0 30 60	0 30 60
C	top middle bottom	120 60 0	0 30 120	0 60 0
D	top middle bottom	120 60 0	0 60 120	0 0 0

6. An escalator is 60 m long and lifts passengers through a vertical height of 30 m, as shown.



To drive the escalator against the forces of friction when there are no passengers requires a power of 2.0 kW.

The escalator is used by passengers of average mass 60 kg and the power to overcome friction remains constant.

How much power is required to drive the escalator when it is carrying 20 passengers and is travelling at 0.75 m s^{-1}?

A 4.4 kW

B 6.4 kW

C 8.8 kW

D 10.8 kW

7. A turntable is rotating at a constant number of revolutions per second. What is the relationship between the angular velocity of a point on the turntable and the distance of the point from the centre of the turntable?

A Angular velocity is directly proportional to the distance.
B Angular velocity is inversely proportional to the distance.
C Angular velocity is directly proportional to the distance squared.
D Angular velocity is independent of distance.

8. A satellite of mass M is in circular orbit with radius r around the Earth with a period of T. A second satellite of mass $2M$ moves around the Earth with radius $4r$. What is the period of this second satellite in terms of T?

A $\frac{T}{4}$

B $2\,T$

C $4\,T$

D $8\,T$

9. What is the approximate number of atoms in a cubic metre of an ideal monatomic gas at the temperature of 27 °C and a pressure of 1×10^5 Pa?

A 1×10^{22} **B** 6×10^{23} **C** 2×10^{25} **D** 3×10^{26}

10. A fixed mass of monatomic ideal gas at a volume V at temperature T and pressure P has a root mean square speed c. After absorbing heat, its final volume is V and final pressure is $2P$.

What is the new root mean square speed of the ideal gas?

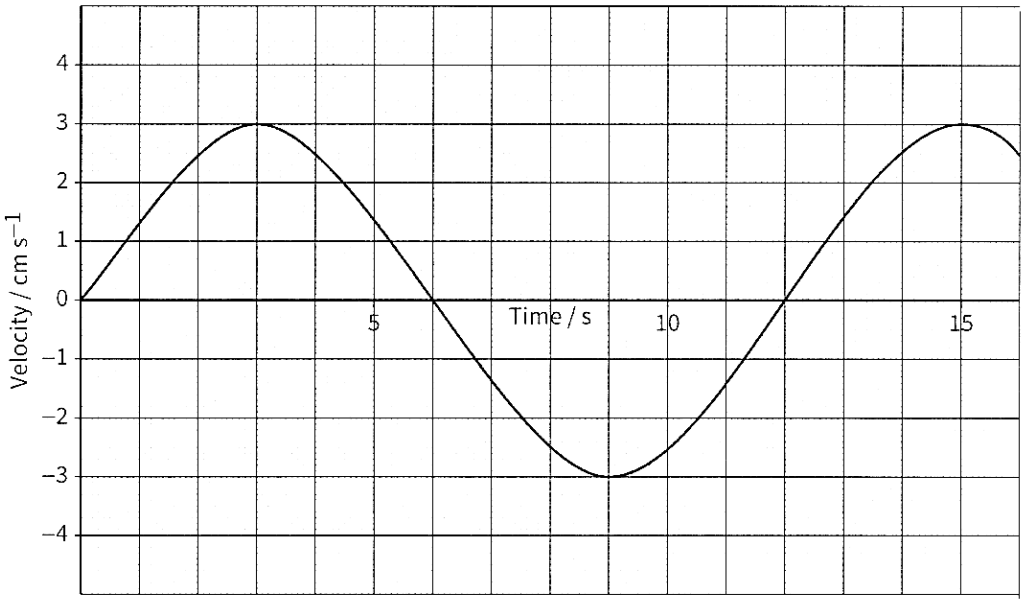
A $0.5\,c$ **B** $0.71\,c$ **C** $1.4\,c$ **D** $2.0\,c$

11. An ideal gas is confined in a cylinder fitted with a frictionless piston. When 90 J of heat is supplied and the gas is allowed to expand 2.5×10^{-4} m^3 in volume at a constant pressure of 2.0×10^5 Pa, the temperature rises by 4.5 K.

What is the increase in internal energy during this process?

A 40 J **B** 50 J **C** 90 J **D** 140 J

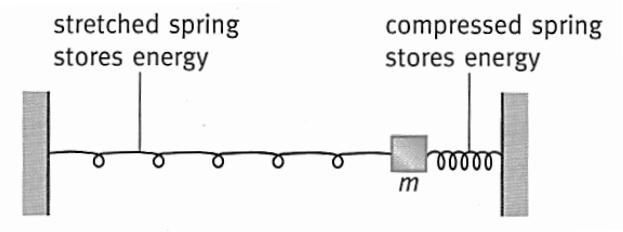
12. The graph below shows the variation with time of the velocity of a 5.0 kg oscillating mass.



