Candidate Name ______________________

Centre Number	Candidate Number

CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

PHYSICS 9702/4

PAPER 4

MAY/JUNE SESSION 2002

1 hour

Candidates answer on the question paper.
No additional materials.

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You may lose marks if you do not show your working or if you do not use appropriate units.

FOR EXAMINER'S USE

This question paper consists of 15 printed pages and 1 blank page.

SPA (NH/CG) S14609/4

University of Cambridge
Local Examinations Syndicate

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
gravitational potential,	$\phi = -\dfrac{Gm}{r}$
simple harmonic motion,	$a = -\omega^2 x$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \dfrac{Q}{4\pi\epsilon_0 r}$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
energy of charged capacitor,	$W = \frac{1}{2}QV$
alternating current/voltage,	$x = x_0 \sin \omega t$
hydrostatic pressure,	$p = \rho g h$
pressure of an ideal gas,	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = \dfrac{3H_0^2}{8\pi G}$
equation of continuity,	$Av = \text{constant}$
Bernoulli equation (simplified),	$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$
Stokes' law,	$F = Ar\eta v$
Reynolds' number,	$R_e = \dfrac{\rho v r}{\eta}$
drag force in turbulent flow,	$F = Br^2 \rho v^2$

For Examiner's Use

Answer **all** the questions in the spaces provided.

1 **(a)** The Earth may be considered to be a uniform sphere of radius 6.38×10^6 m. Its mass is assumed to be concentrated at its centre.

Given that the gravitational field strength at the Earth's surface is $9.81\ \mathrm{N\,kg^{-1}}$, show that the mass of the Earth is 5.99×10^{24} kg.

[2]

(b) A satellite is placed in geostationary orbit around the Earth.

(i) Calculate the angular speed of the satellite in its orbit.

angular speed = ... rad $\mathrm{s^{-1}}$ [3]

(ii) Using the data in **(a)**, determine the radius of the orbit.

radius = ... m [3]

For Examiner's Use

2 Some water in a saucepan is boiling.

(a) Explain why

(i) external work is done by the boiling water,

....

....

....

(ii) there is a change in the internal energy as water changes to steam.

....

....

....
[5]

(b) By reference to the first law of thermodynamics and your answers in **(a)**, show that thermal energy must be supplied to the water during the boiling process.

....

....

....[2]

3 **(a)** **(i)** The kinetic theory of gases leads to the equation

$$\tfrac{1}{2}m\langle c^2\rangle = \tfrac{3}{2}kT.$$

Explain the significance of the quantity $\tfrac{1}{2}m\langle c^2\rangle$.

....

....

(ii) Use the equation to suggest what is meant by the absolute zero of temperature.

....

....

[3]

(b) Two insulated gas cylinders **A** and **B** are connected by a tube of negligible volume, as shown in Fig. 3.1.

