TAMPINES JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Higher 1

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CANDIDATE NAME

CIVICS GROUP | 0 | 8 | | | |

PHYSICS 8866/02

Paper 2 Structured Questions

Friday, 11 Sep 2009

2 hours

Candidates to answer on the Question Paper
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **any two** questions.

You are advised to spend about one hour on each section.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 10
2	/ 3
3	/ 9
4	/ 8
5	/ 10
6	/ 20
7	/ 20
8	/ 20
Total	/ 80

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$
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,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
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,	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$

Section A

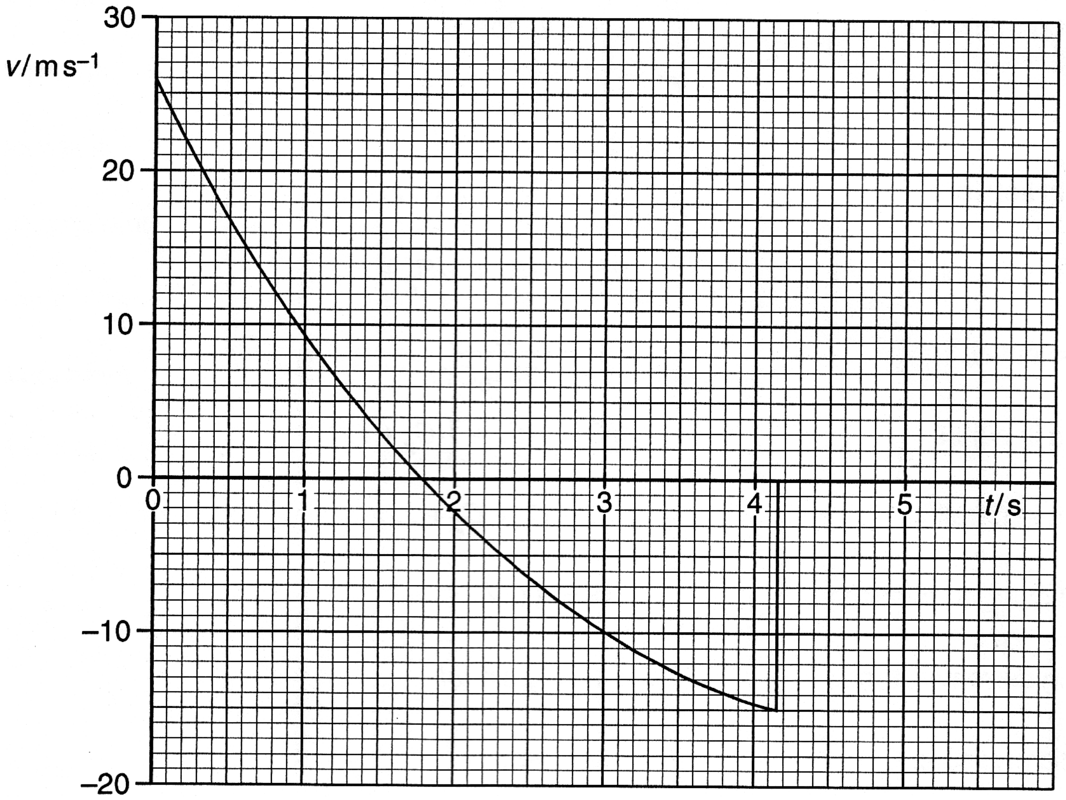
Answer **all** the questions in this section.

1 **(a)** Define acceleration.

....

.... [1]

(b) The graph below shows the variation with time of the velocity v of a ball from the moment it is thrown with a velocity of 26 m s^{-1} vertically upwards.



(i) State the time at which the ball reaches its maximum height.

time = ... s [1]

(ii) State the feature of a velocity-time graph that enables the acceleration to be determined.

....

....

.... [1]

(iii) Just after the ball leaves the thrower's hand, it has a downward acceleration of approximately 20 m s^{-2}. Explain how this is possible.

....

....

....

.... [2]

(iv) State the time at which the acceleration is *g*. Explain why the acceleration has this value only at this particular time.

....

