SECTION A

You should spend a maximum of 40 minutes on this section.

Write your answer for each question in the box provided.

Answer **all** the questions.

1 Which pair contains one vector and one scalar quantity?

× **A** velocity V acceleration V

× **B** displacement V force V

× **C** kinetic energy S work done S

D momentum V distance S

Your answer D **[1]**

2 The unit of electrical resistance is the ohm Ω. 1 Ω is the same as

A $1\ \mathrm{C\ V^{-1}}$ ×

B $1\ \mathrm{S^{-1}}$

C $1\ \mathrm{C^2\ J^{-1}\ s^{-1}}$ ×

D $1\ \mathrm{A\ V^{-1}}$ × = S

$R = 1/G$

Your answer B **[1]**

3 Which quantity is followed by a reasonable estimate of its order of magnitude?

A	weight of an apple	$10^0\,\mathrm{N}$ = 1N ✓
B	volume of a table tennis ball	$10^3\,\mathrm{cm^3}$ = 1 litre ×
C	wavelength of infra-red radiation	$10^4\,\mathrm{m}$ = 10km ×
D	temperature of Sun's surface ~ 6000 K	$10^5\,\mathrm{K}$ ×

Your answer A **[1]**

4 A signal is being digitised by sampling at 12 kHz. → So f_{max} = 6 kHz
The total voltage is 5.0 V and the noise voltage is 4.9 mV. $V_t/V_n = 5/4.9\times10^{-3} \approx 10^3$

Which statement is correct?

A $\frac{V_{total}}{V_{noise}} \approx 10^3$ ✓

B The highest frequency in the signal should not exceed 24.0 kHz. ×

C The recommended number of bits per sample is 8. × $\log_2 10^3 = 9.9 \Rightarrow$ 10 bits

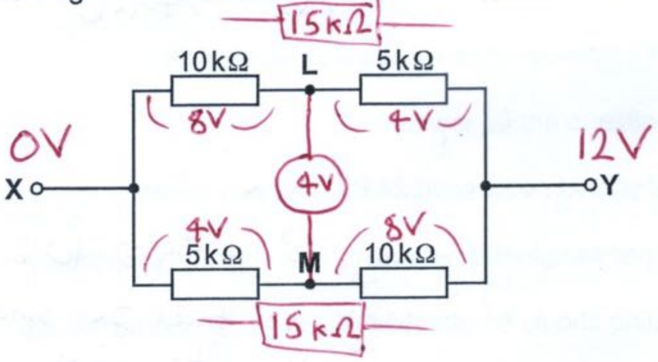
D The voltage resolution of the sampling should be about 1 mV. × No that's 5x smaller than the noise

Your answer A [1]

Turn over for the next question

The following information is for use in questions **5** and **6**.

The diagram shows a combination of four resistors.



5 What is the resistance between **X** and **Y**? 15kΩ/2 =

A 5kΩ

B 7.5kΩ ✓

C 15kΩ

D 30kΩ

Your answer [B] **[1]**

6 A battery of e.m.f. 12V and negligible internal resistance is connected across **X Y**.

What is the magnitude of the p.d. between **L** and **M**?

A 2V

B 4V

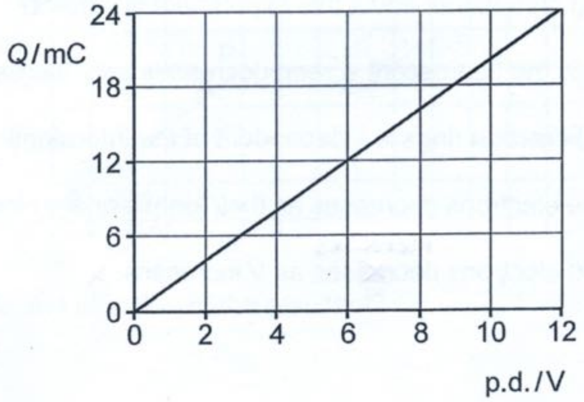
C 6V

D 8V

Your answer [B] **[1]**

The following information is for use in questions **7** and **8**.

The diagram shows the $Q - V$ graph for a capacitor charged to 12 V.



7 What is the capacitance?

A 2×10^{-3} F

B 144×10^{-3} F

C 288×10^{-3} F

D 500 F

$C = Q/V = \frac{24 \times 10^{-3}}{12} = 2 \times 10^{-3}$ F

Your answer A **[1]**

8 Which of the following is the energy stored?

A 2×10^{-3} J

B 144×10^{-3} J

C 288×10^{-3} J

D 500 J

$E = \frac{1}{2}CV^2 = \frac{1}{2}QV$

$= \frac{1}{2} \times 24 \times 10^{-3} \times 12 = 0.144$ J

Your answer B **[1]**

OR $= \frac{1}{2} \times 2 \times 10^{-3} \times 12^2$

$= 0.144$ J

9 Electrons accelerated through a potential difference *V* pass through a thin layer of graphite. The beam forms a diffraction pattern of rings on a fluorescent screen.
When *V* is made larger the diameter of the rings get smaller and they also become brighter.

Which **one** of the following statements about this experiment is correct?

A The power delivered to the fluorescent screen decreases as *V* increases. × Brighter

B The diameter of the diffraction rings is independent of the interatomic spacings in graphite. × $n\lambda = dx/L$

C The wavelength of the electrons decreases as their kinetic energy increases. $\lambda = h/mv$ so YES

D The momentum of the electrons decreases (increases) as *V* increases. ×

Your answer C **[1]**

10 Which **one** of the following statements about photons is correct?

The probability of arrival of a photon at a position

A is proportional to the amplitude² of the waves arriving at that position. ×

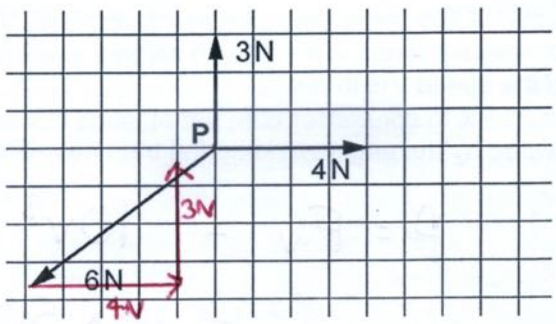
B is greater if the phasor amplitudes for paths from the source to that position "curl up" (→ smaller amplitude) when they are added. ×

C is proportional to the (resultant phasor amplitude)^2 for all photon paths from the source to that position. YES

D is proportional to the phasor amplitude for the photon path straight from the source to that position. ×

Your answer C **[1]**

11 The three forces in this vector diagram act in one plane on an object **P**.



Add tip to tail

What is the magnitude and direction of the resultant?

A 1 N ↙

B 1 N ↗

C 1 N →

D 11 N ↙

Your answer A

[1]

12 A car travelling at $10\,m\,s^{-1}$ is brought to rest in a braking distance of 10 m.

Using the same average braking force, in what distance can the car be brought to rest from a speed of $40\,m\,s^{-1}$?