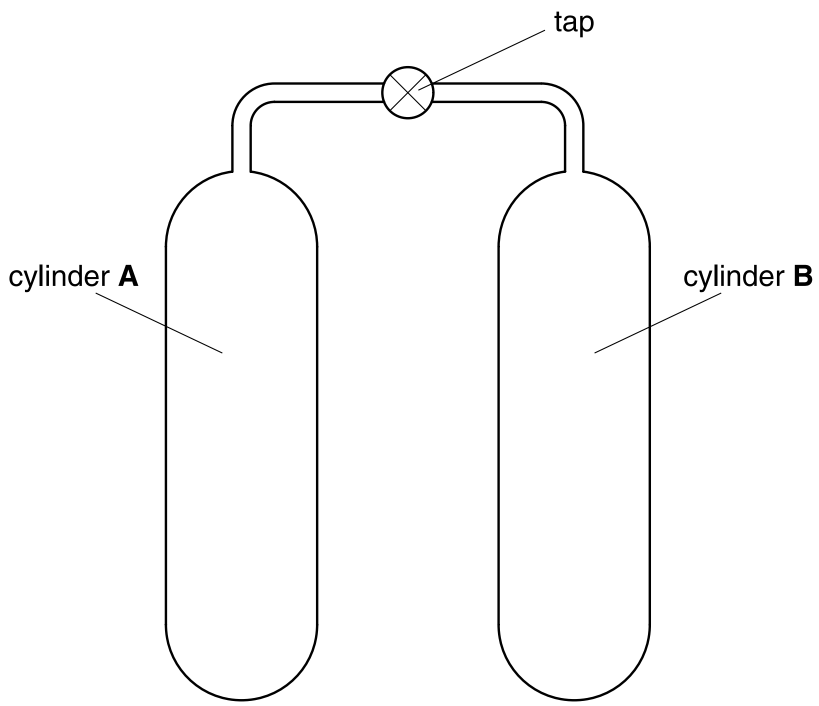


Fig. 3.1

Each cylinder has an internal volume of $2.0 \times 10^{-2}\,m^3$. Initially, the tap is closed and cylinder **A** contains 1.2 mol of an ideal gas at a temperature of 37 °C. Cylinder **B** contains the same ideal gas at pressure 1.2×10^5 Pa and temperature 37 °C.

(i) Calculate the amount, in mol, of the gas in cylinder **B**.

amount = ... mol

(ii) The tap is opened and some gas flows from cylinder **A** to cylinder **B**. Using the fact that the total amount of gas is constant, determine the final pressure of the gas in the cylinders.

pressure = ... Pa
[6]

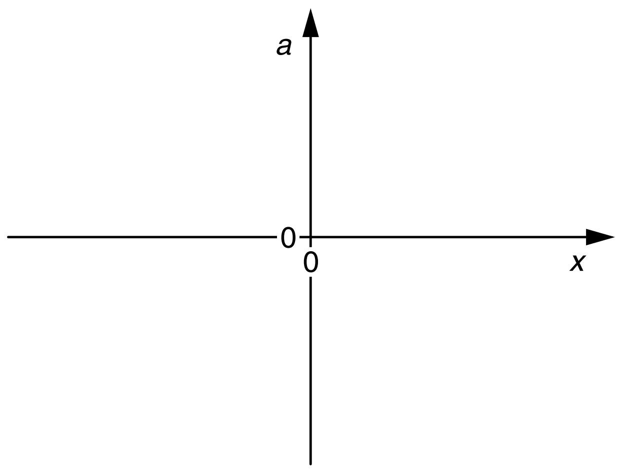
4 **(a)** **(i)** Define simple harmonic motion.

....

....

....

(ii) On the axes of Fig. 4.1, sketch the variation with displacement x of the acceleration a of a particle undergoing simple harmonic motion.



[4]

Fig. 4.1

(b) A strip of metal is clamped to the edge of a bench and a mass is hung from its free end as shown in Fig. 4.2.

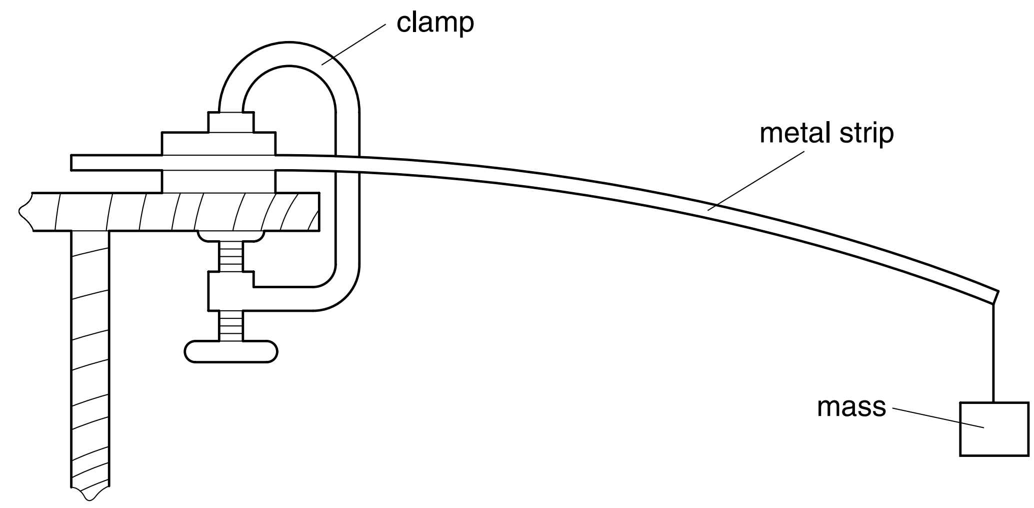


Fig. 4.2

The end of the strip is pulled downwards and then released. Fig. 4.3 shows the variation with time t of the displacement y of the end of the strip.