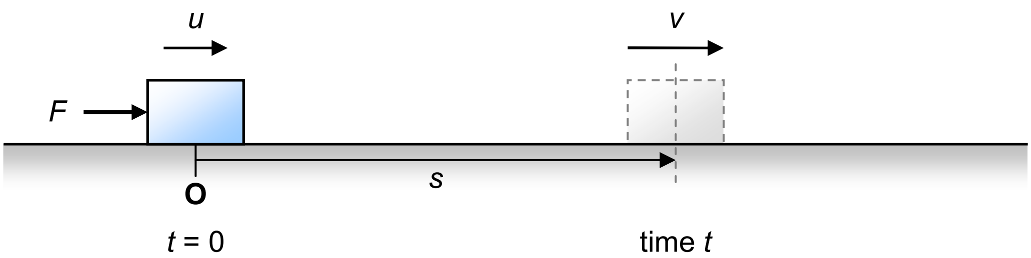
....

....

.... [2]

(v) Sketch the acceleration-time graph for the motion. Show the value of *g* on the acceleration axis. [3]

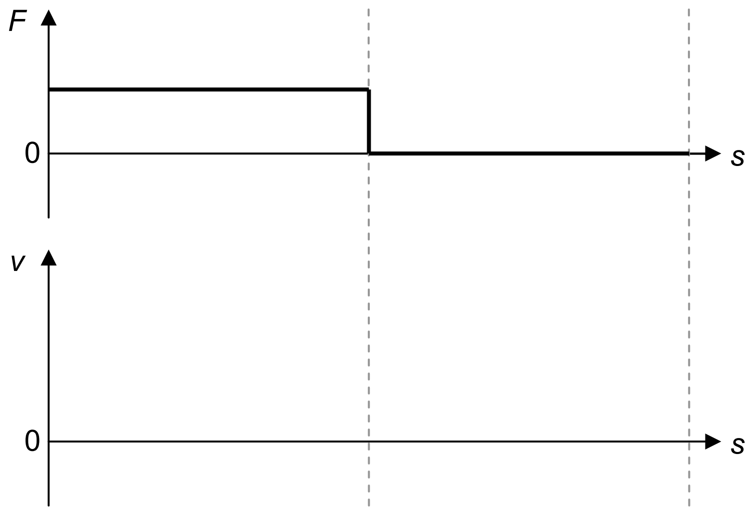
2 A box, initially at **O** with velocity u, is pushed by a variable horizontal force F on a smooth horizontal surface. After time t, it is at displacement s and has velocity v.



(a) Define work done.

.... [1]

(b) If the force F varies with displacement s as shown:



on the above axes, sketch how velocity varies with displacement. [2]

3 **(a)** Distinguish between *potential difference* and *e.m.f.* based on energy considerations.

....

....

....

.... [2]

(b) An electrical component X has an *I*-*V* characteristic as shown in Fig 3.1 below.

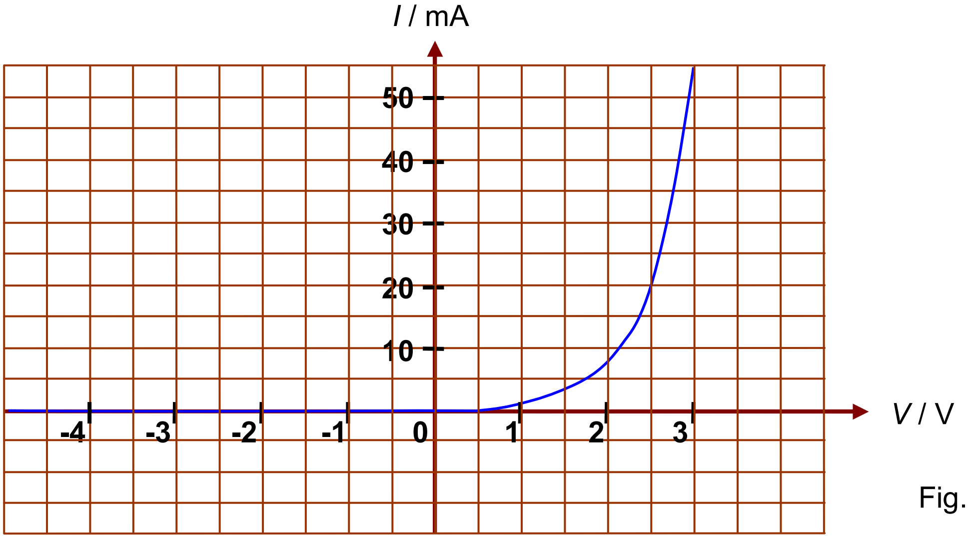


Fig. 3.1

(i) Component X is represented by the symbol  .Name component X.