A 20 m

B 40 m

C 80 m

D 160 m

$v^2 = u^2 + 2as$ & $v = 0$

$\therefore s \propto u^2$

u is $\times 4$ so u^2 is $\times 16$

$10\,m \times 16 = 160\,m$

Your answer D

[1]

13 The drag force F of the air on a train is

$$F \approx 10v^2$$

where F is in newtons and the speed v is in $m\,s^{-1}$.

What **power** must be delivered by the engine to keep the train travelling at a constant $50\,m\,s^{-1}$?

A 25 kW

B 125 kW

C 1.25 MW

D 2.5 MW

$P = Fv = 10v^3$
$= 10 \times 50^3$
$= 1.25 \times 10^6\ W$

Your answer C **[1]**

14 Suppose that a particular radioactive nucleus is observed for a period of time to find when it decays.
The isotope's half-life is 1 hour, and after 1 hour the particular nucleus has **not** decayed.

The chance that it will decay in the next second

A cannot be stated because the chance varies randomly from second to second.

B is now half the chance that it had to decay in the first second.

C is just the same as the chance that it would have decayed in the first second or any other second. ie Decay constant is fixed

D is the same as the chance that it will not decay in the next second.

Your answer C **[1]**

The following information is for use in questions **15** and **16**.

Two heater coils **X** and **Y** dissipate the same power when coil **X** runs at 12 V and coil **Y** runs at 6 V. The coils are made from equal lengths of wire of the same material, but different diameter.

15 Which one of **A** to **D** below is equal to the ratio $\frac{\text{resistance of } \mathbf{X}}{\text{resistance of } \mathbf{Y}}$?

A $\frac{1}{4}$

B $\frac{1}{2}$

C 2

D 4

X $12V \times I_x = P$

Y $6V \times I_Y = P$

I_x must be half I_y but p.d. is double so R must be x4 greater

Your answer 4 **[1]**

16 Which one of **A** to **D** below is equal to the ratio $\frac{\text{diameter of wire } \mathbf{X}}{\text{diameter of wire } \mathbf{Y}}$?

A $\frac{1}{4}$

B $\frac{1}{2}$

C 2

D 4

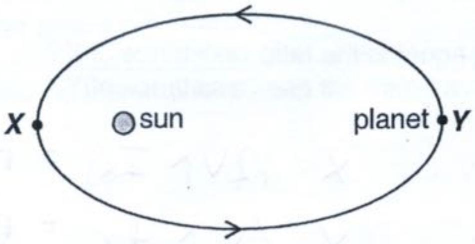
$R = \frac{\rho L}{A}$ & $A \propto d^2$

∴ d must be half.

Your answer B **[1]**

The following information is for use in questions **17** and **18.**

A planet is in elliptical orbit around the Sun as shown.



17 Which of the following is correct?

A As the planet leaves ***X*** it is speeding up. ×

B As the planet approaches ***X*** it is slowing down. ×

C As the planet approaches ***Y*** it is speeding up. ×

D As the planet leaves ***Y*** it is speeding up. ✓

Your answer D **[1]**

Further

18 Which of the following quantities is **greater** at ***Y*** than at ***X***?

A the gravitational force on the planet from the sun ×

B the gravitational potential energy of the planet-sun system ✓

C the kinetic energy of the planet in its orbit ×

D the total energy of the planet-sun system × constant

Your answer B **[1]**

19 Two samples **L** and **M** contain the same mass of an ideal gas.

→ so same gas.

In which of the following cases will it always be true that the molecules in **L** have a larger root mean square speed than those in **M**?

1 **L** is at a greater temperature than **M** ✓

2 **L** has a greater volume than **M** ×

3 **L** is at a greater pressure than **M** ×

$pV = nRT = \frac{1}{2}Nm\overline{c^2}$

Same mass of same gas ∴ n R N m all same ∴

$\overline{c^2} \propto pV$

$\overline{c^2} \propto T$

A 1, 2 and 3 are correct

B only 1 and 2 are correct

C only 2 and 3 are correct

D only 1 is correct

Your answer D **[1]**

20 At 300 K a process has an activation energy $E = 10kT$.

The temperature is raised to 330 K.

Which statement about the rate of the process is correct?

It will increase by

A 10% because temperature has increased by 10%.

B 10% because the mean square speed of the particles has increased by 10%.

C 9.1 times because $\frac{E}{kT} = \frac{3000k}{330k} = 9.1$.

D 2.5 times because $e^{\frac{-E}{kT}}$ has increased by $\frac{e^{-9.1}}{e^{-10}} = 2.5$ times.

Your answer D **[1]**

21 Which of the following changes doubles the flux in a magnetic circuit?

1 doubling the permeance

2 doubling the current-turns

3 halving the circuit length

A 1, 2 and 3 are correct

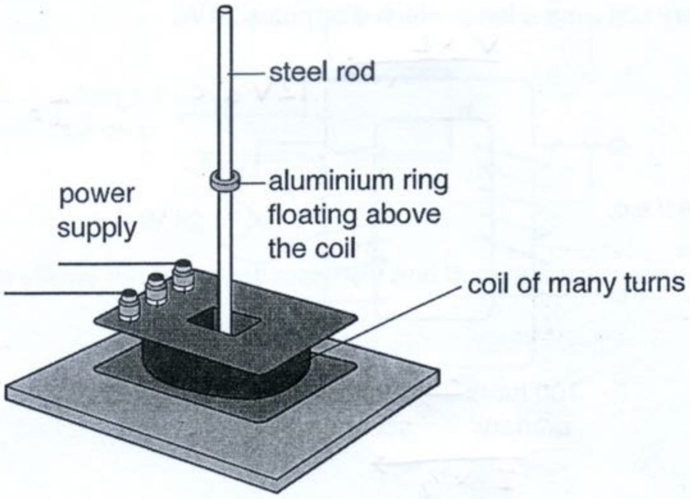
B only 1 and 2 are correct

C only 2 and 3 are correct

D only 1 is correct

Your answer A **[1]**

22 An aluminium ring is free to move on a steel rod.
When the power supply is on, the ring floats.



Which of the following is correct?

A An a.c. or d.c. power supply can be used. ×

B The induced current in the ring is in the same direction as the current in the coil. ×

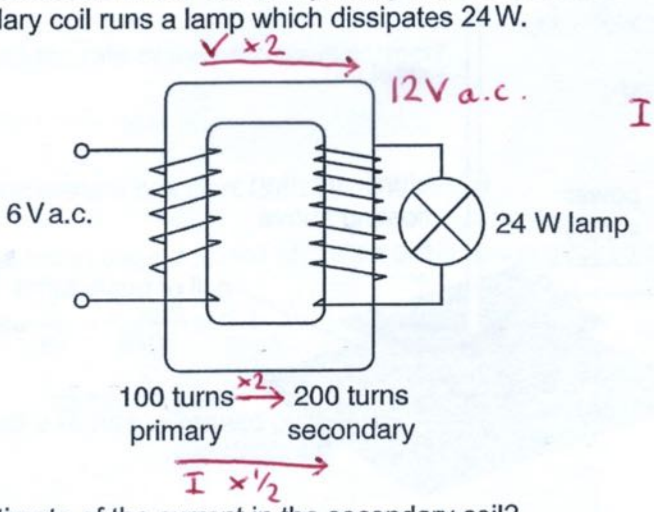
C The only purpose of the steel rod is to support the ring. ×

D When the ring is pushed down towards the coil more flux links it and the induced current increases. ✓

Your answer D **[1]**

The following information is for use in questions **23** and **24**.