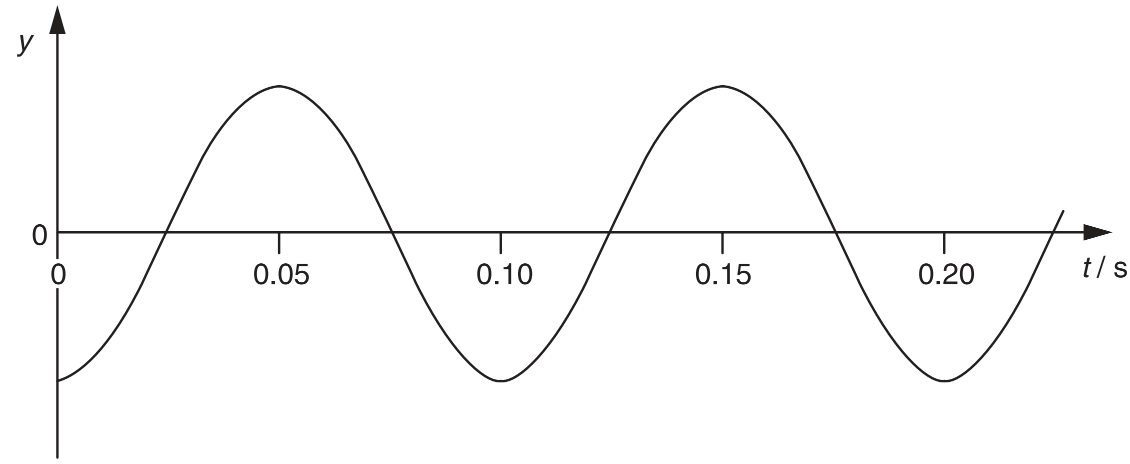


Fig. 4.3

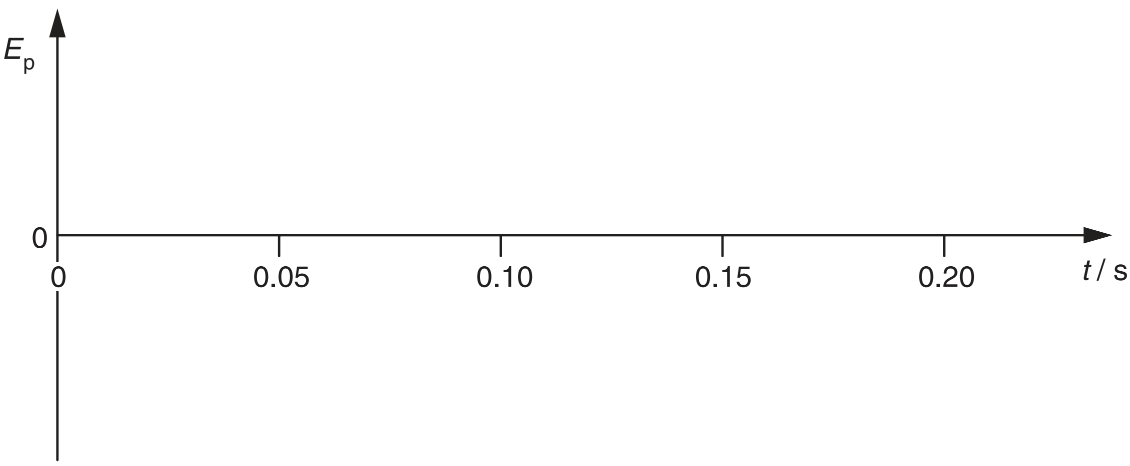


Fig. 4.4

On Fig. 4.4, show the corresponding variation with time t of the potential energy E_p of the vibrating system. [3]

(c) The string supporting the mass breaks when the end of the strip is at its lowest point in an oscillation. Suggest what change, if any, will occur in the period and amplitude of the subsequent motion of the end of the strip.

period: ....

amplitude: ....[2]

5 **(a)** Define potential at a point in an electric field.

....

....[2]

(b) An isolated metal sphere of radius r carries a charge $+Q$. The charge may be assumed to be concentrated at the centre of the sphere.

(i) State, in terms of r and Q, the electric potential V at the surface of the sphere. Identify any other symbols you use.

