Casio fx-4113

Registration Number 0352624

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NATIONAL JUNIOR COLLEGE
JC 2 TERM 2 COMMON TEST

PHYSICS — **9248**

Tuesday — 23 March 2004 — 1 hour 40 min

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Write your **name** and **registration number** in the spaces at the top of this page.

Section B [80 marks]

Answer **ALL** questions.

You are given **1 hour 40 minutes** to complete this paper.

Write your answers in the **spaces provided on the question paper.**

For numerical answers, **all working should be shown.**

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

FOR EXAMINER'S USE	
Section A	
1 to 25 Subtotal	38 / 50

FOR EXAMINER'S USE	
Section B	
Qn	**Marks**
1	6
2	5+2
3	3
4	4
5	6
6	8
7	5+1+2+3
Subtotal	45 / 80

Total : 83 / 1300

This section consists of 16 printed pages including this cover page.

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	μ_0	$= 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	ϵ_0	$= 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$ $\approx (1/(36\pi)) \times 10^{-9}\ \mathrm{F\,m^{-1}}$
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	$= 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	R	$= 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	N_A	$= 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
the Boltzmann constant,	k	$= 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
gravitational constant,	G	$= 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
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,	$W = p\Delta V$
gravitational potential,	$\phi = -Gm/r$
refractive index,	$n = 1/\sin C$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = Q/4\pi\epsilon_0 r$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
energy of charged capacitor,	$W = \frac{1}{2}QV$
alternating current/voltage,	$x = x_0 \sin \omega t$
hydrostatic pressure,	$p = \rho gh$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = 3H_0^2/8\pi G$
equation of continuity,	$Av = \text{constant}$
Bernoulli equation (simplified),	$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$
Stokes' law,	$F = Ar\eta v$
Reynolds' number,	$R_e = \rho vr/\eta$
drag force in turbulent flow,	$F = Br^2\rho v^2$

$\frac{1}{2}mv$

$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}nRT$

$\langle c^2\rangle = \frac{3nRT}{m}$

$=$

Answer all the questions.
(You are advised to spend not more than 1 hr 15 min for questions 1 to 6.)

1 **(a)** What is meant by an *isothermal process*? Describe how an isothermal process can be achieved in practice. [2]

An isothermal process occurs when there is no change in temperature when work is done, therefore no change in internal energy.

$\Delta T = 0$
$\Delta U = 0$
$q = -w$

Isothermal process can be achieved by pushing the piston very slowly and using poor heat conductors for the gas container.

good thermal conductors

$V_I = 2\times10^{-4}$
$n = 1$
$p = 10^5 Pa$
$T_I = 300K$
$T_f = 600K$
$V_f = V_1$

(b) A cylinder fitted with a frictionless piston contains an initial volume of 2.00 x 10^{-4} m^3 of a fixed mass of monatomic ideal gas at a pressure of 1.00 x 10^5 Pa and a temperature of 300 K. The gas is heated at constant pressure under process α to a temperature of 600 K and a volume V_1, and then cooled at constant volume under process β to the original temperature of 300 K and pressure P_2.

isobaric

(i) Determine the values of V_1 and P_2. [2]

$\Delta U = q + w$

$pV = nRT$

$V_1 = \frac{(1)(8.31)(600)}{1.00\times10^5}$

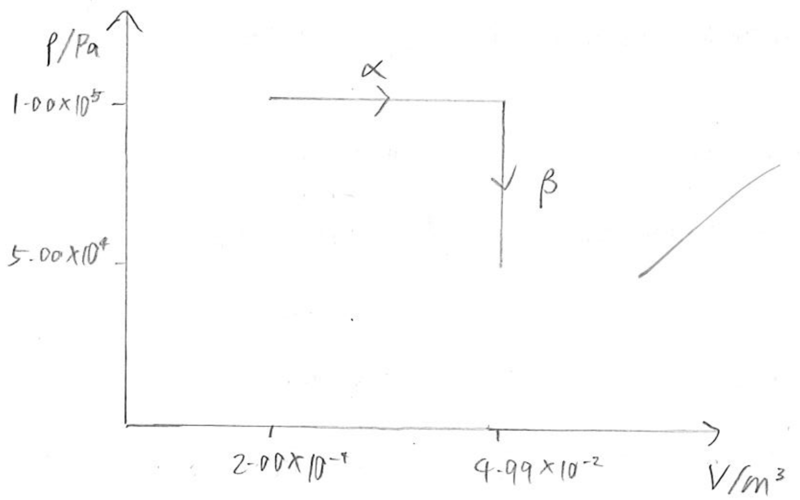
$= 4.99 \times 10^{-2}\ m^3$ (3s.f) 10^{-4}