A 6 V a.c. supply is connected to the 100 turn primary coil of an ideal transformer. The 200 turn secondary coil runs a lamp which dissipates 24 W.



$I = \frac{P}{V} = \frac{24}{12} = 2A$

23 Which is the best estimate of the current in the secondary coil?

A $\frac{1}{4}$ A

B $\frac{1}{2}$ A

C 2 A

D 4 A

Your answer C **[1]**

24 Which is the best estimate of the current in the primary coil?

Also 24 W ∴ $I = \frac{24}{6} = 4A$

A $\frac{1}{4}$ A

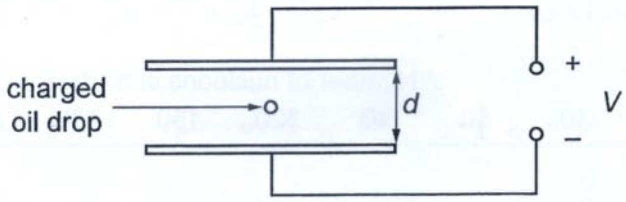
B $\frac{1}{2}$ A

C 2 A

D 4 A

Your answer D **[1]**

25 An oil drop of mass m charged by one electron is balanced between two parallel horizontal metal plates. A potential difference V is applied between the plates as shown.



Which expression shows the balanced electrical and gravitational forces acting?

A $eVd = mg$

B $\frac{eV}{d} = mg$

C $\frac{V}{ed} = mg$

D $\frac{dV}{e} = mg$

$\frac{Vq}{d}$ ↑ ↓ mg

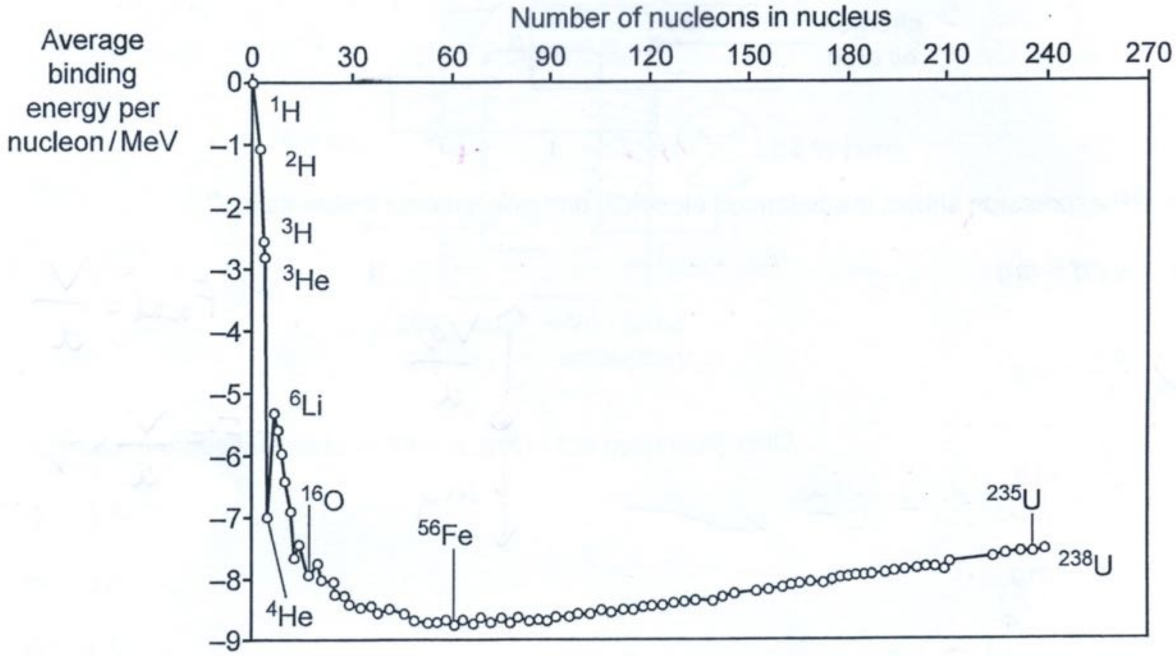
Field $= \frac{V}{d}$

$F = \frac{V}{d} \times q$

Your answer B **[1]**

The following information is for use in questions **26** and **27**.

The graph shows how the binding energy per nucleon varies with the nucleon number for stable nuclei.



26 Which **one** of the following statements is correct?

A All unstable nuclei have less binding energy than stable nuclei.

B ^{56}Fe requires less energy per nucleon than other stable nuclei to pull it apart into individual nucleons.

C Binding energy can be released in the fission of some heavy elements

D Binding energy is the energy released when a nucleus breaks down into individual nucleons.

Your answer C

[1]

27 Which is the best estimate for the total binding energy for a nucleus of $^{16}_{8}O$ (Oxygen)?

A – 10 pJ

B – 20 pJ

C – 64 pJ

D – 128 pJ

-8 MeV per nucleon

$= -8\times10^{6}\times1.6\times10^{-19}\times16$

$= -2\times10^{-11}$ J

Your answer B **[1]**

28 Isotopes of a given element all have the same

A proton number.

B charge / mass ratio.

C neutron number.

D nucleon number.

Your answer A **[1]**

29 Which of the following statements about the α-particle and the β-particle is correct?

A If both have the same kinetic energy, the speed of the β-particle is less than that of the α-particle.

B If both have the same momentum, the de Broglie wavelength of the α-particle must be the same as that of the β-particle.

C If both have the same momentum, the kinetic energy of the α-particle is greater than that of the β-particle.

D The rest energies of both the α-particle and the β-particle are the same.

Your answer B **[1]**

30 $^{214}_{82}Pb$ decays by a series of transformations to a final stable product.

The particles emitted are: β, β, α, β, β, α.

Which one of the isotopes below is the final product?

A $^{206}_{82}Pb$

B $^{210}_{82}Pb$

C $^{208}_{83}Bi$

D $^{214}_{83}Bi$

Your answer A **[1]**

SECTION B

Answer **all** the questions.

31 The main bolt of a lightning strike flows through air already ionised by a "leader" strike.

(a) State why air needs to be ionised to carry an electric current.

Air molecules are neutral - there are no charge carriers .... [1]

(b) The current in a main strike is 30 kA and lasts for 250 μs.

Show that the charge delivered by this strike is less than 8 C.

$Q = It = 30 \times 10^{3} \times 250 \times 10^{-6}$

$= 7.5\ C$

[2]

32 This question is about refractive index.

For light passing from a vacuum into a medium, the refractive index is $n_{\text{medium}} = \dfrac{c}{c_{\text{medium}}}$

(a) Complete this line of algebraic reasoning.

$$n_{\text{glass}} = \frac{c}{c_{\text{glass}}}, \quad n_{\text{water}} = \frac{c}{c_{\text{water}}} \rightarrow \frac{n_{\text{glass}}}{n_{\text{water}}} = \frac{\dfrac{c}{c_{glass}}}{\dfrac{c}{c_{water}}} = \frac{c_{\text{water}}}{c_{\text{glass}}}$$ **[1]**

(b) **Fig. 32.1** shows a ray of light going from glass into water at an angle of incidence $i = 30°$.

