Name of the Student:_____
Max. Marks : 23 Marks **Time :** 23 **Minutes**

Q1.

Scintillation counters are used to detect beta particles. A scintillation counter consists of a scintillation material and a photomultiplier tube (PMT).

(a) Beta particles collide with atoms in the scintillation material, which emits photons of light as a result.

Explain how photons are produced by collisions between beta particles and atoms.

_____

_____

_____

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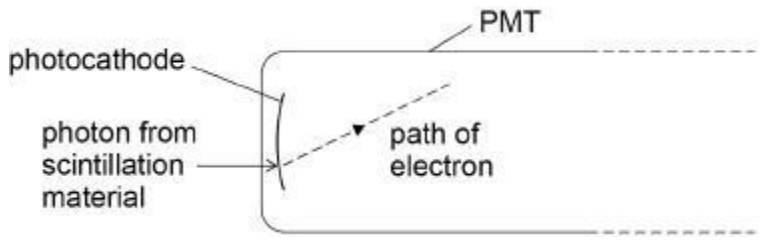
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(2)

(b) A photon of light from the scintillation material enters the PMT, as shown in **Figure 1**. The front of the PMT contains a thin photocathode. The photon strikes the photocathode to release an electron.

Figure 1



The longest wavelength of light that releases an electron from this photocathode is 630 nm.

Calculate the minimum photon energy required to remove an electron from the photocathode.

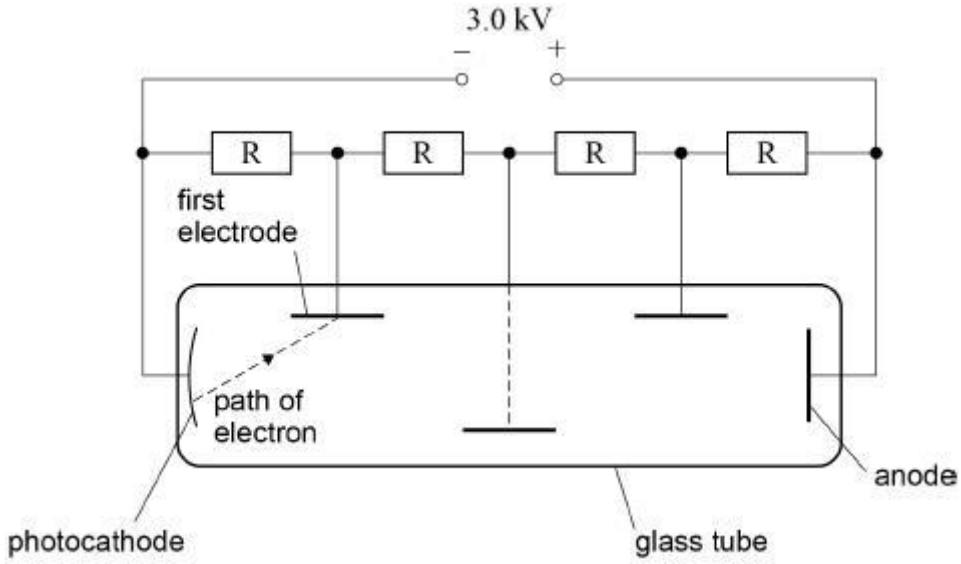
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minimum photon energy = _____ J

(2)

(c) The PMT consists of an evacuated glass tube containing the photocathode, an anode and three metal electrodes, as shown in **Figure 2**.

Figure 2



The electrodes, anode and photocathode are connected to a potential divider consisting of four identical resistors R. The emf of the electrical supply is 3.0 kV.

The potential difference between the photocathode and the first electrode accelerates the electron along the path shown in **Figure 2**.

Calculate, in J, the maximum kinetic energy transferred to the electron when it accelerates from the photocathode to the first electrode.

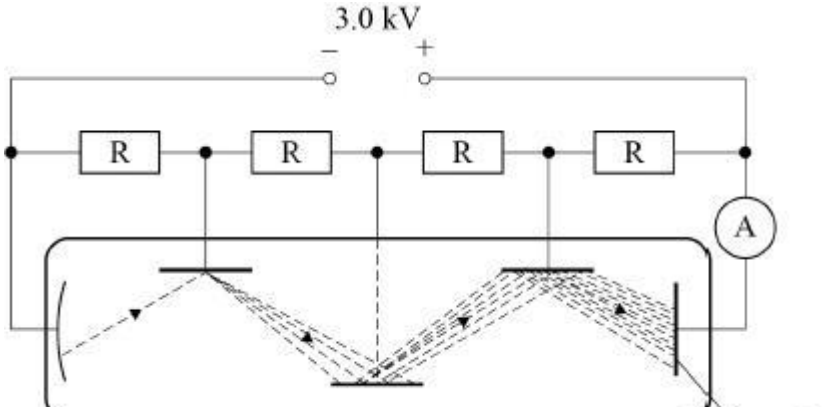
maximum kinetic energy = _____ J

(2)

(d) The electron hits the first electrode and causes the release of several electrons. **Figure 3** shows how a series of accelerations and collisions produces a large number of electrons. These electrons hit the anode and produce a pulse of current in an ammeter.