....

....

(ii) Write down the relationship between capacitance C, charge Q and potential V.

....

(iii) Hence show that the capacitance C of the sphere is given by

$$C = 4\pi\varepsilon_0 r.$$

[3]

(c) The sphere in **(b)** has a radius of 15 cm and carries a charge of 2.0×10^{-6} C.

Calculate

(i) the capacitance of the sphere,

capacitance = ... μF

(ii) the energy stored on the sphere.

energy = ... J
[4]

For Examiner's Use

6 **(a)** Two similar coils **A** and **B** of insulated wire are wound on to a soft-iron core, as illustrated in Fig. 6.1.

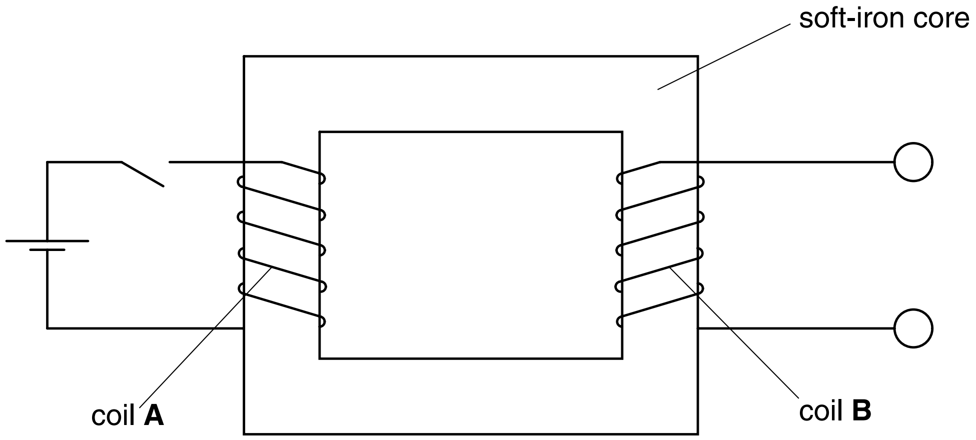


Fig. 6.1

When the current I in coil **A** is switched on and then off, the variation with time t of the current is shown in Fig. 6.2.

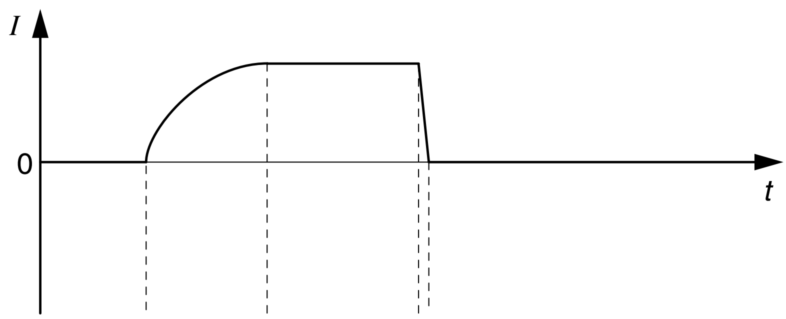


Fig. 6.2

Fig. 6.3

On Fig. 6.3, draw a graph to show the variation with time t of the e.m.f. E induced in coil **B**. [3]

(b) Fig. 6.4 is the circuit of a bridge rectifier.

