Answer **all** the questions.

SECTION A

1 Look at the list of particle names and properties.

lepton **negative** **neutral** **hadron** **nucleon** **quark**

(a) Choose **two** words from the list that describe neutrinos.

........lepton........ and ....neutral........ **[1]**

(b) Choose **two** words from the list that describe protons.

........hadron........ and ....nucleon........ **[1]**

2 Fig. 2.1 shows the path of an alpha particle as it passes a nucleus.

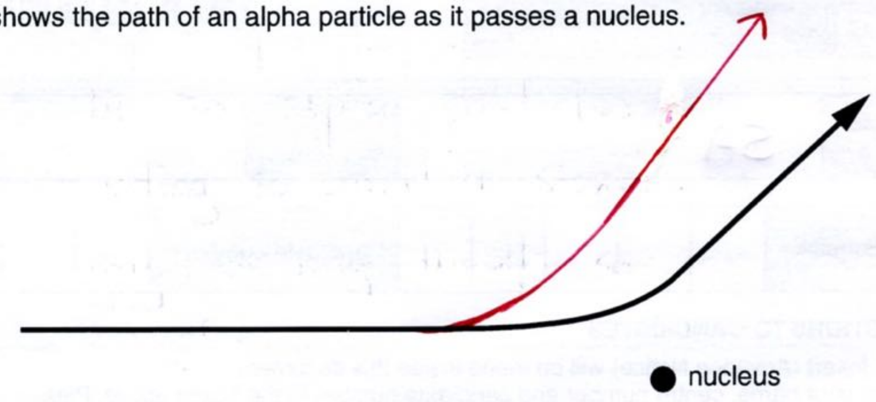


Fig. 2.1

Draw a second line on the diagram representing the path of an alpha particle with **lower** energy taking the same initial path. Give a reason why the paths are different.

Due to lower velocity force from nucleus acts for a longer time giving a larger change in momentum

[3]

3 Fig. 3.1 shows two metal plates. There is a potential difference between the plates.

Fig. 3.1

Fig. 3.2 shows the variation in potential between the plates.

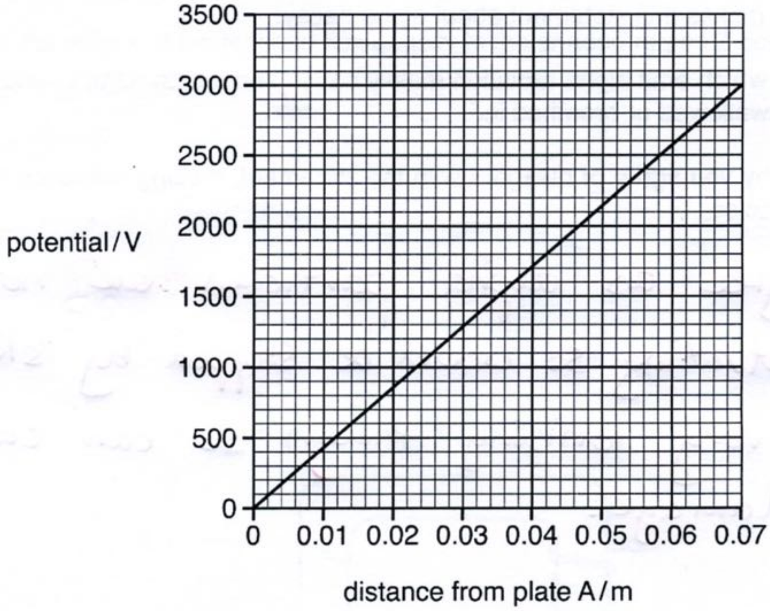


Fig. 3.2

Use the graph to describe the electric field between the plates. Explain your reasoning.

You may use data from the graph for calculations in your answer.

The straight line indicates a uniform electric field. The field strength is given by the gradient = 3000V/0.07m = 4.3×10^{4} Vm^{-1}

[3]

4 The radium isotope $^{224}_{88}Ra$ decays into radon through alpha decay as shown:

$$^{224}_{88}Ra \rightarrow ^{220}_{86}Rn + ^{4}_{2}He$$

(a) Here is a list of quantities.

nucleon number **charge** **mass** **quark number**

Choose the **one** quantity which is **not** conserved in this decay process.

mass .... **[1]**

(b) A student makes this statement about alpha decay:

"Isotopes which emit alpha radiation mainly cause serious damage to body tissue only when they are swallowed or breathed in."

Explain why you agree or disagree with the statement, making reference to the properties of alpha particles.

I agree as alpha particles are not very penetrating so would be stopped by skin. They are very ionising though so can cause a lot of damage.