What is the maximum restoring force acting on the mass as it oscillates?

A 0.041 N **B** 0.050 N **C** 0.079 N **D** 0.15 N

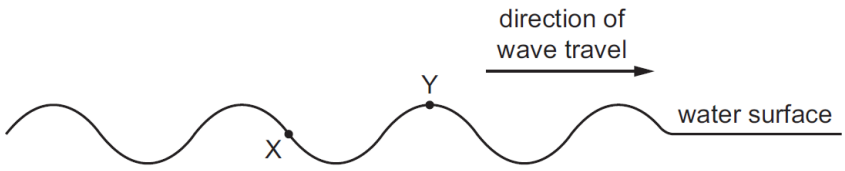
13. An object of mass *m* oscillates in simple harmonic motion between two springs as shown below. The amplitude of the motion is x_o.



What is the ratio $\frac{\text{elastic potential energy of the two springs}}{\text{kinetic energy of the object}}$ when the object is $\frac{x_o}{2}$ from its equilibrium?

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

14. X and Y are two points on the surface of water in a ripple tank. A source of constant frequency generates a wave which travels past X and Y, causing them to oscillate vertically.



What is the phase difference between X and Y?

A 45° **B** 135° **C** 180° **D** 270°

15. A point source of sound emits energy equally in all directions at a constant rate and a detector placed 3.0 m form the source measures an intensity of 3.0 W m^{-2}.

What intensity would the detector measure if it is now placed at a distance 5.0 m from the source?

A 1.1 W m^{-2} **B** 1.8 W m^{-2} **C** 2.5 W m^{-2} **D** 8.3 W m^{-2}

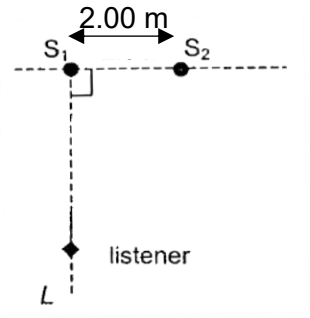
16. A musical organ produces notes by blowing air into a set of pipes that are open at one end and closed at the other.

The speed of sound in the air in the pipes is 320 m s^{-1}.

What is the lowest frequency of sound produced by a pipe of length 2.0 m?

A 20 Hz **B** 40 Hz **C** 80 Hz **D** 160 Hz

17. The figure below shows two speakers, S_1 and S_2, placed 2.00 m apart. The two speakers are both part of a stereo system connected to the same source, which produces sound of wavelength 1.00 m.



What is the distance from S_1 that a listener must be, along the line S_1L, for him to hear a minimum in sound intensity?

A 1.20 m **B** 1.50 m **C** 2.00 m **D** 3.75 m

18. Two wires of the same material and length are connected in series in an electrical circuit. One wire is thicker than the other.

Which of the following statements is true when a current flows in the circuit?

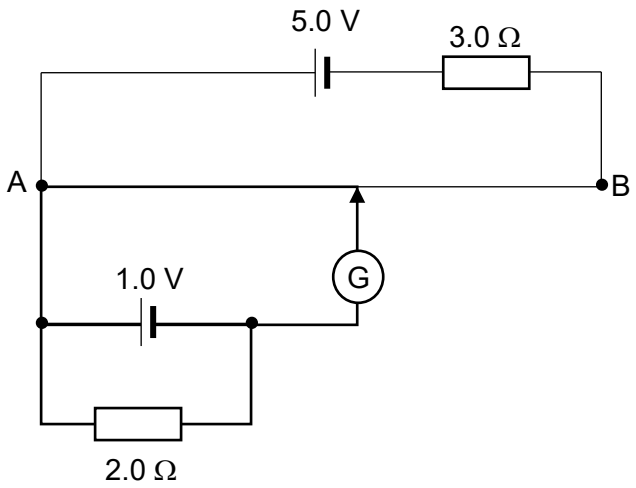
A The drift speed of electrons in the thicker wire is higher than the thinner wire.

B The drift speed of electrons in the thicker wire is lower than the thinner wire.

C The number density of charge carriers in the thicker wire is higher than the thinner wire.

D The number density of charge carriers in the thicker wire is lower than the thinner wire.