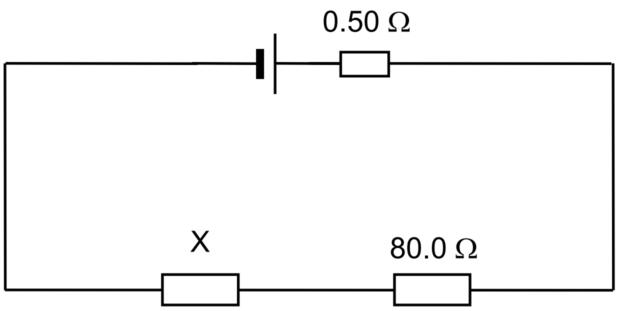
.... [1]

(ii) Calculate the resistance of X when the potential difference across it is 2.5 V.

resistance = …………………… Ω [2]

(c) The component X is connected in a circuit with a cell of internal resistance 0.50 Ω and a resistor of constant resistance 80.0 Ω as shown in Fig 3.2. Given that potential difference across component X is 2.5 V,

Fig. 3.2



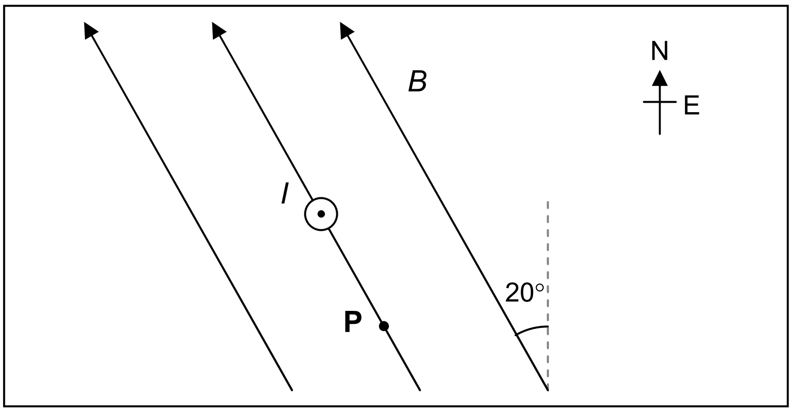
(i) calculate the emf of the cell.

e.m.f. = …………………… V [3]

(ii) calculate the terminal p.d. across the cell.

Terminal p.d. = …………………… V [1]

4 The diagram shows a vertical current *I* of 2.0 A (flowing out of paper) inside a uniform horizontal magnetic field (shown along plane of the paper).



The direction of the magnetic field is at bearing 340° (or 20° west of north). The magnetic flux density *B* of the field is 0.040 T. The wire carrying the current *I* is 30.0 cm long.

(a) Draw on the diagram the magnetic field at P due to the current and label it '(a)'.[1]

(b) Give the bearing of the magnetic field at P due to the current.

bearing = …………………… ° [1]

(c) If the resultant magnetic field at P points exactly north, find the ratio

$$\frac{B}{\text{magnetic flux density at P due to the current}}.$$

ratio = …………………… [2]

(d) Draw on the diagram the magnetic force acting on the current and label it '(d)'. [1]

(e) Find the magnetic force acting on the current and give its bearing.

magnetic force = …………………… N [1]

bearing = …………………… ° [1]

(f) If a second vertical current flowing into the paper is now placed at **P**, give the bearing of the resultant force acting on this second current.

bearing = …………………… ° [1]

5 According to some scientists, battery-powered cars offer many advantages over petrol-driven cars. Rechargeable lead-acid are the most common type of batteries used in cars. The data below shows some properties of petrol, a particular lead-acid battery and a typical car.

Petrol
Density = 700 kg m^{-3}
Chemical energy available = 45 MJ kg^{-1}

Typical lead-acid battery
Energy available when fully charged = 2.8 MJ
Mass = 20 kg
e.m.f. = 12 V

Car
Volume of petrol tank = 4.0×10^{-2} m^3
Efficiency of transfer of chemical energy of petrol to kinetic energy of car = 25%
Resistive force at 30 m s^{-1} = 580 N

(a) Calculate the chemical energy available from a full tank of petrol.

chemical energy = …………………… MJ [2]

(b) A fully-charged car battery delivers a constant current of 8.0 A. Calculate the time in hours before the battery needs to be recharged again.

time = …………………… hours [2]

(c) **(i)** Calculate the total mass of lead-acid batteries needed to provide the same energy as a full tank of petrol.

total mass = …………………… kg [2]

(ii) Suggest how your answer to **(c)(i)** may affect the performance of a battery-powered car.