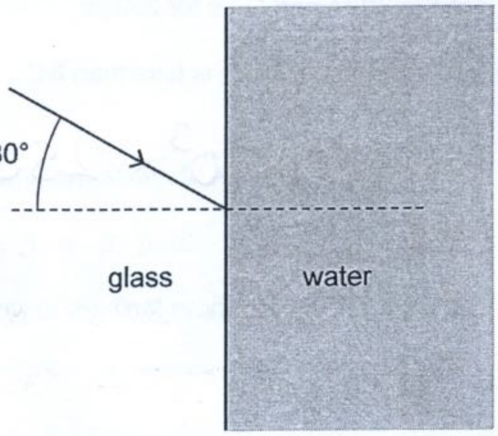


Fig. 32.1

Calculate the angle of refraction r in the water.

$n_{\text{glass}} = 1.6 \qquad n_{\text{water}} = 1.3$

$n_{g \to w} = 1.3/1.6 = 0.813$

$\dfrac{\sin i}{\sin r} = n$

$r =$ 38° ° **[2]**

$\sin r = \dfrac{\sin i}{n}$

$r = \sin^{-1}\left(\dfrac{\sin i}{n}\right) = \sin^{-1}\left(\dfrac{\sin 30}{0.813}\right) = 38°$

33 An electric shower runs at 230 V and 46 A.
In summer it increases the water temperature from 22 °C to 39 °C. $\Delta\theta = 17\,°C$

(a) **(i)** Calculate the thermal energy used to increase the temperature of 1 kg of the water.

Specific thermal capacity of water = 4200 J kg^{-1} K^{-1}

$\Delta E = mc\Delta\theta$

$= 1 \times 4200 \times 17 = 71400\,J$

energy = 71.4 kJ **[2]**

(ii) Calculate the time it will take the heater to deliver this amount of thermal energy.

$P = IV = 46 \times 230 = 10580\,W$

$t = E/P = 71400/10580$

time = 6.75 s **[2]**

(b) In winter the inlet water temperature drops to 5 °C, but the final temperature remains at 39 °C.

State and explain the change to the water flow rate for this shower in winter compared to summer.

$\Delta\theta$ is now 39 − 5 = 34 °C This is double so the flow rate must half to keep the same (input) power. **[2]**

34 A student makes an iterative model for the decay of charge on a capacitor. The time constant of the circuit is $RC = 10\,s$.

time lapsed / **s** t	**charge** Q **on capacitor** / **C** Q	**charge** ΔQ **leaving capacitor in time interval** $\Delta t = 1\,s$ / **C** $\Delta Q \approx \frac{Q\Delta t}{RC}$	**charge** Q **remaining after time interval** Δt / **C** $Q = (Q - \Delta Q)$
0	5	$\frac{5 \times 1}{10} = 0.5$	$5 - 0.5 = 4.5$
1	4.5	$\frac{4.5 \times 1}{10} = 0.45$	$4.5 - 0.45 = 4.05$

(a) Complete the numerical values in the two blank cells in the table. **[2]**

(b) **(i)** Explain the physics behind the approximation in the third column of the table $\Delta Q \approx \frac{Q\Delta t}{RC}$.

$\Delta Q = I\Delta t$ & $I = V/R$ ∴ $\Delta Q = V/R\ \Delta t$

also $V = Q/C$ ∴ $\Delta Q = Q/RC\ \Delta t$

[2]

(ii) State the assumption made in using this approximation and explain how its effect can be made insignificant.

During the time interval Δt it is assumed that Q does not change. If Q is constant then so is V and also I.

[2]

35 An asteroid is tracked from the Earth by radar pulses.
A pulse places it at a distance of 44.444 light-minutes from Earth.
After 24 hours a second pulse places it 44.204 light-minutes from Earth. $\Delta s = 0.24$ light min

(a) Use this data to calculate the average velocity of approach of the asteroid relative to Earth.

$$v = \frac{\Delta s}{\Delta t} = \frac{0.24 \times 3\times10^8 \times 60}{24 \times 60 \times 60} =$$

relative velocity = 5.0×10^4 m s^{-1} **[2]**

(b) The path of the asteroid is shown in **Fig. 36.1**. After 24 hours the angular shift in position of the asteroid relative to Earth is 1.8 mrad.

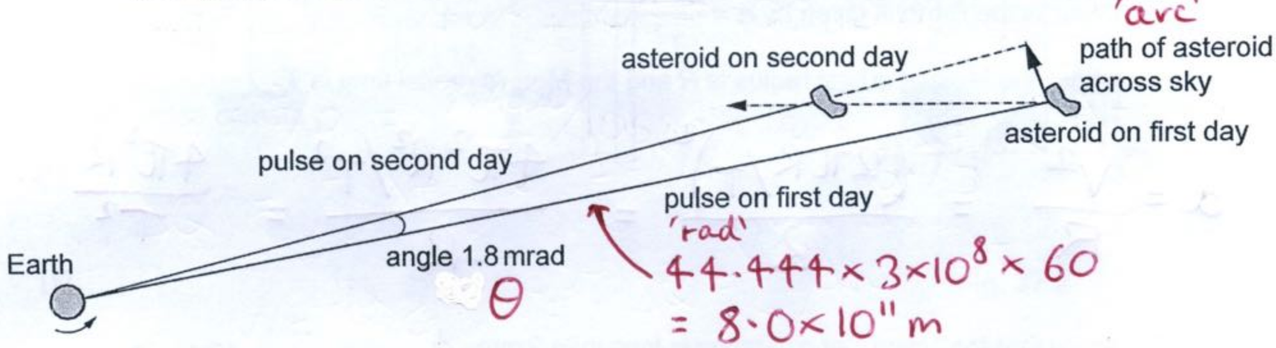


Fig. 36.1 (not to scale)

Estimate the velocity component of the asteroid perpendicular to its direction from Earth.
Make your method clear.

$$\theta = \frac{\text{arc}}{\text{rad}} \quad \therefore \quad \text{arc} = \theta \times \text{rad} = 1.8\times10^{-3} \times 8\times10^{11} = 1.44\times10^9\,\text{m}$$

$$v = \frac{\Delta s}{\Delta t} = \frac{1.44\times10^9}{24\times60\times60} =$$

perpendicular velocity = 1.67×10^4 m s^{-1} **[3]**

SECTION C

Answer **all** the questions.

36 The Moon is in circular orbit around Earth at constant speed.

(a) Explain why we describe the Moon as accelerating towards the Earth.

Acceleration is the rate of change of velocity and the velocity vector is constantly changing direction towards the Earth. **[2]**

(b) (i) Starting from the equation for circular motion show that the acceleration of the Moon towards the Earth is given by $a = \frac{4\pi^2 R}{T^2}$

where the Moon's orbital radius is R and the Moon's orbital time is T.

$$a = \frac{v^2}{R} = \frac{(2\pi R/T)^2}{R} = \frac{4\pi^2 R^2/T^2}{R} = \frac{4\pi^2 R}{T^2}$$

[1]

(ii) Show that the Moon's acceleration is less than $3\,\text{mm}\,\text{s}^{-2}$.