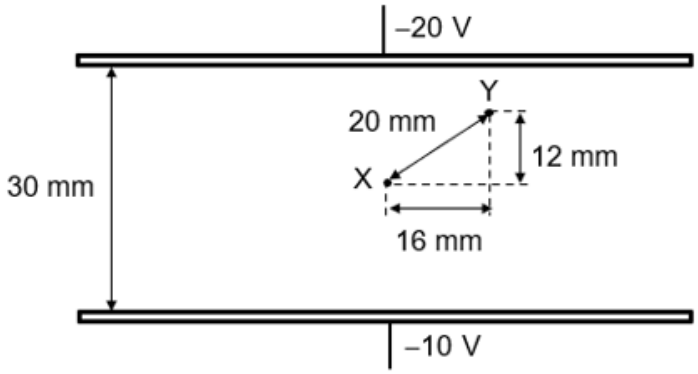
19. A potentiometer circuit using a 1.0 m resistance wire of resistance 1.0 Ω placed across AB is shown below. Both cells are ideal:



What is the balance length required for the galvanometer to show a null deflection?

A 20 cm **B** 50 cm **C** 60 cm **D** 80 cm

20. The diagram shows two large horizontal metal plates situated 30 mm apart. The top and bottom plates are at potentials -20 V and -10 V respectively. The magnititude of the electric field between the plates is 333 V m^{-1}.



What is the work done by the electric field when a charge of -5.0 µC is moved from point X midway between the metal plates to point Y?

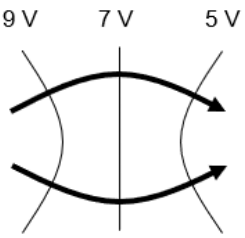
A -3.3×10^{-5} J **B** -2.0×10^{-5} J

C 2.0×10^{-5} J **D** 3.3×10^{-5} J

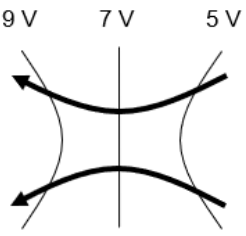
21. In the following diagrams, the thin lines show equipotential lines and the bold arrows show the electric field lines and their directions.

Which set of equipotential lines and field lines is possible?

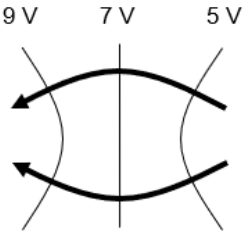
A



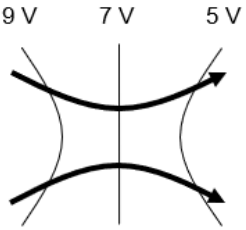
B



C

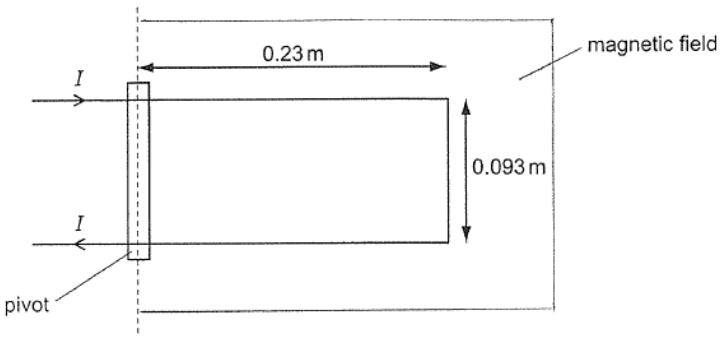


D



22. A current, *I* of magnitude 9.6 mA is passed into a current balance which consists of a U-shaped wire of negligible mass placed in a region of constant magnetic field which is in the plane of the paper and perpendicular to the pivot.

The U-shaped wire has length 0.23 m and the arms are 0.093 m apart, as shown in the diagram below.

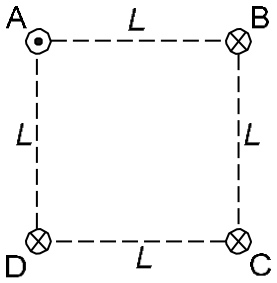


The U-shaped wire experiences a turning moment about the pivot of value 4.7×10^{-6} N m

What is the magnitude of the magnetic flux density of the constant magnetic field?

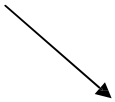
A 5.27 mT **B** 22.9 mT **C** 45.8 mT **D** 4.37 T

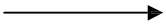
23. Four identical wires A, B, C and D carry currents, of equal magnitude, in the directions as shown in the figure below. What is the direction of the resultant magnetic force experienced by wire A?



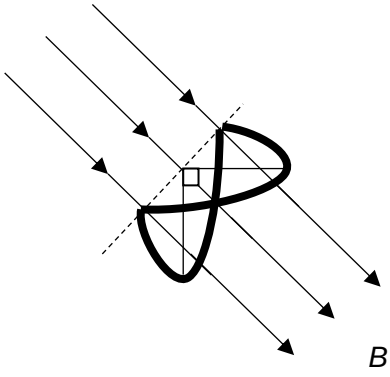
A 

B

C 

D 

24. A closed circular loop of wire has a radius of 3.7 cm. It is bent along a diameter such that the two halves are perpendicular to each other. A uniform magnetic flux density of B = 76 mT is directed perpendicular to the fold diameter and makes equal angles (45^o) with the planes of the semicircle.



