RAFFLES INSTITUTION
2017 Preliminary Examination

PHYSICS **9749/01**
Higher 2

26 September 2017
Paper 1 Multiple Choice Questions **1 hour**

Additional Materials: OMR Form

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your index number, name and class on the OMR Form in the spaces provided. Shade the appropriate boxes.

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 OMR Form.

Read the instructions on the OMR Form 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 appropriate scientific calculator is expected, where necessary.

This document consists of **13** printed pages and **1** bank page.

Data

speed of light in free space	$c = 3.00 \times 10^8$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ 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 K^{-1} mol^{-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	$\phi = -Gm/r$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
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.	$x = x_0 \sin \omega t$
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	$V = Q/(4\pi\varepsilon_0 r)$
alternating current / voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
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	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 Which of the following contains only SI base units?

A kilogram, metre, mole, ampere

B metre, mole, ampere, mass

C kelvin, kilogram, coulomb, second

D ampere, kelvin, gram, mole

2 Which of the following estimates is **not** reasonable?

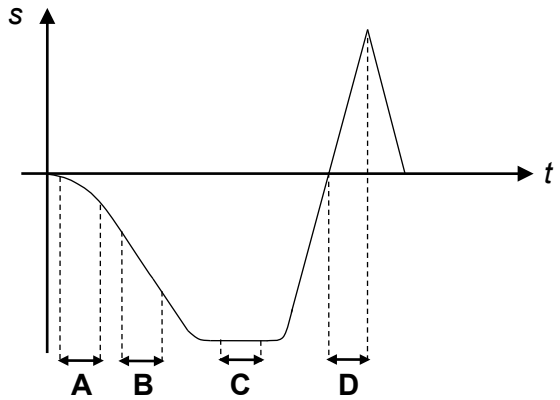
A The average density of a car is about 300 kg m^{-3}.

B The mass of one sheet of paper in this booklet is about 5 g.

C The useful power delivered by a crane in lifting a 1000 kg concrete block is about 10^4 W.

D A typical classroom in RI contains about 3000 moles of air molecules at room temperature.

3 The graph shows the variation with time *t* of the displacement *s* of a vehicle moving along a straight road.



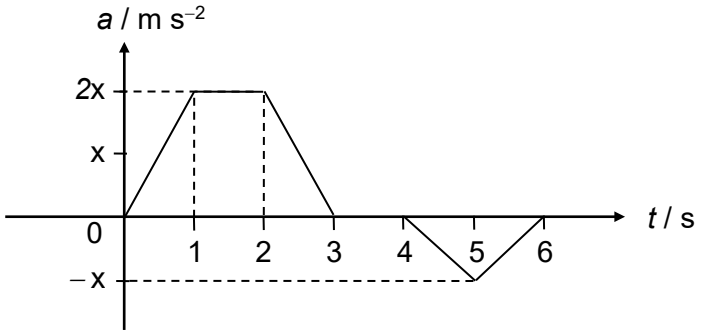
During which time interval is the acceleration of the vehicle the greatest?

4 A hot air balloon is rising at an angle of 20.0° above the horizontal with a speed of 3.50 m s^{-1}. When it is 300 m above the ground, a ball is projected at an angle of 5.00° above the horizontal with a speed of 10.0 m s^{-1} relative to the balloon. Air resistance is negligible.

What is the time taken for the ball to hit the ground?

A 7.61 s **B** 7.91 s **C** 7.94 s **D** 8.03 s

5 The variation with time t of acceleration a for a 2.0 kg mass moving along a straight line is shown. The change in momentum of the mass in 6.0 s is 30 kg m s^{-1}.



What is the value of x?

A 3.0 **B** 5.0 **C** 6.0 **D** 10

6 In a perfectly elastic collision between two particles, it is always true that

A the initial speed of one particle is equal to the final speed of the other particle.

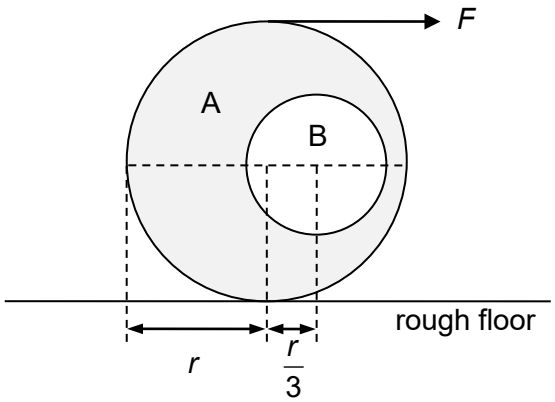
B whatever their initial states of motion, neither particle can be stationary after the collision.