....

.... [1]

(d) Calculate the total distance in km traveled by the car on a full tank of petrol when travelling at a constant speed of 30 m s^{-1} on a level road.

total distance = …………………… km [3]

Section B

Answer **any two** questions in this section.

6 **(a)** Newton's third law of motion can be stated in the form:

when object X exerts a force on object Y, then object Y exerts a force of the same type that is equal in magnitude and opposite in direction on object X

(i) Explain what is meant by *of the same type* in this statement of the law.

....

.... [1]

(ii) Object X is a book resting in equilibrium on a table (object Y). Draw labeled free body force diagrams to show the forces on X and on Y. [4]

(iii) Circle the pair of forces in **(ii)** which are always equal in magnitude and opposite in direction. [1]

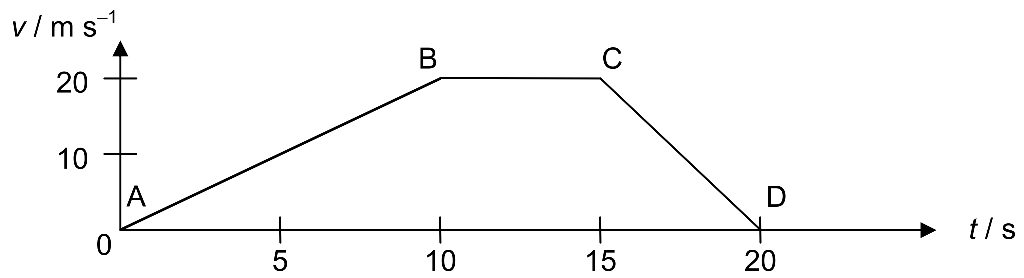
(iv) If X is a falling book that has just made contact with the table (object Y) but still moving downwards. On your sketch in part **(ii)**, label with "(iv)" the forces which will be different in magnitude from previously. [1]

(b) State Newton's second law of motion.

....

.... [2]

(c) A car of mass 1000 kg is initially at rest. It moves along a straight road for 20 s and then comes to rest again. The speed-time graph for the movement is:



(i) What is the total distance travelled?

total distance travelled = …………………… m [1]

(ii) What resultant force acts on the car during the part of the motion represented by CD?

resultant force during CD = …………………… N [2]

(iii) What is the change in momentum of the car when it has reached its maximum speed? Show how this momentum change can be used to find the resultant force during AB.

momentum = …………………… kg m s^{-1} [1]

resultant force during AB = …………………… N [2]

(iv) Suppose, when travelling at this maximum speed, the 1000 kg car struck a stationary vehicle of mass 1500 kg. The collision is 'perfectly inelastic'.

1. What is a 'perfectly inelastic' collision?

.... [1]

2. Find the speed of the 1500 kg vehicle when the speed of the 1000 kg car has decreased to 10 m s^{-1}.

speed = …………………… m s^{-1} [2]

3. Find the speed of the 1000 kg car immediately after collision.

speed = …………………… m s^{-1} [2]

7 **(a)** **(i)** If two wave sources **S_1** and **S_2** are in phase, write down the condition imposed on the path difference needed for the waves to interfere constructively at a point **P**. [1]

(ii) State the principle of superposition.

....

....

.... [2]

(b) Two microphones, **M_1** and **M_2**, are positioned at a distance apart. The signals from the microphones are added and the resultant signal is displayed by a CRO. A speaker **S** which is producing sinusoidal sound waves is placed along a line joining the microphones.

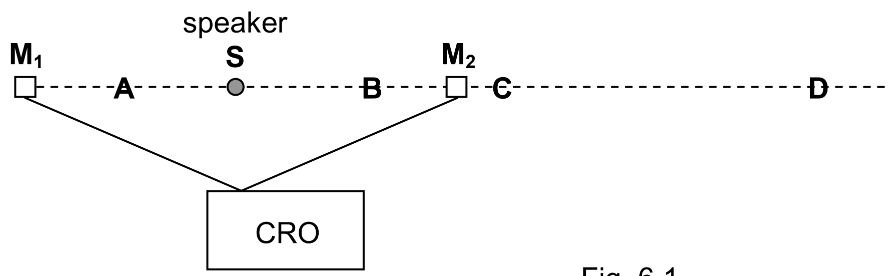


Fig. 6.1

(i) When the speaker is moved from point **A** to **B**, the amplitude of the resultant waveform shown on the CRO goes through a series of maxima and minima. Explain the formation of the maxima and minima.