[2]

5 An ideal transformer has 1500 turns on its primary coil and 750 turns on its secondary coil. The alternating voltage across the primary is 12 V and the primary current is 0.18 A.

½ so V = 6V

Choose which pair of data correctly shows the values for the secondary coil.

A 24 V 0.09 A
B 24 V 0.36 A
C 6 V 0.36 A
D 6 V 0.09 A

If V is halved I must double to keep power the same

The correct pair of values for the secondary coil is ....C.... . **[1]**

6 Fig. 6.1 shows an iron core. There is a magnetic flux in the core produced by the current-carrying coil. The shaded region **Z** has half the cross-sectional area of the rest of the core.

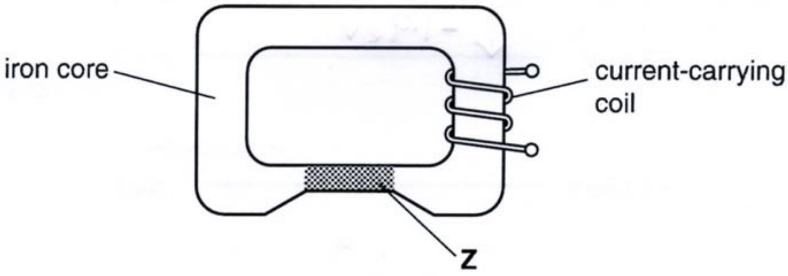


Fig. 6.1

(a) State how the values of the flux and flux density in the shaded region **Z** compare with those in the rest of the core.

flux: same

flux density: double

[2]

(b) A crack forms across the core at **X** as shown in Fig. 6.2.

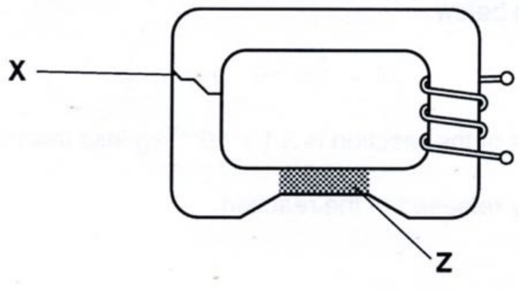


Fig. 6.2

State and explain the effect the crack will have on the values of flux and flux density in region **Z**.

Both will decrease as the air gap has much lower permeability so permeance of core is reduced.

[2]

7 Fig. 7.1 shows the lowest three energy levels of a hydrogen atom.

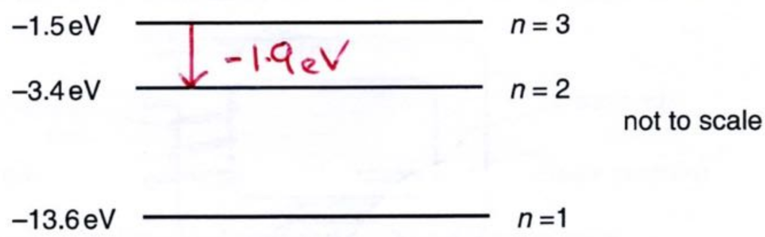


Fig. 7.1

Calculate the frequency of the photon emitted when an electron falls from the $n = 3$ energy level to the $n = 2$ energy level.

The Planck constant $h = 6.6 \times 10^{-34}$ J s

$\Delta E = 1.9 \times 1.6 \times 10^{-19} = 3.04 \times 10^{-19}$ J

Electronic charge $e = 1.6 \times 10^{-19}$ C

$\Delta E = hf \therefore f = \frac{\Delta E}{h} = 3.04 \times 10^{-19} / 6.6 \times 10^{-34} =$

frequency = 4.6×10^{14} Hz **[2]**

8 Physicists are investigating the possibility of using nuclear fusion as an energy source. One possible reaction is given below:

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$$

The mass of the products of the reaction is 3.1×10^{-29} kg less than the mass of the original nuclei.

(a) Calculate the energy released in the reaction.

$c = 3.0 \times 10^{8}$ m s^{-1}

$E = mc^2 = 3.1 \times 10^{-29} \times (3 \times 10^{8})^2 =$

energy = 2.8×10^{-12} J **[2]**

(b) State why high temperatures are needed for this reaction to take place.

To overcome the electrostatic repulsion of the hydrogen nuclei.

[1]

SECTION B

9 This question is about the electric field near point charges.

The field near a charge is represented by the field lines shown in Fig. 9.1.