C their total momentum is conserved, but some kinetic energy may be lost after the collision.

D their relative speed of approach is equal to their relative speed of separation.

7 A uniform cylinder A of radius r and weight 48 N is placed on a rough floor. When a cylindrical hole B is drilled through cylinder A, the weight of the remaining portion is 36 N. The centre of B is at a distance of $\frac{r}{3}$ from the centre of A as shown.

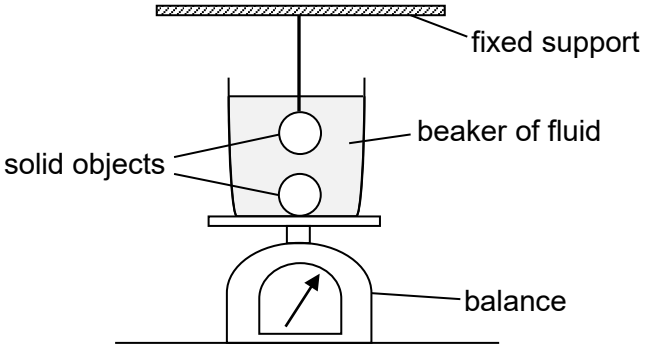
A force F is applied horizontally to the top of the cylinder so that the centres of A and B are at the same height from the floor as shown.



What is the force F required to keep the cylinder in this equilibrium position?

A 2.0 N **B** 4.0 N **C** 6.0 N **D** 12 N

8 A beaker of fluid has weight Z. A solid object of weight X in air displaces weight Y of the fluid when it is fully immersed in the fluid. An identical solid object is placed at the bottom of the beaker as shown.



What is the balance reading?

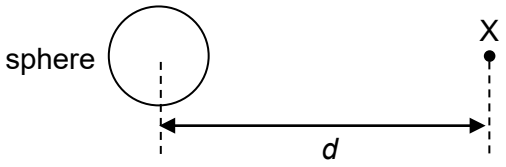
A $X + Z$ **B** $2Y + Z$ **C** $X + Y + Z$ **D** $2X - 2Y + Z$

9 Two objects have masses m_1 and m_2, and kinetic energies K_1 and K_2, respectively.

If the momentum of mass m_2 is two times that of mass m_1, the ratio $\frac{K_1}{K_2}$ is equal to

A $\frac{m_2}{4m_1}$ **B** $\frac{m_2}{2m_1}$ **C** $\frac{4m_2}{m_1}$ **D** $\frac{4m_1}{m_2}$

10 A positive point charge X is released from rest a distance d from the centre of a positively charged sphere as shown.



Which of the following statements best describes the work done in moving point charge X in time t, if X is a positron and if X is a proton?

A The work done on the positron is the same as that on the proton because the same force acts on them.

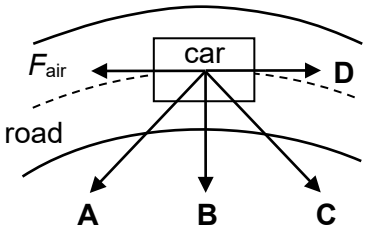
B The work done on the positron is the same as that on the proton because of the principle of conservation of energy.

C The work done on the positron is more than that on the proton because the positron moves a larger distance than the proton.

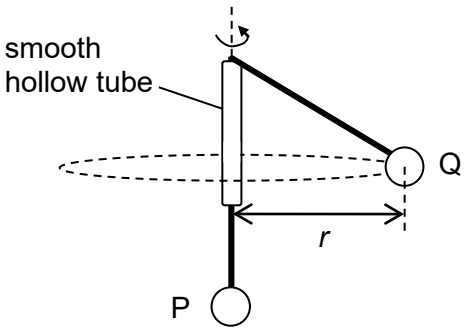
D The work done on the positron is less than that on the proton because the force acting on the positron weakens more rapidly than that on the proton.

11 A car is travelling at a constant speed on a horizontal circular road as shown. F_{air} is the air resistance on the car.

Which of the arrows best represents the horizontal force of the road on the car?