$R = 3.84 \times 10^8\,\text{m}$ $\quad T = 2.35 \times 10^6\,\text{s}$

$$a = \frac{4\pi^2 R}{T^2} = \frac{4\pi^2 \times 3.84 \times 10^8}{(2.35 \times 10^6)^2} = 2.7 \times 10^{-3}\,\text{ms}^{-2}$$

[1]

(iii) The Moon's orbital radius $R = 60 \times R_{\text{Earth}}$.
The gravitational acceleration at the Earth's surface $g = 9.8\,\text{m}\,\text{s}^{-2}$.
Calculate the acceleration due to the Earth's gravity at the Moon's orbit.
Compare this value to the value calculated in **(ii)**.

$g = \frac{-GM}{r^2}$ ∴ inverse square

$g_{moon} = g_{Earth}/60^2 =$

acceleration = 2.7×10^{-3} $\text{m}\,\text{s}^{-2}$

The values are the same **[3]**

37 A ball bearing of diameter 12 mm was dropped through a tube of glycerol (a viscous liquid). The tube was next to a millimetre scale as shown in **Fig. 37.1**. The ball bearing was dropped from rest at the surface of the liquid. It was filmed using a video camera.

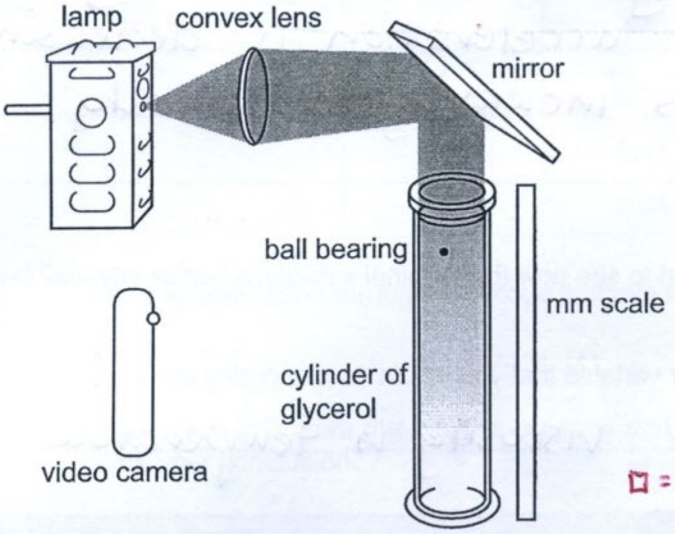


Fig. 37.1

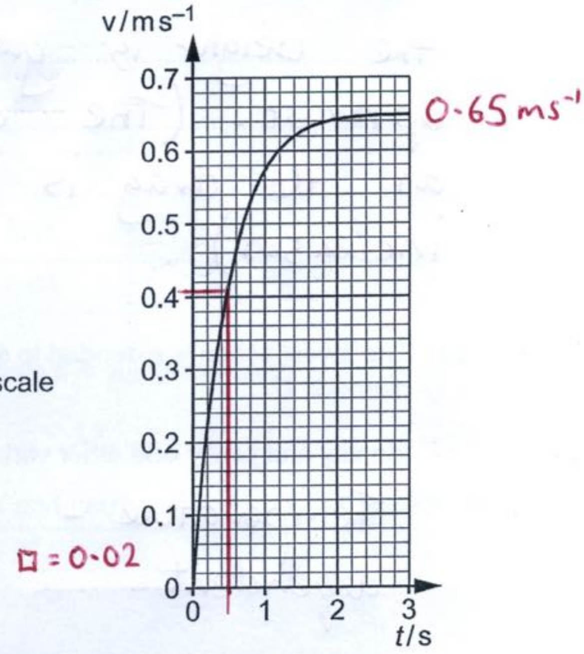


Fig. 37.2

(a) **Fig. 37.2** shows the graph of velocity against time obtained by analysing the video recording. This method has an uncertainty of about ± 3% for velocity measurement.

Use data from **Fig. 37.2** and the measurement precision to calculate the terminal velocity of the ball bearing and its absolute uncertainty.

$0.65 \times 0.03 = 0.0195$
$= 0.02$ 1s.f.

terminal velocity = 0.65 ± 0.02 m s^{-1} **[2]**

(b) Describe the motion shown in the graph at time $t = 0.5\,s$ and explain it by reference to the forces acting on the ball bearing.

The ball is accelerating downwards as the weight is greater than the drag + upthrust. (The acceleration is decreasing as the drag is increasing as velocity increases)

[2]

(c) (i) The investigation is extended to see how the terminal velocity v_T varies with ball bearing diameter D.

Identify and justify **one** other variable that you would control during this investigation.

Temperature - viscosity is temperature dependent.

[2]

also density of glycerol - it affects upthrust
viscosity " " - it affects drag
purity " " - it affects viscosity

density/mass of ball - they affect the weight

(ii) This table shows the data obtained in the extended investigation.

Diameter D /mm	**Terminal velocity v_T /m s^{-1}**
12.0	0.65
10.0	0.49
6.0	0.25
4.0	0.11
2.4	0.04

For a sphere falling through a viscous medium it is suggested that

$$v_T \propto D^2$$ $V_T = k D^2 \therefore \frac{V_T}{D^2} = \text{const}(k)$

Use data points from the table to propose and carry out a test of this relationship and state your conclusion.

proposal	working m/s/mm^2	conclusion
$V_T/D^2 = \text{const}$	$0.65/12^2 = 4.5\times10^{-3}$ $0.49/10^2 = 4.9\times10^{-3}$	These do not fit suggested relationship.
	$0.25/6^2 = 6.9\times10^{-3}$ $0.11/4^2 = 6.9\times10^{-3}$ $0.04/2.4^2 = 6.9\times10^{-3}$	$V_T \propto D^2$ for the smaller diameter balls at least to 2 sig fig.

[5]

or use $D^2/V_T = \text{const}$

38 **Fig. 38.1** shows a displacement *s* against time *t* graph for the motion of a swing in simple harmonic motion.