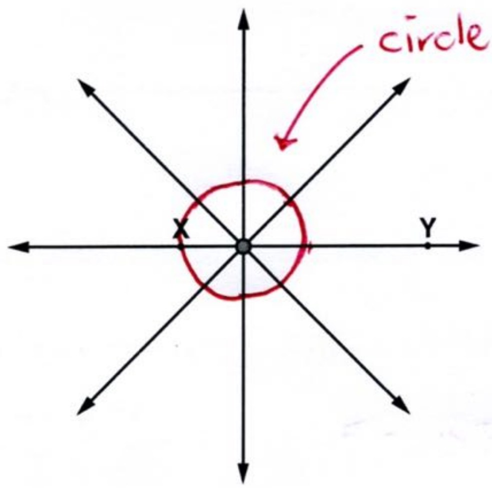


Fig. 9.1

(a) (i) State the feature of the diagram in Fig. 9.1 that shows that the field is stronger at point **X** than at point **Y**.

The field lines are closer together at X

[1]

(ii) Draw a complete equipotential line through point **X**. ✓ **[1]**

(b) As shown in Fig. 9.2, point **Y** is four times the distance of point **X** from the charge.

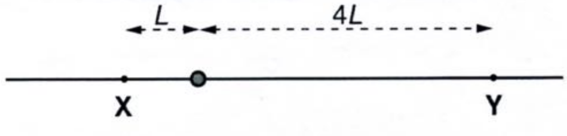


Fig. 9.2

(i) The potential at **X** is +1800 V. Calculate the potential at **Y**.

$V_{elec} = \frac{kQ}{r}$ so $1800/4 =$

potential = 450 V **[1]**

(ii) The electric field strength at **X** is $9.7 \times 10^4\,\text{N C}^{-1}$. Calculate the field strength at **Y**.

$E = \frac{kQ}{r^2}$ so $\frac{9.7 \times 10^4}{16} =$

field strength = 6.1×10^3 N C^{-1} **[1]**

(c) Fig. 9.3a shows two positive charges of the same magnitude. Fig. 9.3b shows two charges also of the same magnitude but of the opposite sign.

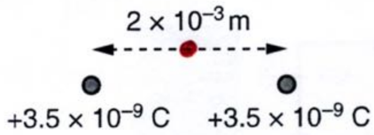


Fig. 9.3a

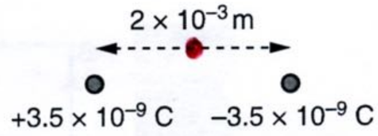


Fig. 9.3b

(i) Explain using calculations why the field strength at the midpoint between the charges in Fig. 9.3a is zero but is $6.3 \times 10^7\,\mathrm{N\,C^{-1}}$ at the midpoint between the charges in Fig. 9.3b.

electric force constant $k = 9.0 \times 10^9\,\mathrm{N\,m^2\,C^{-2}}$

In 9.3a the field from each charge is equal in magnitude but opposite in direction so they cancel each other out. In 9.3b the fields are in the same direction so they add up.

$$E = \frac{kQ}{r^2} \times 2 = \frac{9\times10^9 \times 3.5\times10^{-9}}{(1\times10^{-3})^2} \times 2 = 6.3\times10^7\,\mathrm{NC^{-1}}$$

[3]

(ii) Explain why the **potential** at the midpoint between the charges in Fig. 9.3b is zero.

Potential from each charge is equal in magnitude but has opposite sign.

[2]

[Total: 9]

10 This question is about a simple d.c. motor. Fig. 10.1 shows a square current-carrying coil between two permanent magnets.

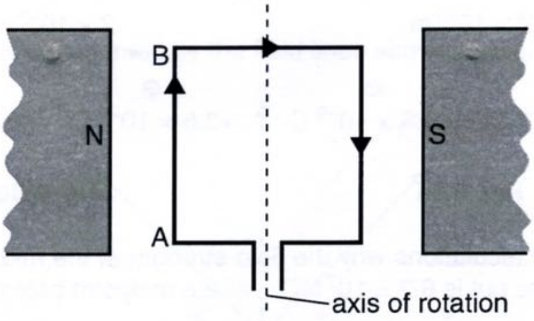


Fig. 10.1

(a) (i) Use the data below to calculate the force on side AB of the coil.

length of AB = 6.0×10^{-2} m
current in coil $I = 0.57$ A
magnetic field strength $B = 90$ mT
number of turns $N = 75$

F = BIL × turns

= 90×10⁻³ × 0.57 × 6×10⁻² × 75 =

force = ...0.23...... N **[1]**

(ii) The force on the coil makes the coil rotate. Suggest and explain how you expect the rate of rotation to change if all the sides of the square coil are reduced to 3.0×10^{-2} m. The current in the coil is not changed.

If the length of the sides are halved the turning force will halve. A smaller coil will have lower air resistance though so it would be hard to predict the outcome. **[2]**

(b) An emf is generated in the coil in Fig. 10.1 when it rotates in the magnetic field. Fig. 10.2 shows the coil in positions of zero flux linkage and maximum flux linkage viewed along the axis of rotation.