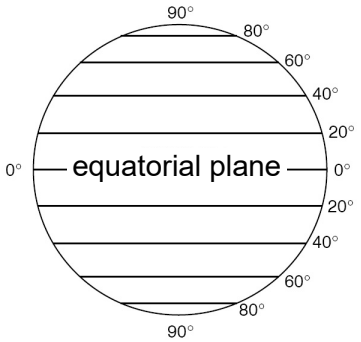
12 Two masses P and Q are connected by a light inextensible string through a smooth hollow tube as shown. When mass Q is swung in a horizontal circle at a constant speed of 2.3 m s^{-1}, mass P remains stationary.



If the mass of P is twice the mass of Q, what is radius r of the horizontal circle?

A 0.14 m **B** 0.31 m **C** 0.93 m **D** 3.21 m

13 All geostationary satellites lie on the equatorial plane of 0° latitude.



There is no geostationary satellite at the other latitudes shown because such a satellite would

A require a continuous input of energy to maintain its orbit.

B not have a period of 24 hours.

C orbit from east to west.

D be too heavy.

14 A gas cylinder is fixed with a safety valve which releases a gas when the pressure inside the cylinder reaches 1.5×10^6 Pa. The mass of the gas that the cylinder can hold at 20 °C is 20 kg.

What is the maximum temperature of the gas if the cylinder were to hold a mass of 15 kg?

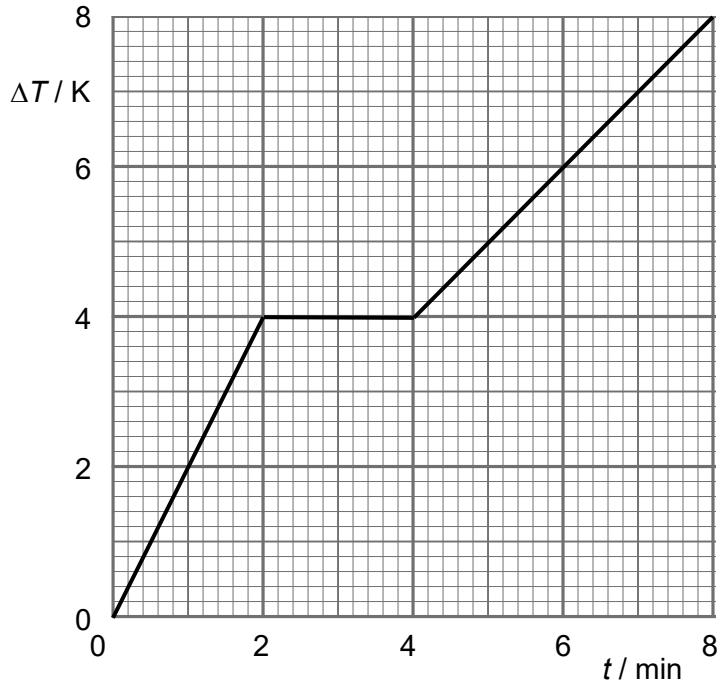
A 15 °C **B** 27 °C **C** 120 °C **D** 390 °C

15 A molecule of gas A has half the mass of a molecule of gas B. The molecules of gas A have a root-mean-square speed of *c* at a temperature of 30.0 °C. Assume that both gases are ideal.

What is the root-mean-square speed of the molecules of gas B at 300 °C

A 0.945 *c* **B** 0.972 *c* **C** 1.94 *c* **D** 2.24 *c*

16 The graph shows the variation of temperature change ΔT with time *t* for 1 kg of a substance, initially solid at room temperature. The substance is heated at a uniform rate of 1000 J min^{-1}.



What can be deduced from this graph?

A After 2 min of heating, the substance is all liquid.

B After 8 min of heating, the substance is all gaseous.

C The specific heat capacity of the substance is smaller when liquid than when solid.

D The specific latent heat of fusion of the substance is 2000 J kg^{-1}.

17 To determine the specific latent heat of vaporisation of water, a student uses a heater to boil water. When the water is boiling, the mass of water vapour produced per minute is measured at two different powers of the heater.