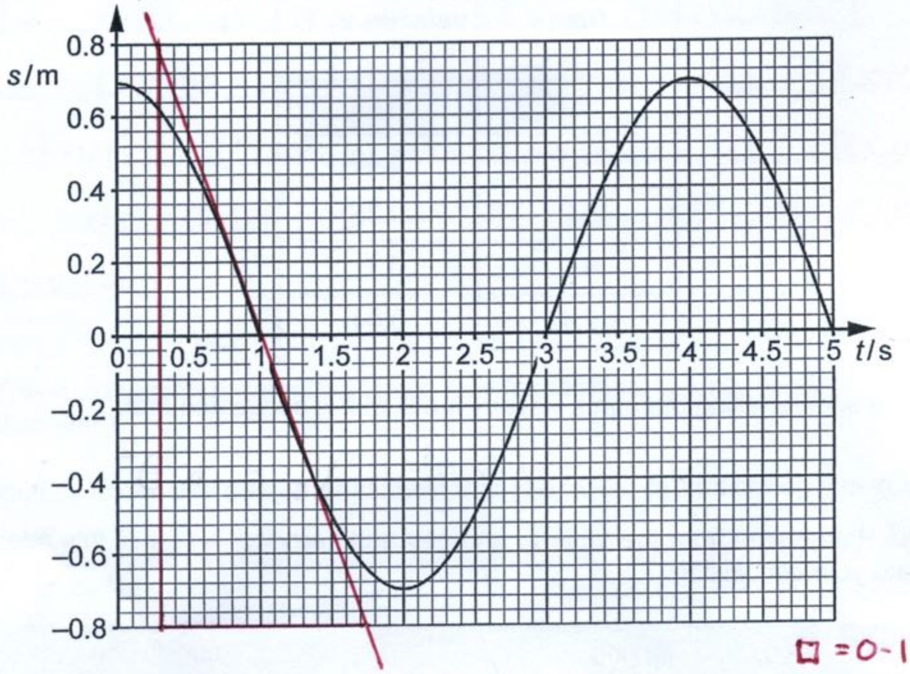


Fig. 38.1

(a) Use **Fig. 38.1** to find the magnitude of the maximum velocity of the swing.
Make your method clear.

$$V = \frac{\Delta s}{\Delta t} = \frac{1{\cdot}6\text{m}}{1{\cdot}75 - 0{\cdot}3} = 1{\cdot}1$$

velocity = 1·1 ms^{-1} **[2]**

OR $A = 0{\cdot}70\text{m}$ & $f = 0{\cdot}25\text{ Hz}$

$$V_{max} = A\omega = 0{\cdot}7 \times 0{\cdot}25 \times 2\pi$$
$$= 1{\cdot}1\text{ ms}^{-1}$$

(b) On **Fig. 38.2** scale the *y*-axis suitably and draw the velocity *v* against time *t* graph for this motion.

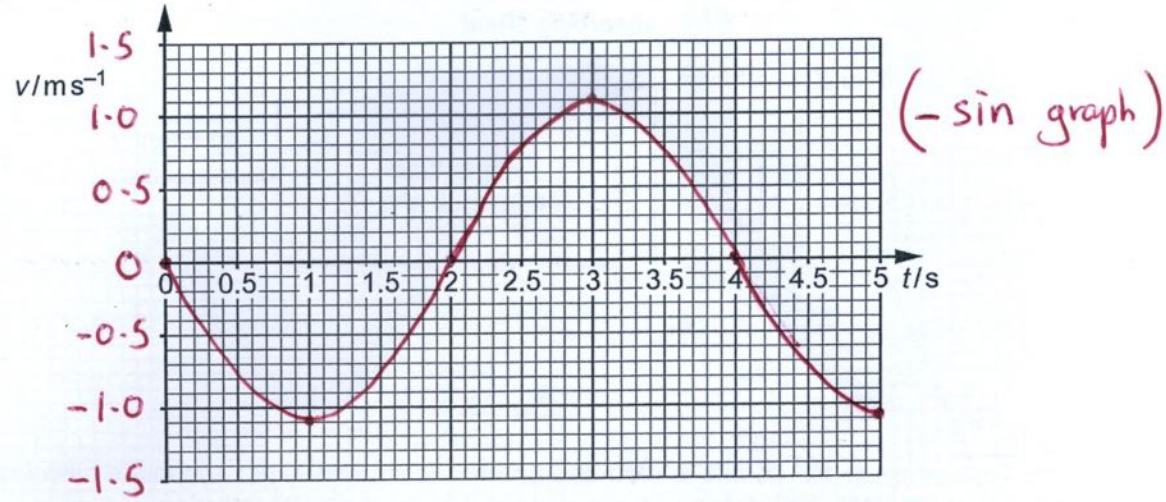


Fig. 38.2

[2]

(c) Show that the length of the simple pendulum having the same time period as the swing in **Fig. 38.1** is less than 4.0 m.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$\therefore T^2 = \frac{4\pi^2 L}{g}$$

$$\therefore L = \frac{T^2 g}{4\pi^2} = \frac{4^2 \times 9.8}{4\pi^2} = 3.97\,m$$

[2]

39 A class observes the absorption of α, β and γ radiation.
A Geiger tube is placed 1.0 cm from radioactive sources **X**, **Y** and **Z** as shown in **Fig. 39.1**.

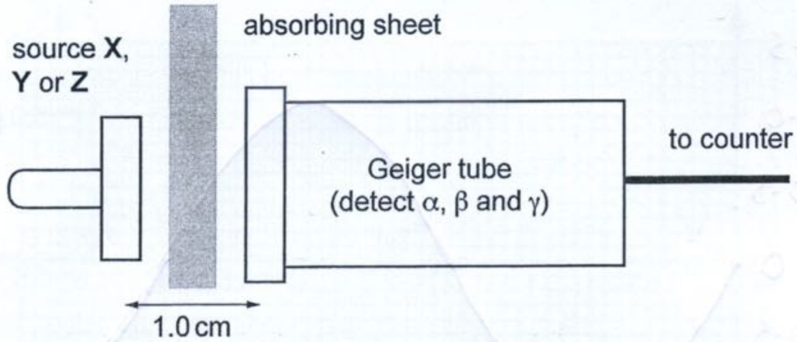


Fig. 39.1

The time to reach 10^4 counts is recorded and the count rate C per second is calculated with an uncertainty of ±1%. The data has been corrected for background radiation.

	count rate C / s^{-1}			
Absorbing material	**1.0 cm air** α + β + γ	**0.1 mm paper** (stops α) β + γ	**2 mm aluminium** (stops α + greatly reduces β) γ (+β)	**5 mm lead** (reduces γ stops α + β) γ
Source X	395	→ 397	↓ 22	background
Source Y	950	↓ 420	↓ 138	↓ 35 γ
Source Z	550	→ 547	↓ 238	↓ 27 γ

(a) One of the sources emits α, β and γ radiation,
one source emits β and γ
and one source emits pure β.

For each source below state which radiations are emitted. Justify your choices using data from the table.

X emits pure β justification there is no γ present as 5mm lead gives background count.

Y emits α, β, γ justification Large drop with 0.1mm paper so must have α

Z emits β, γ justification No α as no significant drop with 0.1mm paper but does have γ as count with 5mm of lead is not zero.

[3]

(b) A source emits α, β and γ radiation. The corrected count rate C from the source is plotted against distance R from a thin window Geiger tube as shown in **Fig. 39.2**.
Fig. 39.3 shows the same data in log/log graph form.