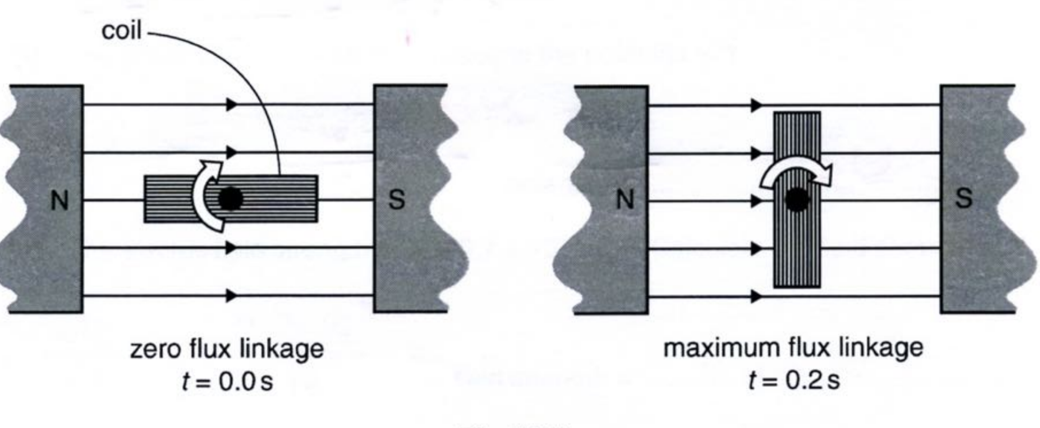


Fig. 10.2

(i) Use data from **(a)(i)** to calculate the maximum flux linkage of the **square** coil.

Flux linkage = BAN

$= 90\times10^{-3}\times(6\times10^{-2})^2\times75$

maximum flux linkage = 0.024 Wb-turns **[1]**

(ii) The coil moves through one quarter turn in 0.2 s as shown in Fig. 10.2. Calculate the average emf induced during this time.

$\text{emf} = \frac{d\phi N}{dt} = \frac{0.024}{0.2} =$

average emf induced = 0.12 V **[1]**

(iii) If the motor is jammed so that it stops turning, the current in the coil increases. Explain why.

In your answer you should use ideas about electromagnetic induction to explain why the current is higher when the motor turns more slowly.

When the coil is turning it is cutting flux lines so an emf is generated/induced which opposes the applied p.d. reducing it & so reducing the current in the coil. When the coil is not turning there is no 'back' emf so the resultant p.d. and hence current is higher.

[4]

[Total: 9]

11 This question is about the deflection of particles in a magnetic field.

(a) Fig. 11.1 shows the path of an alpha particle in a uniform magnetic field.

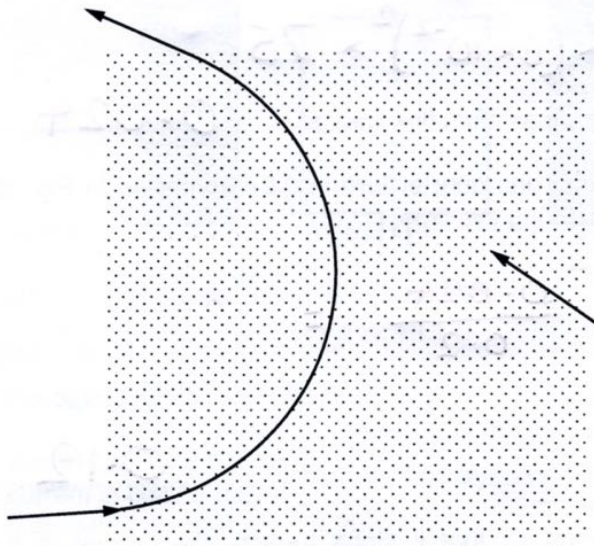


Fig. 11.1

The magnetic field produces a force on the alpha particle which travels in a circular path.

(i) State why the force on the alpha particle deflects the particle in a circular path.

Force acts at 90° to velocity vector.

[1]

(ii) Use equations for the force on a moving charge in a magnetic field and for the force on a mass moving in a circle to show that the radius r of the path taken by a particle moving at speed v at right angles to a magnetic field of flux density B is given by

$$r = \frac{mv}{Bq}$$

where m is the mass of the particle and q is the charge on the particle.

$$F = \frac{mv^2}{r} = qvB$$

$$\therefore \quad r = \frac{mv^2}{qvB} = \frac{mv}{qB}$$

[1]

(b) Fig. 11.2 shows a diagram that often appears in physics textbooks. It gives a misleading impression of how much alpha and beta particles are typically deflected by a magnetic field. The diagram is not to scale.