The student repeats the experiment using a different power of the heater to

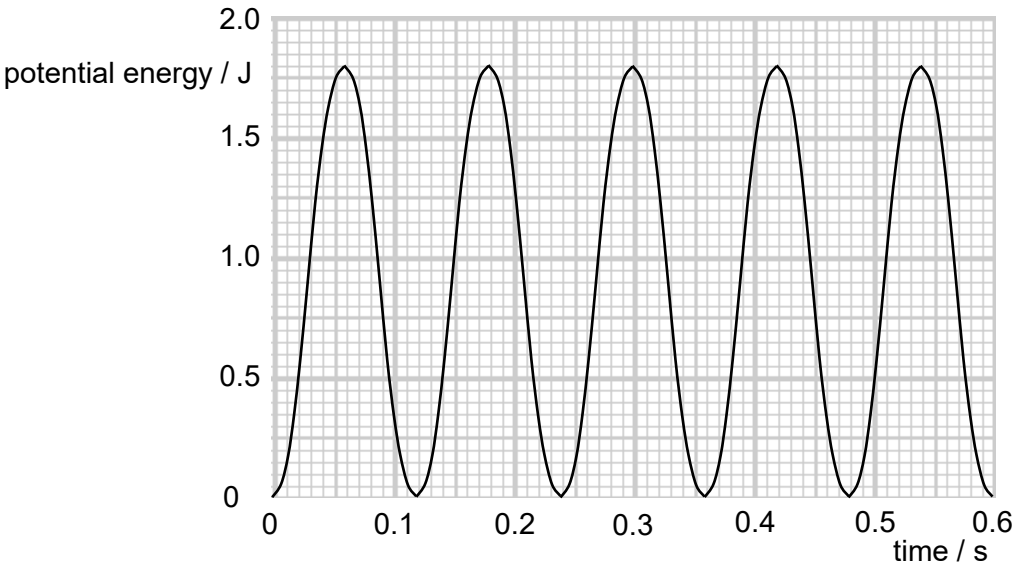
A reduce random errors in the measurements of the mass of water vapour produced per minute.

B allow the rate of heat loss from the apparatus to be eliminated from the calculations.

C determine an average value of the specific latent heat of vaporisation.

D check for reproducibility of the measurements.

18 A particle performs simple harmonic motion of amplitude 0.050 m. The graph shows the variation of the potential energy of the particle with time.



What is the mass of the particle?

A 0.53 kg **B** 1.8 kg **C** 2.1 kg **D** 2.8 kg

19 An oscillator vibrates vertically in a ripple tank and moves to the right with speed v, as shown in Fig. 19(a).

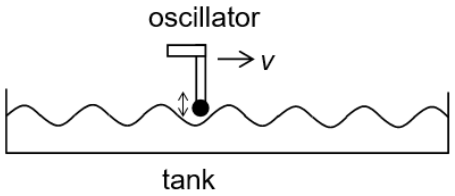


Fig. 19(a)

Fig. 19(b) represents the water waves as seen from the top of the ripple tank. The speed of the water waves is 20 cm s^{-1}.

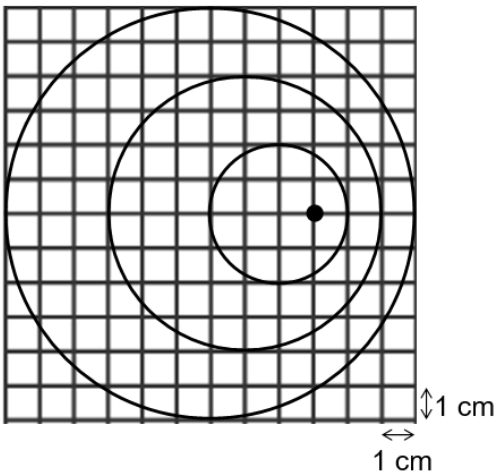
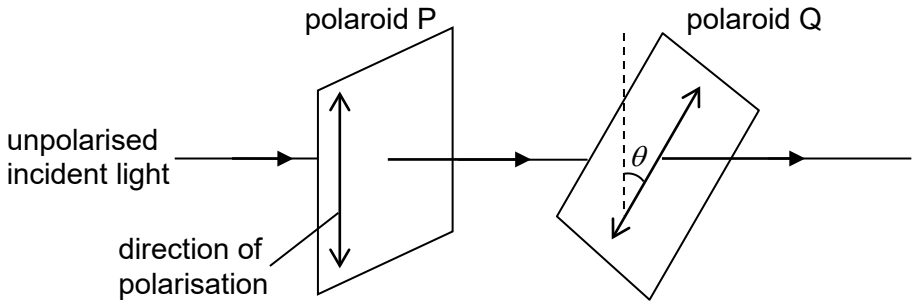


Fig. 19(b)

What is the speed v and frequency f of the oscillator?

	v / cm s^{-1}	f / Hz
A	10	5.0
B	10	10
C	20	5.0
D	20	10

20 Two sheets of polaroids P and Q are placed such that their directions of polarisation are at an angle θ to each other as shown.