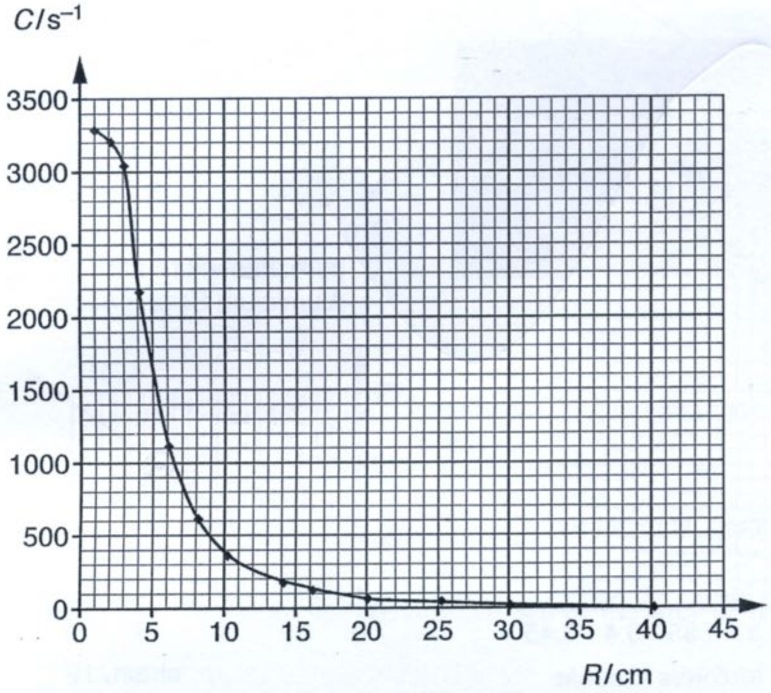


Fig. 39.2

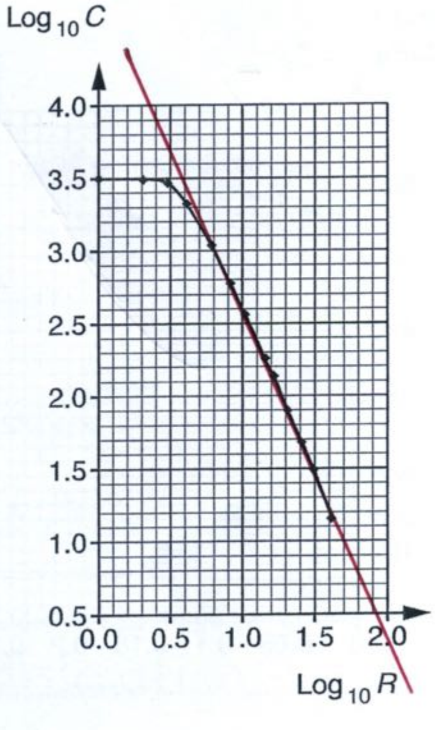


Fig. 39.3

(i) Calculate the gradient of the sloping part of the log/log graph in **Fig. 39.3**.

$\frac{\Delta \log C}{\Delta \log R} = \frac{-4.0 + 0.5}{1.9 - 0.35} = \frac{-3.5}{1.55} =$

gradient = -2.3 **[2]**

(ii) State whether the graph shows that the count rate C varies as $C \propto \frac{1}{R^2}$

and explain which radiation(s) α, β or γ might be responsible for such a variation.

$C = k/R^2$ gives $\log C = \log k - 2 \log R$
which is straight line $y = c - mx$
The gradient of -2.3 is close to -2 so
fit is OK but not exact. **[4]**

The $1/R^2$ is an inverse square law you would expect for γ comming from a point source.

40 This question compares the properties of pure aluminium with Aluminium Strong Alloy. **Fig. 40.1** and **Fig. 40.2** show stress against strain graphs for these metals. **Fig. 40.2** shows that both metals have the same initial elastic regions.

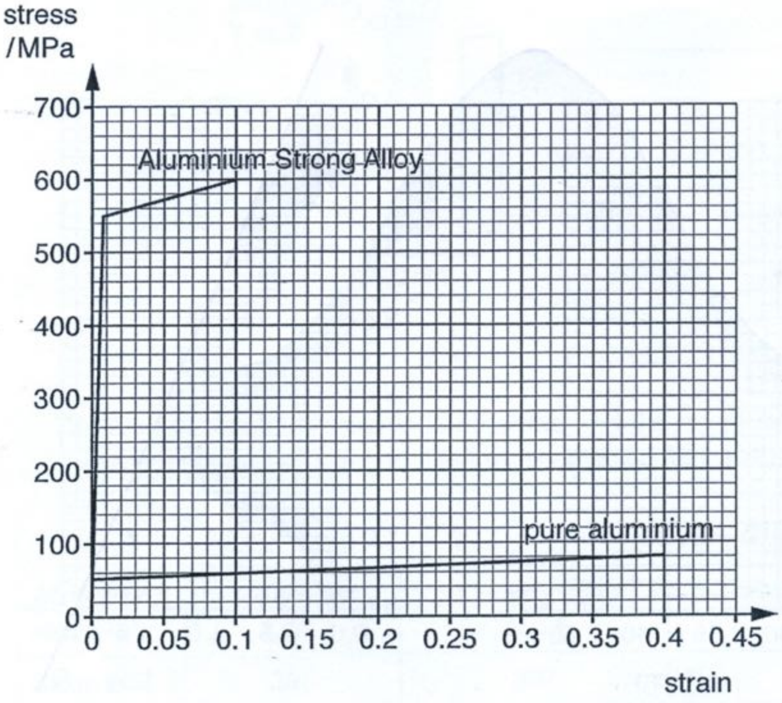


Fig. 40.1

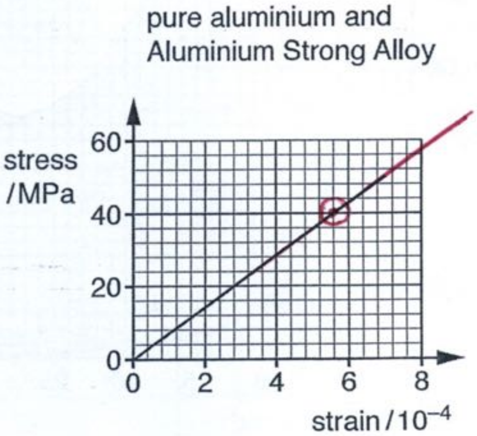


Fig. 40.2

(a) Calculate the Young modulus for the metals using data from **Fig. 40.2**.

$E = \frac{\text{stress}}{\text{strain}} = \frac{40\times10^{6}}{5.6\times10^{-4}}$

Young modulus = 7.14×10^{10} Pa **[1]**

(b) State and justify which of the metals you would use for the crumple zone of a car.

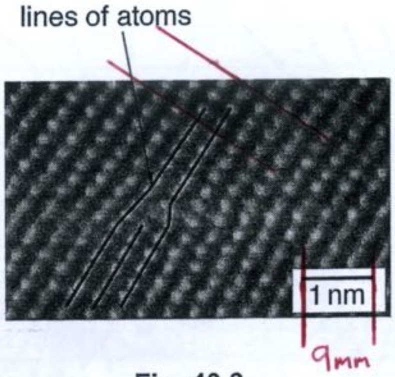
The strong alloy as it is stronger and absorbs more energy on deformation. (W = Fs)

[2]

→

	Elastic	Plastic
Aluminium	Bonding	
Strong Alloy	and Structures	

(c) **Fig. 40.3** shows a TEM (transmission electron microscope) image of atoms in a metal with a scale marker of 1 nm.



roughly 4 atoms in 1 nm (1×10^{-9} m)

Fig. 40.3

(i) Use the **Fig. 40.3** to estimate the diameter of a metal atom.