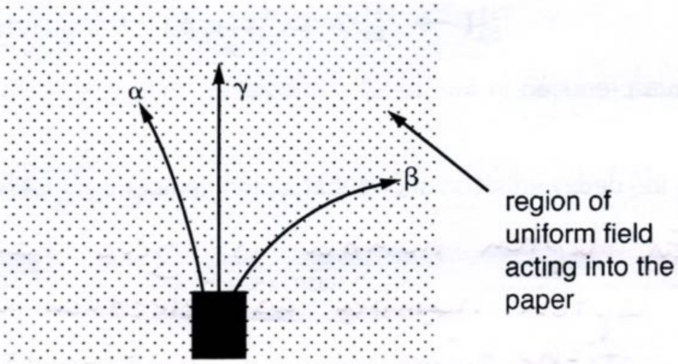


Fig. 11.2

Suggest why the diagram is correct to show that an alpha particle is deflected less than a beta particle, and that a gamma ray is not deflected.

β particle has lower mass than α particle and γ is an uncharged photon so is not deflected.

[2]

(c) Here are some typical data about alpha and beta particles released in radioactive decays.

Particle	Mass/kg	Typical velocity on release/m s^{-1}	Charge/C
alpha	6.6×10^{-27}	1.0×10^{7}	$+3.2 \times 10^{-19}$
beta	9.1×10^{-31}	2.0×10^{8}	-1.6×10^{-19}

Use these data and the equation given in **(a)(ii)** to explain why Fig. 11.2 does not accurately compare the paths of the alpha and beta particles.

In your answer you should link the results of any calculations to the paths shown on Fig. 11.2.

$$r_\alpha = \frac{mv}{Bq} = \frac{6.6\times10^{-27}\times 1\times10^{7}}{B\times 3.2\times10^{-19}} = 0.21/B$$

$$r_\beta = \frac{mv}{Bq} = \frac{9.1\times10^{-31}\times 2\times10^{8}}{B\times 1.6\times10^{-19}} = 1.1\times10^{-3}/B$$

$$r_\alpha/r_\beta = \frac{0.21/B}{1.1\times10^{-3}/B} = 191$$

[4]

[Total:8]

In diagram $r_\alpha/r_\beta \approx 10$ which is much smaller.

12 This question is about a radioisotope used in medicine.

Iodine-131 is a beta emitter. It decays to xenon as shown.

$$^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}\mathrm{e} + {}^{0}_{0}\bar{\upsilon}$$

Each xenon nucleus produced in the decay immediately emits a gamma ray photon of energy 364 keV.

(a) Describe how the decay equation shows that lepton number is conserved in this process.

Initial lepton number is zero and so is final lepton number as electron is a lepton and an anti-neutrino is an anti-lepton

[2]

(b) In a medical procedure, 1.20×10^{-13} kg of iodine-131 is absorbed into the thyroid gland in the neck.

(i) The initial activity of the iodine is stated to be about 5×10^{5} Bq.

Confirm this value of the activity, showing each step of your calculation.

mass of iodine-131 atom = 2.18×10^{-25} kg
half life of iodine-131 = 6.95×10^{5} s (8 days)

$N = 1.2 \times 10^{-13} / 2.18 \times 10^{-25} = 5.50 \times 10^{11}$ atoms

$\lambda = \ln 2 / t_{\frac{1}{2}} = \ln 2 / 6.95 \times 10^{5} = 9.97 \times 10^{-7}\ \mathrm{s}^{-1}$

$A = N\lambda = 5.5 \times 10^{11} \times 9.97 \times 10^{-7} = 5.49 \times 10^{5}$ Bq

[3]

(ii) It is said that a person treated with iodine-131 may still emit enough gamma rays to set off airport alarms twelve weeks after the treatment. Calculate the activity of the iodine sample in **(i)** after twelve weeks.

$A = A_0 e^{-\lambda t} = 5 \times 10^{5} e^{-9.97 \times 10^{-7} \times 7.3 \times 10^{6}\,\mathrm{s}} =$

$\left(12 \text{ weeks} = \frac{84}{8} \times 6.95 \times 10^{5} = 7.30 \times 10^{6}\,\mathrm{s}\right)$

activity = ...345........ Bq **[2]**

(c) Calculate the maximum dose in gray delivered to the thyroid gland from the beta emission, assuming all the iodine-131 decays in the gland. State why your answer is a maximum value.

average energy of beta particle = 2.9×10^{-14} J
mass of thyroid gland = 1.8×10^{-2} kg

5.5×10^{11} atoms $\times 2.9 \times 10^{-14}$ J $= 1.60 \times 10^{-2}$ J

$1.60 \times 10^{-2} / 1.8 \times 10^{-2} = 0.89$ J/kg

This assumes all β particles are absorbed by thyroid.

maximum dose = 0.89 Gy **[3]**

(d) Iodine-131 has been used as a 'tracer'. The movement of the iodine through the body is detected by gamma sensors around the body.