A beam of light passes through both polaroids. After passing through polaroid Q, the transmitted beam has intensity I when θ is 30° .

When θ is 120°, what is the intensity of the transmitted beam?

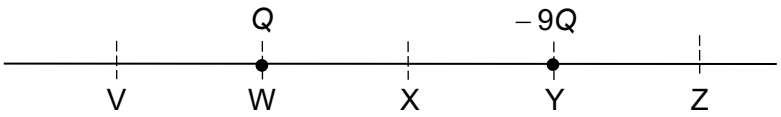
A 0.19 I **B** 0.25 I **C** 0.33 I **D** 0.58 I

21 The lowest resonant frequency emitted by a cylindrical pipe that is open at both ends is *f*.

What is the lowest resonant frequency emitted by a pipe of the same length that is closed at one end?

A $\frac{f}{4}$ **B** $\frac{f}{2}$ **C** $2f$ **D** $4f$

22 Points V, W, X, Y and Z are evenly spaced along a straight line. A positive charge of magnitude *Q* is placed at point W. A negative charge of magnitude 9*Q* is placed at point Y.



Which of the following gives the directions of the electric fields at points *V*, *X* and *Z*?

	at point V	at point X	at point Z
A	to the left	to the right	to the left
B	to the left	no net electric field	to the left
C	no net electric field	to the left	to the right
D	no net electric field	to the right	to the left

23 Which of the following statements regarding the filament of a light bulb is true?

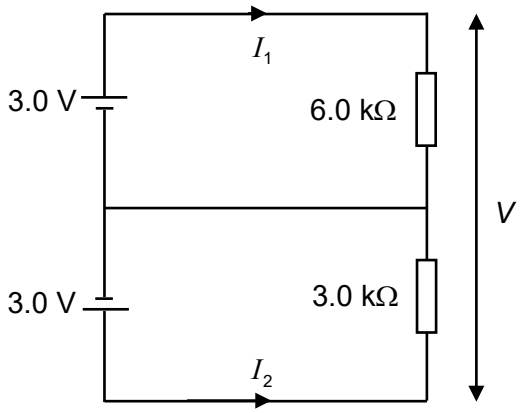
A The filament is ohmic if its resistance is always equal to the ratio of the potential difference across it to the current through it.

B The filament is ohmic if its resistivity does not depend on its physical dimensions.

C The filament is ohmic if its resistance is constant at a fixed temperature.

D The filament is ohmic regardless of the potential difference applied across it.

24 Two 3.0 V cells are connected to resistors of resistance 3.0 kΩ and 6.0 kΩ as shown.

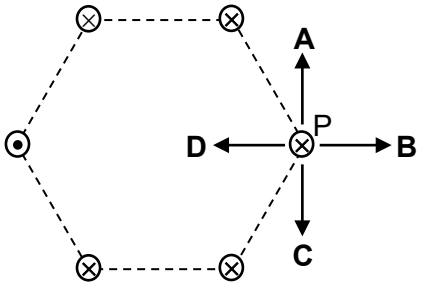


What are the currents I_1 and I_2, and the potential difference *V*?

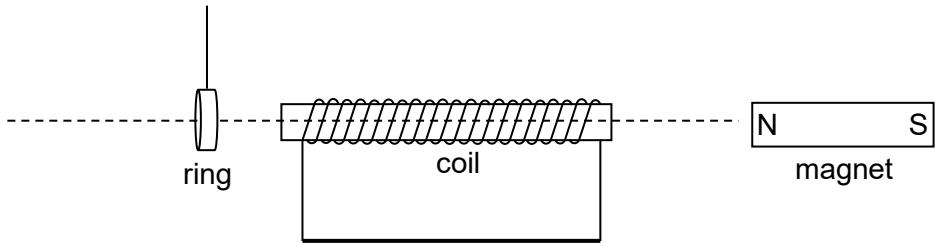
	I_1 / mA	I_2 / mA	*V* / V
A	0	0	0
B	0.50	1.0	0
C	0.50	1.0	6.0
D	0.67	0.67	6.0

25 Six vertical wires are placed at the corners of a regular hexagon. The wires carry equal currents in the directions shown.

What is the direction of the force acting on wire P?



26 An aluminium ring is suspended near one end of a long coil of wire and a magnet is placed near the other end with its north pole facing the coil as shown. Assume that the magnetic field from the magnet does not reach the ring.