If the magnetic flux density B is reduced to zero at a uniform rate during a time interval of 4.5 ms, what is the magnitude of the induced e.m.f in the loop?

A 0.026 V **B** 0.051 V **C** 0.073 V **D** 0.098 V

25. A plane flies through Canada from West to East where the Earth's magnetic field is inclined at an angle below the horizontal, into the Earth.

Which of the diagrams shows the correct accumulation of charges on the plane after some time has passed?

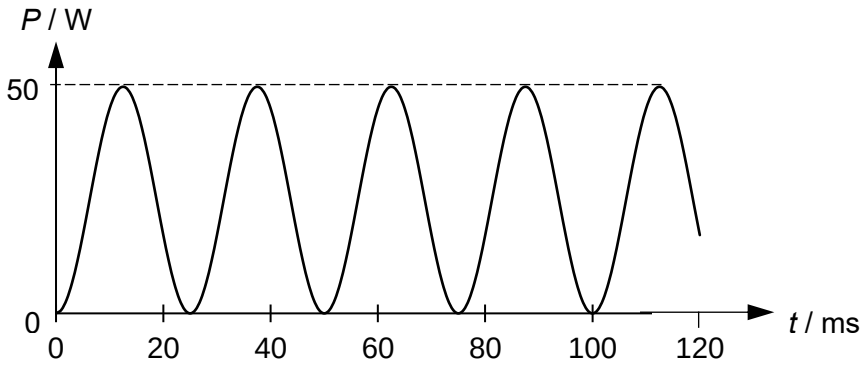
A

B

C

D

26. A sinusoidal alternating supply is connected to a 10 Ω resistor in series. The graph shows how the power P dissipated across the resistor varies with time t.



What are the frequency f and the root-mean-square current $I_{r.m.s.}$ of the alternating supply?

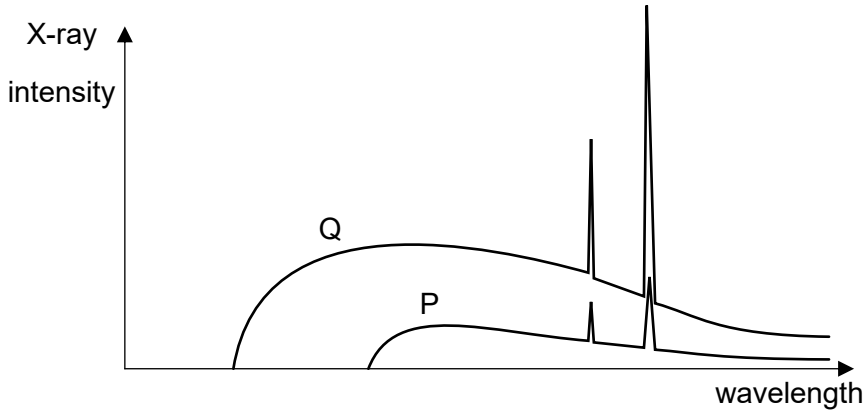
	f / Hz	$I_{r.m.s.}$ / A
A	20	1.6
B	40	1.6
C	20	2.2
D	40	2.2

27. The minimum intensity of light that the human eye can detect is 2.0×10^{-11} W m^{-2}.

Given that the pupil of the eye has a diameter of 4.0 mm, how many photons per second of wavelength 550 nm must enter the eye for a distant star to be visible?

A 700 **B** 2800 **C** 1.3×10^{9} **D** 5.1×10^{9}

28. In the figure below, graph P shows an X-ray spectrum from an X-ray tube.



What are the possible changes that can be made to obtain graph Q?

A Change the target metal.

B Increase the filament current of the cathode.

C Reduce the distance between the cathode and the target.

D Increase the potential difference between the cathode and target.

29. Which of the following statements is true?

A α particles can be stopped by 1 m of lead.
B β particles can be deflected when travelling parallel to a magnetic field.
C γ particles can be stopped by paper.
D α, β and γ particles are all charged particles.

30. Technetium-99 has a half life of 6.0 hrs. It is used as a biological tracer. A sample of technetium-99 with an activity of 8.0×10^{10} Bq is injected into the bloodstream of a patient. 20 hours later, when the technetium-99 is assumed to be uniformly distributed throughout the blood of the patient, a 10 cm^3 blood sample is obtained. The activity from the sample is found to be 1.6×10^7 Bq.

What is the total volume of blood in the patient?

A 3100 cm^3 **B** 4700 cm^3 **C** 5000 cm^3 **D** 6300 cm^3

End of paper