Explain why isotopes that emit gamma rays are required for use as tracers, and suggest why iodine-131 is now rarely used for this purpose.

Gamma radiation is penetrating enough to pass through body and be detected externally.

Beta radiation from I-131 is absorbed by tissue and can therefore lead to cell damage & cancer.

[3]

[Total: 13]

SECTION C

The questions in this section are based on the insert.

13 Optical microscopes use combinations of glass lenses to produce magnified images (line 10). The objective lens is a short focal length converging lens as shown in Fig. 13.1.

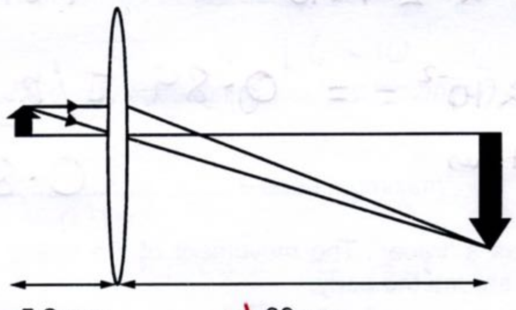


Fig. 13.1

(a) Calculate the magnification of the image.

$m = \frac{v}{u} = \frac{89}{5.3} =$

magnification = ...16.8...... **[1]**

(b) Calculate the power of the lens.

$P = \frac{1}{f}$ & $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$

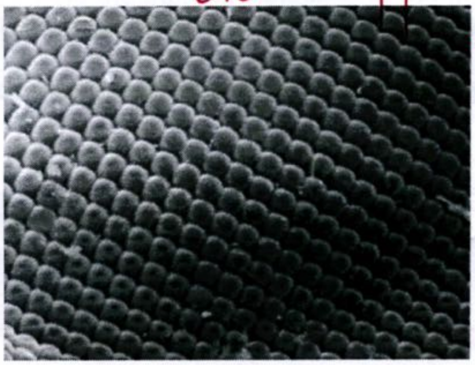
$\therefore \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{89\times10^{-3}} - \frac{1}{-5.3\times10^{-3}} =$

power = ...200...... dioptre **[2]**

[Total: 3]

14 The image shown in Fig. 14.1 is that of part of a fly's eye, obtained with an electron microscope. The eye consists of a large array of lenses (line 75).

3mm
640
480
258μm
46.5 mm



640 x 480 pixels

100 μm

18 mm

Fig. 14.1

(a) From the information given in Fig. 14.1, calculate the resolution of the image.

$\frac{46.5}{18} \times 100\mu m / 480 =$

resolution = 5.4×10^{-7} metres per pixel **[2]**

(b) The surface area of the fly's eye covered by the lenses is about $6.2 \times 10^{-6}\,m^2$. Calculate the approximate number of lenses covering one eye.

One lens is ~ $3/18 \times 100\mu m = 1.67 \times 10^{-5}$ across

Area $= (1.67 \times 10^{-5})^2 = 2.79 \times 10^{-10}\,m^2$

$6.2 \times 10^{-6} / 2.79 \times 10^{-10} =$

approximate number of lenses covering one eye = 22000 **[2]**

[Total: 4]

15 While in operation, an electron microscope produces a continuous beam of electrons travelling along an evacuated tube (line 50).

(a) The beam of electrons carries a current of 2.0×10^{-12} A. = C/s

Calculate the number of electrons leaving the electron gun each second.

electronic charge $e = 1.6 \times 10^{-19}$ C

$2 \times 10^{-12} / 1.6 \times 10^{-19} = 1.25 \times 10^{7}$

number of electrons per second = 1.3×10^{7} **[1]**

(b) The pressure in the tube is 1.0×10^{-5} Pa.
The device is operating at 300 K (room temperature).
Calculate the number of gas particles per cubic centimetre in the chamber.

Boltzmann constant $k = 1.4 \times 10^{-23}$ J K^{-1}

$1\ cm^3 = 1 \times 10^{-6}\ m^3$

$pV = NkT$

$\therefore N = \frac{pV}{kT} = \frac{1 \times 10^{-5} \times 1 \times 10^{-6}}{1.4 \times 10^{-23} \times 300} = 2.38 \times 10^{9}$

number of gas particles per cubic centimetre = 2.4×10^{9} **[3]**

(c) The source of the electrons is a small coil of tungsten wire (the filament). A current is passed through the coil and electrons boil off the hot surface of the wire. The electrons receive the energy to do this from the thermal vibrations of the metal lattice. The energy, E, required to remove an electron in this way is about 7×10^{-19} J (just over 4 eV, line 42).

