Static Electricity and Energy

Definitions

If charged particles are in an electric field – negative charges – such as electrons and beta particles - move towards positive plate.

Positive particles - including alpha particles – move toward the negative plate.

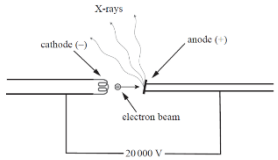
As the charges move, electrical potential energy is converted to kinetic energy ($E = ½ mv^2$).

Equations

$E = \frac{V}{d}$	Electric Field Strength	E	V m^{-1}
	Voltage	V	V
	Distance	d	m
$F = Eq$	Force	F	N
	Electric Field Strength	E	N C^{-1}
	Charge	q	C
$\Delta E_p = Eqd$	Change in Potential Energy	ΔE_p	J
	Electric Field Strength	E	N C^{-1}
	Charge	q	C
	Distance	d	m
$E_k = \frac{1}{2}mv^2$	Kinetic Energy	E_k	J
	Mass	m	kg
	Velocity	v	m s^{-1}
$V = \frac{\Delta E}{q}$	Voltage	V	V
	Change in Energy	ΔE	J
	Charge	q	C

Questions

Static Electricity (2016;1)

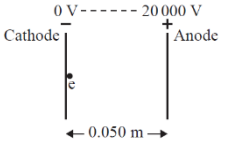


In an X-ray machine, a heating element releases electrons from a negatively charged plate called the cathode. The electrons are then accelerated by an electric field that exists between the cathode and a positively charged tungsten plate called the anode. The cathode and the anode are connected to a high voltage source of 20 000 V. The distance between the cathode and anode plates is 0.050 m. The beam of electrons causes X-rays to be released from the anode.

Charge on an electron = 1.60 x 10^{-19} C

Mass of an electron = 9.11 x 10^{-31} kg

The diagram on the right shows the arrangement to accelerate the electrons as they leave the cathode.



(a) Calculate the electric field strength between the plates and state its direction.

(b) State what type of energy an electron would have at the cathode (negative plate), and what would happen to that energy as the electron moved towards the anode (positive plate).

(c) Calculate the speed of the electron as it reaches the anode (positive plate).

Terms

Tips

- Remember the conservation of energy applies

Answers

(a)
$$E = \frac{V}{d}$$
$$= \frac{20\,000}{0.05}$$
$$= 400\,000 \text{ V m}^{-1} = 4 \times 10^5 \text{ V m}^{-1}$$

Direction positive (anode) to negative (cathode) plate.

(b) The electron loses electrostatic potential energy (EPE) and gains kinetic energy (KE). The electric field is working on the electron, so it loses EPE and lost EPE changes into KE.

(c) work done = $E\,q\,d$ *so* work done = $4 \times 10^5 \times 1.6 \times 10^{-19} \times 0.05$
$= 3.2 \times 10^{-15}$
work done = $½\,mv^2$
$3.2 \times 10^{-15} = ½ \times 9.1 \times 10^{-31} \times v^2$
$v = 8.39 \times 10^7$ m s^{-1}