....

....

.... [2]

(ii) Later, when the speaker is placed at **C** and moved to **D**, the amplitude of the resultant waveform does not fluctuate. Explain. (Assume the intensity of the wave did not drop significantly with distance from the speakers)

....

.... [1]

(c) In another scenario, a microphone **M** is placed in between 2 identical speakers $\mathbf{S_1}$ and $\mathbf{S_2}$. A signal generator now drives the speakers to produce sound waves of constant frequency 3.0 kHz.

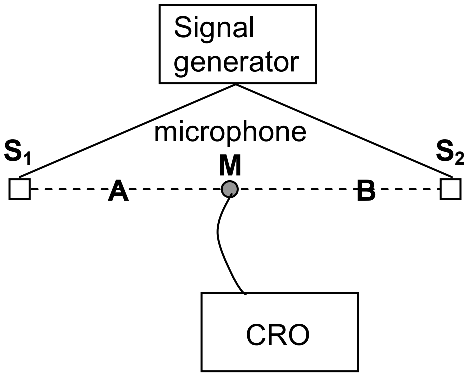


Fig. 6.2

(i) When the microphone **M** is moved from **A** to **B** at a speed of 10.0 cm s^{-1}, the amplitude of the waveform at the CRO goes through a series of maxima and minima at a rate of 2 maxima per second. Calculate the speed of sound.

speed of sound = …………………… m s^{-1} [2]

(ii) Explain why in practice, the amplitude shown on the CRO at most minima points is not zero.

....

....

....

.... [3]

(d) To further investigate wave interference, a beam of laser of wavelength 600 nm is directed onto an opaque slide with a pair of narrow slits at a distance of 0.30 mm apart. A pattern consisting of bright and dark fringes is observed 1.0 m away from the double-slit. Calculate

(i) the frequency of light from the laser.

frequency of light = …………………… Hz [1]

(ii) the spacing between the bright fringes.

spacing = …………………… m [2]

(e) This double-slit arrangement is now used to measure the speed of solid particles carried along by a gas stream in a transparent pipe as shown in **Fig. 6.3**. The pipe is also placed 1.0 m from the double-slit. From time to time, a photo detector detects a series of flashes from the pipe, at a constant frequency of 5.0 kHz.

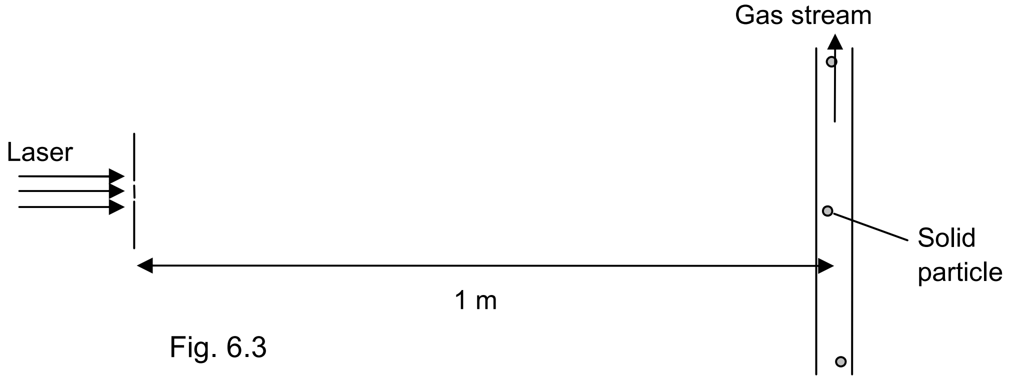


Fig. 6.3

(i) Explain what causes the flashes and state what happens to the flash rate if the speed of gas stream increases.

....

....

.... [2]

(ii) What is the speed of gas stream?

speed of gas stream = …………………… m s^{-1} [2]

(iii) State one assumption that you have made in your calculation.

....