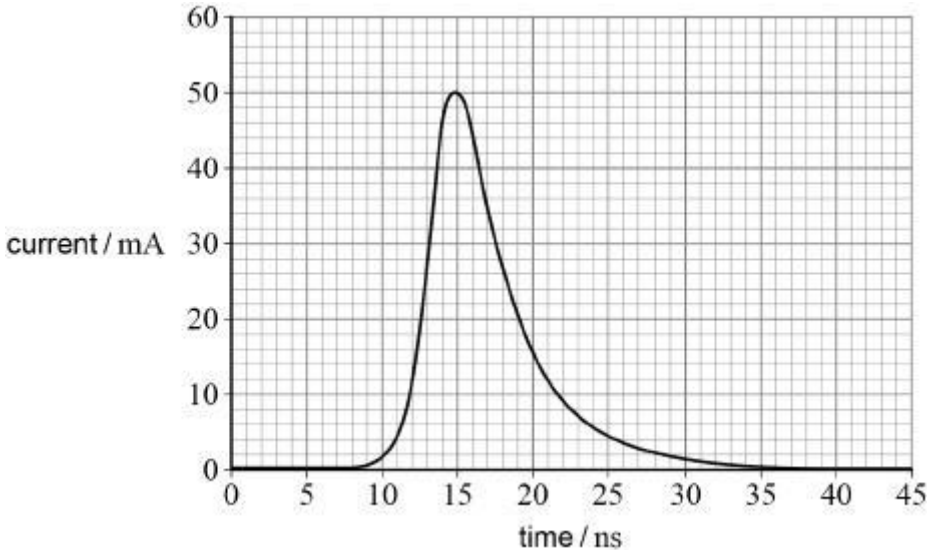
Figure 3

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The **Figure 4** shows the variation of current in the ammeter with time due to this pulse.

Figure 4



Determine the number of electrons that flow through the ammeter.

number of electrons = _____

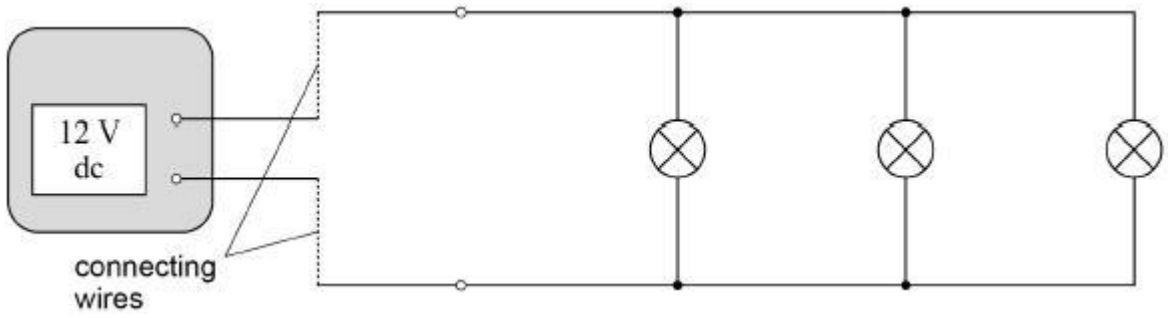
(4)

(Total 10 marks)

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Q2.

The diagram shows some of the apparatus used in a demonstration of electrical power transmission using a dc power supply.



A power supply of emf 12 V and negligible internal resistance is connected to three identical 12 V, 1.5 W lamps in parallel.

(a) Show that the resistance of one of the lamps when it is operating at 12 V is about 100 Ω.

(1)

(b) Initially the power supply is connected to the lamps using two short copper wires of negligible resistance.

Calculate the current in the power supply.

current = _____ A

(2)

(c) The two short copper wires are replaced with two long constantan wires.

Show that the resistance of each length of constantan wire is about 50 Ω.

length of each constantan wire	= 2.8 m
diameter of constantan wires	= 0.19 mm
resistivity of constantan	= 4.9×10^{-7} Ω m

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(3)

(d) The demonstration is intended to show that the lamps are significantly dimmer when connected using the long constantan wires than when using the short copper wires.

Discuss whether the demonstration achieves this.
Support your answer with suitable calculations.

_____

_____

_____

(4)

(e) Scientists and engineers are investigating the use of superconductors in electrical transmission.

Discuss **one** advantage and **one** difficulty when using superconductors in electrical transmission over long distances.

Advantage _____

_____

_____

_____

Difficulty _____

_____

_____

_____

(3)
(Total 13 marks)

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