Which of the following describes the motion of the ring when the magnet is first pushed towards the coil, and then pulled away?

	magnet pushed towards coil	magnet pulled away from coil
A	ring swings left	ring swings left
B	ring swings right	ring swings left
C	ring swings left	ring swings right
D	ring swings right	ring swings right

27 The magnetic flux linking a conducting loop changes sinusoidally with time.

Which of the following describes the phase difference between the magnetic flux linkage and the e.m.f. induced?

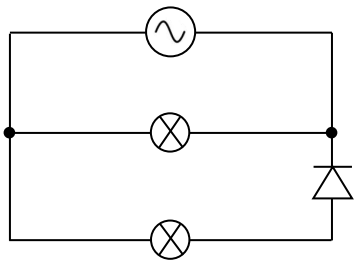
A They are in phase with each other.

B They are out of phase by $\pi/4$ rad.

C They are out of phase by $\pi/2$ rad.

D They are out of phase by π rad.

28 An alternating current supply of negligible internal resistance is connected to two identical bulbs and an ideal diode as shown. The resistance of each bulb is R and the peak voltage of the a.c. supply is V_0.



Which of the following is the average power dissipated in the circuit?

A $\dfrac{3V_0^2}{4R}$ **B** $\dfrac{3V_0^2}{2R}$ **C** $\dfrac{3V_0^2}{\sqrt{2}R}$ **D** $\dfrac{3V_0^2}{R}$

29 Photoelectrons are emitted when an electromagnetic radiation is incident on a metal surface.

When the intensity and wavelength of the radiation are reduced,

A the maximum kinetic energy of the photoelectrons is reduced, but their rate of emission is increased.

B both the maximum kinetic energy of the photoelectrons and their rate of emission are reduced.

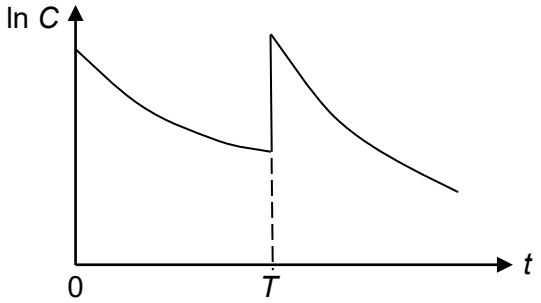
C both the maximum kinetic energy of the photoelectrons and their rate of emission are increased.

D the maximum kinetic energy of the photoelectrons is increased, but their rate of emission is reduced.

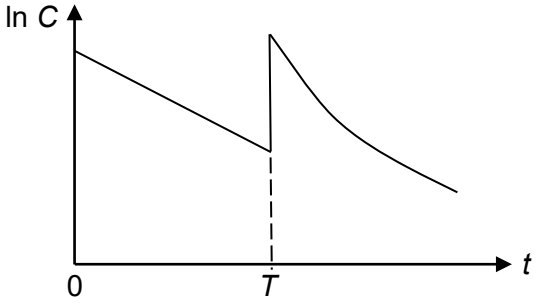
30 At time $t = 0$, a radioactive gas is injected into a sealed vessel. At time $t = T$, a different radioactive gas of a shorter half-life than the first gas is injected into the same vessel.

Which of the following graphs best represents the variation of the logarithm of the count-rate C of the gases with time t?

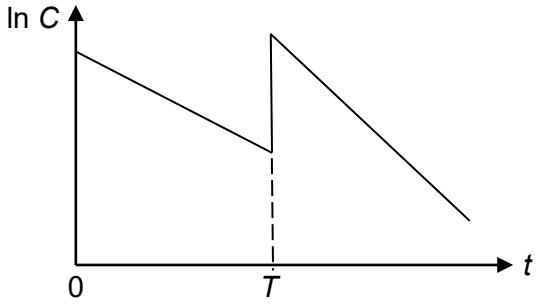
A



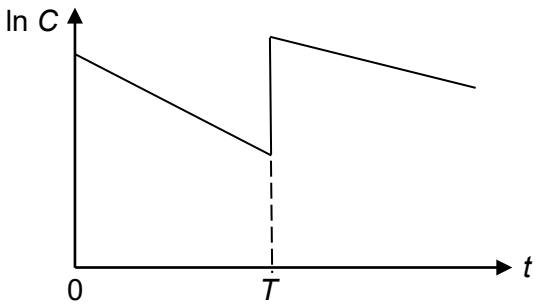
B



C



D



End of Paper 1