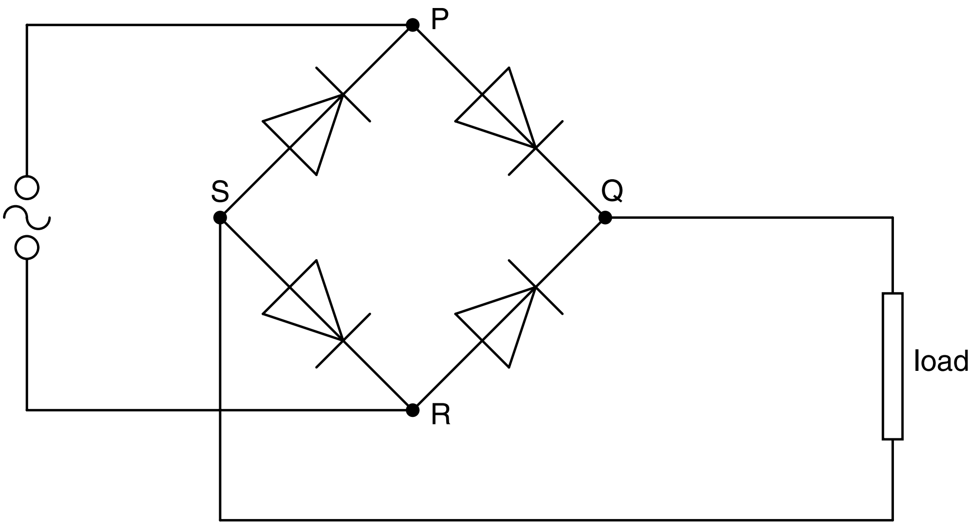


Fig. 6.4

An alternating supply connected across PR has an output of 6.0 V r.m.s.

(i) On Fig. 6.4, circle those diodes that are conducting when R is positive with respect to P. [1]

(ii) Calculate the maximum potential difference between points Q and S, assuming that the diodes are ideal.

potential difference = ... V [2]

(iii) State and explain how a capacitor may be used to smooth the output from the rectifier. You may draw on Fig. 6.4 if you wish.

....

....

....[3]

For Examiner's Use

7 Electrons are emitted from a metal surface when it is illuminated with suitable electromagnetic radiation.

(a) Name the effect described above.

....[1]

(b) The variation with frequency f of the maximum kinetic energy E_k of the emitted electrons is shown in Fig. 7.1.

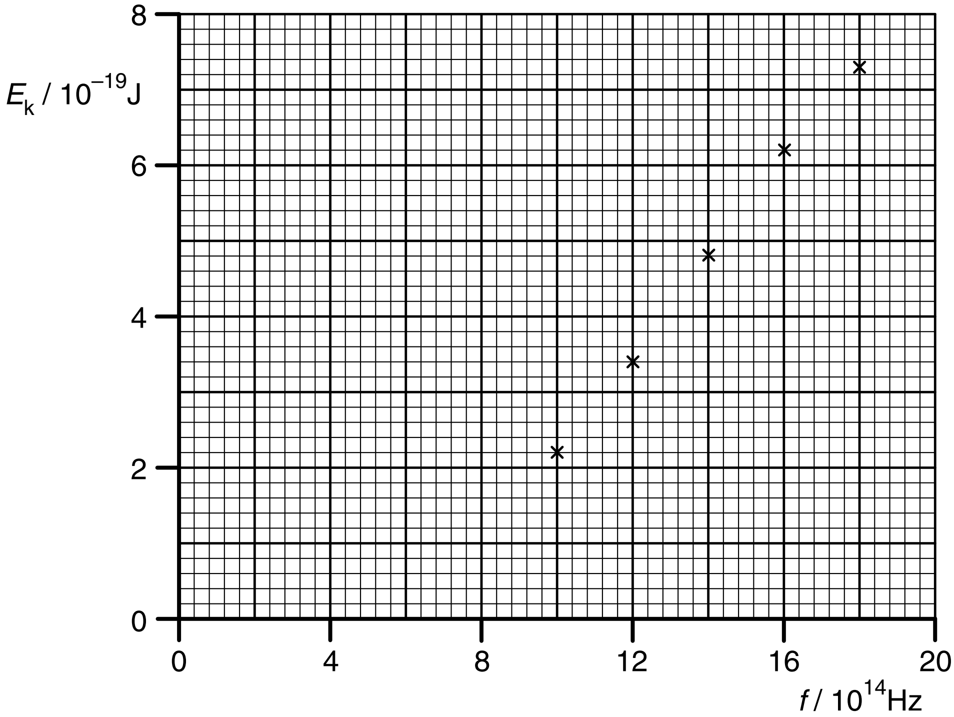


Fig. 7.1

Use Fig. 7.1 to determine

(i) the threshold frequency of the radiation,

threshold frequency = ... Hz

(ii) a value for the Planck constant.

Planck constant = ... J s
[4]

(c) On Fig. 7.1, draw a line to show the variation with frequency f of the maximum kinetic energy E_k of the emitted electrons for a second metal which has a lower work function than that in **(b)**. [2]

(d) The kinetic energy of the electrons is described as the maximum. Suggest why emitted electrons are likely to have a range of values of kinetic energy for any one frequency of the electromagnetic radiation.

....

....

....[2]

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