$1 \times 10^{-9}/4$ =

diameter = 2.5×10^{-10} m **[2]**

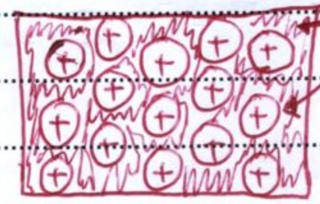
(ii) Name the feature represented by the lines of atoms added to the image.

name of structure dislocation **[1]**

(d)* Use ideas about bonding and structures in pure metals and alloys to explain the similarities and differences in elastic and plastic properties of aluminium and its strong alloy shown in **Fig. 40.1**.

Metals and alloys exhibit metallic bonding:

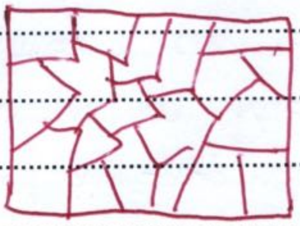
Ions can be pulled further apart elastically.



Sea of mobile electrons

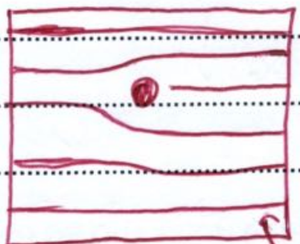
Lattice of regular layers of positive ions bonded be negative electrons.

Crystals can slide past each other plastically



Microcrystalline structure showing individual crystals in different orientations

Dislocations can move easily in pure metal giving low yield stress. Impurity atoms stop this giving high yield stress.



Dislocation pinned by impurity atom ● in alloy but not in pure metal.

layers of ions

[6]

41 **Fig. 41.1** shows the electric field pattern near two protons and **Fig. 41.2** the electric field pattern near a proton and an electron.

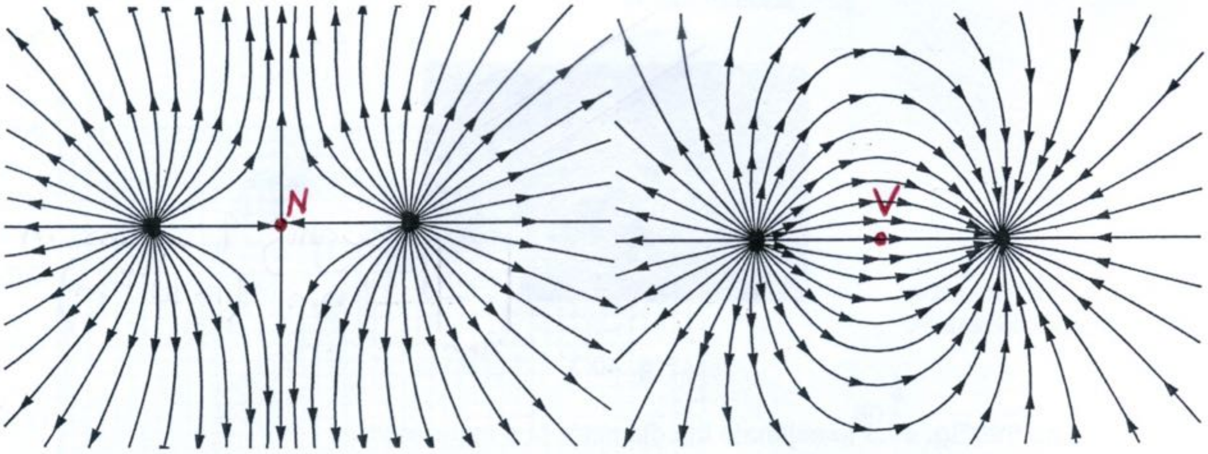


Fig. 41.1 **Fig. 41.2**

(a) On the appropriate figure(s) mark a point **• N** where the electric field is zero and a point **• V** where the electric potential is zero. **[2]**

(b) On each of **Fig. 41.1** and **41.2** draw **three** complete equipotential lines. **[2]**

(c) **Fig. 41.2** can also represent two spherical charge distributions of +1 C and –1 C situated 1 km apart.

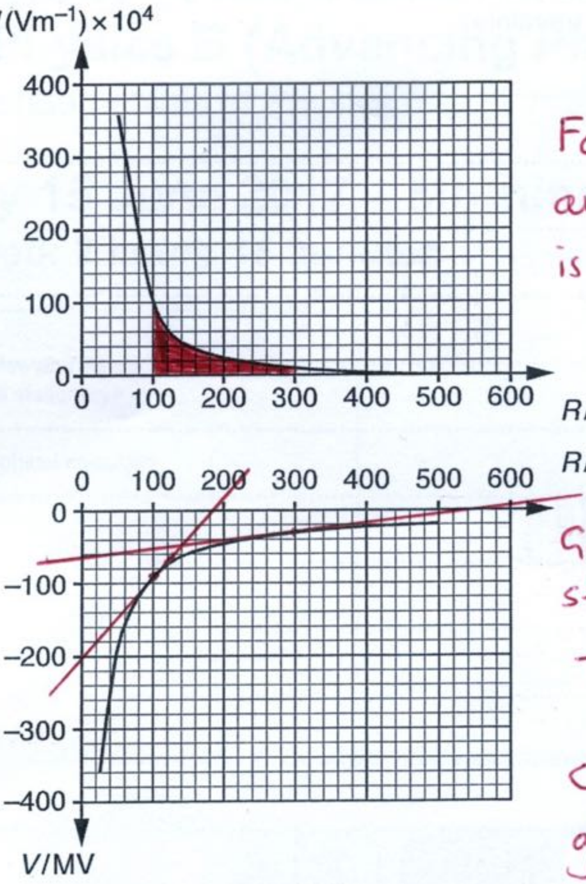
Calculate the electric field midway between the charge centres, at 500 m from each.

For single charge $E = \frac{kQ}{r^2}$ so for 2 the same $E = \frac{2kQ}{r^2}$

$E = \frac{2 \times 9 \times 10^9 \times 1}{500^2} =$

electric field = 7.2×10^4 V m^{-1} **[2]**

(d)* **Fig. 41.3** shows the electrical potential V and the magnitude of the electric field E against distance R for an isolated –1 C charge.



For 1C charge area under graph is change in potential $g\Delta R = \Delta V_{grav}$

Gradient is field strength. $-\Delta V_{grav}/\Delta R = g$

Change in gradient gives change in field strength.

Fig. 41.3

By considering a unit positive charge being moved from R = 100 m to 300 m explain the relationship between the electric field and the electric potential.
You may annotate the graphs in **Fig. 41.3** if it is helpful.

As the +1C charge is moved from 100m to 300m work is done W=Fs. The force F = Efield as the charge is 1C. The area under the graph gives the work done and ΔV as Q=1C. The potential increases as the force is attractive. The gradient of the V-R graph indicates the field strength - in a stronger field more energy / potential is transferred per unit distance as the force is greater.

.... **[6]**

END OF QUESTION PAPER