(i) The beam current I_B will depend upon the Boltzmann factor:

$$I_B \propto e^{-E/kT}$$

Explain why it is reasonable to expect the beam current to be proportional to the Boltzmann factor.

The Boltzmann factor gives the fraction of electrons that have enough energy to boil off and form the beam current. The higher the B.F. the more electrons can escape per second so the higher the beam current.

[3]

(ii) When the filament is at a temperature of 2200 K, N electrons are emitted per second.

Use the Boltzmann factor to calculate an estimate of the temperature the wire must reach to emit $3N$ electrons per second.

$k = 1.4 \times 10^{-23}\,\text{J K}^{-1}$

$$BF = e^{-E/kT} = e^{-7\times10^{-19}/1.4\times10^{-23}\times2200} = 1.35\times10^{-10}$$

$$\therefore\ 3\times1.35\times10^{-10} = e^{-7\times10^{-19}/1.4\times10^{-23}\times T}$$

$$\therefore\ \ln(3\times1.35\times10^{-10}) = -7\times10^{-19}/1.4\times10^{-23}\times T$$

temperature ....2312............ K **[3]**

[Total: 10]

$$T = \frac{-7\times10^{-19}}{\ln(3\times1.35\times10^{-10})\times1.4\times10^{-23}} =$$

16 In a typical scanning electron microscope, the electrons are accelerated from rest through a potential difference of 40 kV.

(a) **(i)** Show that the kinetic energy gained by each electron is about 6×10^{-15} J.

electronic charge $e = 1.6 \times 10^{-19}$ C

40×10^{3} eV $\times 1.6 \times 10^{-19}$ C $= 6.4 \times 10^{-15}$ J

[1]

(ii) Calculate the momentum gained by each electron. Ignore relativistic effects.

mass of an electron $m_e = 9.1 \times 10^{-31}$ kg

$v = \sqrt{2KE/m} = \sqrt{\frac{2 \times 6.4 \times 10^{-15}}{9.1 \times 10^{-31}}} = 1.18 \times 10^{6}\ s^{-1}$

$p = mv = 9.1 \times 10^{-31} \times 1.18 \times 10^{6}$

momentum gained = 1.08×10^{-22} kg m s^{-1} **[2]**

(b) Calculate the maximum theoretical resolution of an instrument using 40 keV electrons. Assume this resolution is given by half the de Broglie wavelength of the electrons.

Planck constant $h = 6.6 \times 10^{-34}$ J s

$\lambda = h/p = 6.6 \times 10^{-34} / 1.08 \times 10^{-22} = 6.1 \times 10^{-12}$

$6.1 \times 10^{-12}/2 =$

resolution = 3.1×10^{-12} m **[2]**

(c) When the electrons strike the sample most of their energy is converted to thermal energy (line 56). Excessive heating could damage the sample.

Calculate the minimum number of electrons required to strike a small sample in order to raise its temperature by 1 K.

electron energy $E = 6.0 \times 10^{-15}$ J
mass of sample $m = 0.25 \times 10^{-6}$ kg
specific thermal capacity of sample $c = 3000\ \text{J kg}^{-1}\text{K}^{-1}$

$\Delta E = mc\Delta\theta = 0.25 \times 10^{-6} \times 3000 \times 1 = 7.5 \times 10^{-4}$ J

$7.5 \times 10^{-4} / 6 \times 10^{-15}$

number of electrons = 1.25×10^{11} **[2]**

(d) Some of the electrons' energy is carried away as x-rays (line 56). The maximum energy of an emitted x-ray photon is equal to that of the incident electron.

Calculate the minimum wavelength of the emitted x-rays.

electron energy $E = 6.0 \times 10^{-15}$ J
Planck constant $h = 6.6 \times 10^{-34}$ J s
speed of light $c = 3.0 \times 10^{8}\ \text{ms}^{-1}$

$E = \frac{hc}{\lambda} \quad \therefore \lambda = \frac{hc}{E} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{6 \times 10^{-15}} =$

wavelength = 3.3×10^{-11} m **[2]**

[Total: 9]

17 In electron microscopes, beams of electrons are focused using circular solenoids producing strong magnetic fields (line 46), typically about 1 tesla in TEMs.