.... [1]

(iv) Explain why there is likely to be only a few particles in the gas stream.

....

.... [1]

7 **(a)** A basic discharge lamp is shown in Fig. 7.1. Electrons emitted with negligible speed from the heated filament are accelerated by a potential difference between the cathode and the anode. The glass tube contains mercury vapour. **A** and **B** are two points inside the glass tube.

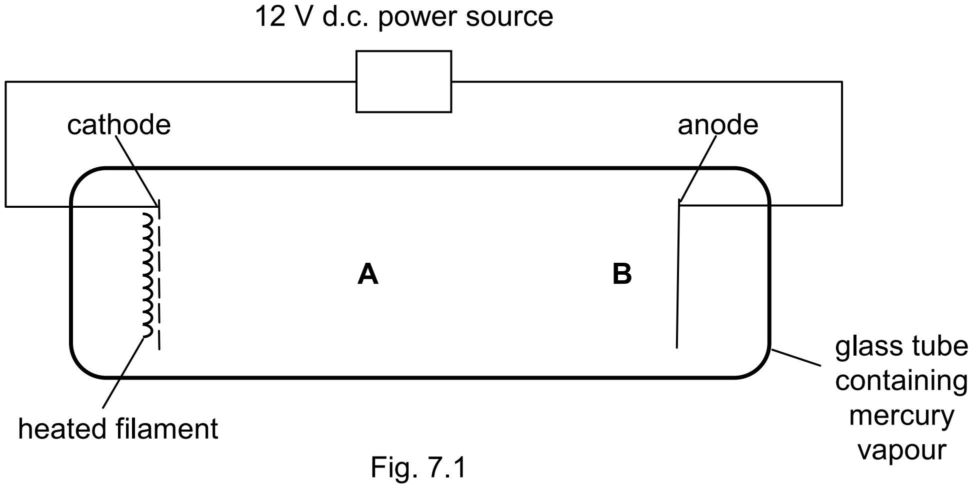


Fig. 7.1

(i) State the energy transformation that occurs for the accelerated electrons.

.... [1]

(ii) If the p.d. between the cathode and anode is 12 V, find the approximate maximum kinetic energy of the electrons when they reach the anode.

maximum energy = ... J [2]

(iii) Explain how the mercury vapour is able to glow.

....

....

.... [2]

(iv) Explain why the mercury atoms at position **B** are able to emit more energetic photons while those at **A** cannot.

....

....

.... [2]

(v) The filament is able to emit electrons easily when heated because the filament has a very small work function. What is meant by *work function*?

....

.... [1]

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(b) Heating however, is not the only way to emit electrons. An alternative is to make use of the *photoelectric effect.*

(i) What is meant by *photoelectric effect*?

....

....

.... [2]

(ii) In a particular photoelectric experiment , the potential difference (p.d.) between the collector and emitter was plotted against the photocurrent as shown below:

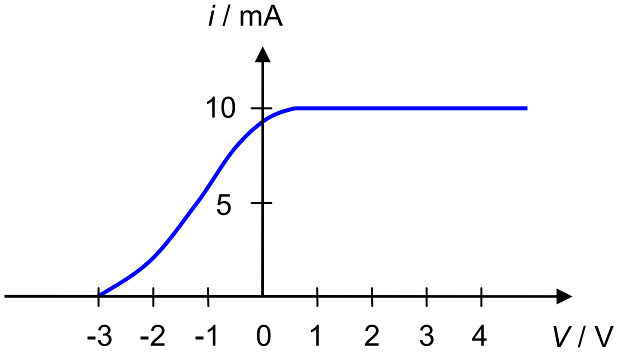

Fig. 7.2

1. Calculate the number of electrons ejected from the emitter per second.

number of electrons ejected per second = ... s^{-1} [2]

2. Explain why fewer electrons reach the collector when the p.d. was made negative.

....

.... [1]

3. Given the *threshold wavelength* of light is 545 nm, find the work function of the metal used in the emitter.

work function = ... J [2]

4. Find the maximum kinetic energy of the electrons emitted in eV.

maximum kinetic energy = ... eV [1]

(iii) On the same axes in Fig. 7.2, draw another curve showing the result when the intensity of the light source is reduced. [2]

(c) Explain how the *photoelectric effect* as well as *electron diffraction* demonstrates the wave-particle duality of matter.

....

....

.... [2]