(a) Show that the number of turns required to produce this field strength in a circular solenoid of mean diameter 0.010 m which carries a current of 2.0 A is about 4000.

field strength in solenoid $B = \mu_o \frac{IN}{d}$

where

B is magnetic field strength in tesla
μ_o is permeability of free space = $1.3 \times 10^{-6}\,\mathrm{N\,A^{-2}}$
I is current in amps
N is number of turns
d is diameter of solenoid in metres

$N = Bd/\mu_o I = 1 \times 0.01 / 1.3 \times 10^{-6} \times 2.0$

$= 3846$ Turns ≈ 4000

[2]

(b) Estimate the potential difference needed across this coil to produce the required field strength.

resistance per unit length of the wire used = $1.6\,\Omega\,\mathrm{m}^{-1}$

Length $= \pi d N = \pi \times 0.01 \times 4000 = 125.7$ m

$R = 125 \times 1.6\,\Omega\,\mathrm{m}^{-1} = 201.1\,\Omega$

$V = IR = 201.1 \times 2\,\mathrm{A} =$

potential difference = 402 V **[2]**

[Total: 4]

18 In some SEM systems, sideways deflection of the beam (for scanning) can be obtained using a uniform electric field (line 70) between two parallel plates (Fig. 18.1).

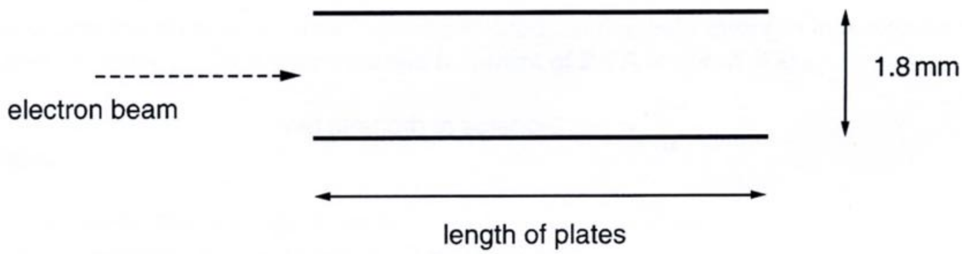


Fig. 18.1

(a) Show that the electric field between a pair of plates 1.8 mm apart with a potential difference across them of 200 volts is more than $10^5\,\mathrm{V\,m^{-1}}$.

$E = V/d = 200/1.8\times10^{-3} = 1.11\times10^{5}\,\mathrm{Vm^{-1}}$

[1]

(b) The electrons move through the field at a speed of 40% of the speed of light so relativistic effects can be ignored.

Calculate the length of plates required to produce a deflection of 5×10^{-4} m at the end of the plates.

electronic charge $e = 1.6 \times 10^{-19}$ C
electron mass $m_e = 9.1 \times 10^{-31}$ kg

$F = Eq = 1.11\times10^{5} \times 1.6\times10^{-19} = 1.78\times10^{-14}\,\mathrm{N}$

$a = F/m = \frac{1.78\times10^{-14}}{9.1\times10^{-31}} = 1.95\times10^{16}\,\mathrm{ms^{-2}}$

$s = ut + \frac{1}{2}at^2 \quad \therefore \quad 5\times10^{-4} = \frac{1.95\times10^{16}}{2}t^2$

$\therefore t = \sqrt{\frac{2\times5\times10^{-4}}{1.95\times10^{16}}} = 2.26\times10^{-10}\,\mathrm{s}$

distance = speed × t $= 0.4\times3\times10^{8}\times2.26\times10^{-10} =$

length of plates = 0.027 m **[4]**

(c) Explain why the size of the deflection of an electron passing through the middle of the gap between the plates would be unchanged if it entered the gap closer to the negative plate.

The field is uniform between the plates so the force and hence the acceleration would be the same.

[2]

[Total: 7]

19 Transmission electron microscopes use electrons of high energy, at which relativistic effects ($\gamma > 1$) are significant.

Calculate the velocity of an electron accelerated through a potential difference of 200 kV, taking relativistic effects into account.

rest energy of the electron = 0.511 MeV
speed of light $c = 3.0 \times 10^8\,\text{ms}^{-1}$

$\gamma = E_{total}/E_{rest} = \dfrac{0.511\times10^6 + 200\times10^3}{0.511\times10^6} = 1.39$

$1.39 = 1/\sqrt{1-v^2/c^2}$ $\therefore$ $1-v^2/c^2 = (1/1.39)^2 = 0.518$

$\therefore$ $v^2/c^2 = 0.482$

velocity = 2.1×10^8 ms^{-1} **[3]**

$\therefore$ $v/c = \sqrt{0.482} = 0.694$

[Total: 3]

END OF QUESTION PAPER

$\therefore$ $V = 3\times10^8 \times 0.694 = 2.08\times10^8\,\text{ms}^{-1}$