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$P_2 = \frac{(300)(1.00\times10^5)}{600}$

$= 5.00\times10^4$ Pa (3s.f)

(ii) Illustrate these changes on a *p-V* diagram labelled with the appropriate values of pressure and volume. [2]



2

$pV = nRT$

1 (b) (iii) Determine how much heat is being extracted from the gas under process β. [2]

$\Delta U = q + w$

$\Delta U = \frac{3}{2}(P_f V_f - P_i V_i)$

Since $\Delta V = 0$, $W = 0$,

$= -30\,J$

$\therefore \Delta U = q$

$q = \Delta U = -30\,J$

~~$q = (\frac{3}{2})(1)(8.31)$~~ Heat extracted $= (\frac{3}{2})(8.31)(600 - 300)$

$=$

Amount of heat extracted $= 30\,J$

(iv) Determine the ratio $\frac{c_1}{c_2}$, where c_1 represents the root mean square speed of the gas molecules at the start of process β and c_2 represents the root mean square speed of the gas molecules at the end of process β. [2]

$C_{rms} = \sqrt{\frac{3RT}{M_m}}$

$C_{rms} \propto \sqrt{T}$

$\frac{C_1}{C_2} = \frac{\sqrt{600}}{\sqrt{300}}$

$= \sqrt{2}$

$= 1.41$ (3 s.f)

2

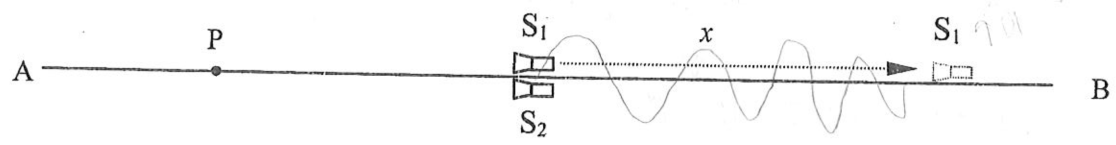
2 (a) When two waves of the same wavelength and frequency meet at the same point, they may interfere constructively or destructively. Explain what is meant by *constructive* interference and *destructive* interference. [2]

Constructive interference occurs when the phase difference of the wave is 0. The ~~amplitudes of the waves are in the same direction~~ direction of displacement are the same and reinforce each other. The amplitude of the resultant wave is twice that of incident waves of same frequency and wavelength.

Destructive interference occurs when phase difference of two waves with the same frequency and wavelength is π. The ~~amplitudes of waves the waves~~ directions of displacement are opposite and cause the waves to cancel each other out.

superimposed to produce min or zero amplitude

2 (b)



The diagram shows two sources of sound, S_1 and S_2 which are close together. They emit sound waves which are in phase, and of the same wavelength and intensity.
Two observations were made:

1. When S_1 is slowly moved parallel to AB in the direction of B, the sound intensity, I, detected at P shows a series of maxima and minima.
2. As the displacement, x, of S_1 from its initial position increases, the intensities of the maxima decrease and the intensities of the minima increase.

(i) Explain the first observation. [2]

$$\frac{\Delta x}{\lambda} = \frac{\Delta \phi}{2\pi}$$

When S_1 and S_2 are a certain distance apart, the waves they emit are in phase or out of phase depending on the distance S_1 and S_2 are away from each other. When they are in phase the sound intensity is maximum as constructive interference occurs. When they are π out of phase, destructive interference occurs the the waves cancel out, resulting in minimum sound intensity.

2

(ii) Sketch a graph of I vs x taking into account for both observations. [1]

2 (b) (iii) Explain

(1) why the greatest observed value of I occurs when x is zero, and [2]

When x is 0, the sources are in phase and hence constrictive interference occurs and I is maximum. Since both sources are closest to P, ~~minimal~~ smaller damping occurs ~~compares~~ than when x is larger and I of resultant sound is highest.

/

?

when $x=0$, $\Delta\phi_P$ at P due to 2 waves S_1P & S_2P are 0.
$\therefore$ 2 waves in phase. Constractive interferences occurs. I greatest
As for other x at which waves meet in phrase at P, amplitude of S_1 $<$ with distance

(2) why I becomes constant when x is very large. [1]

When x is very large, all sound from S_1 is damped completely and resulant amplitude is equal to that of S_2.

At very large distance, amplitude of S_1 would have dropped/decreased significantly ($I \propto \frac{1}{r^2}$, $I \propto A^2$)
$\therefore$ I received at P mostly due to S_2 only. Hence I becomes a constant.

(iv) If the wavelength of the sound used is 1.7 m, for what value of x will the 4th minimum be detected at P? [2]

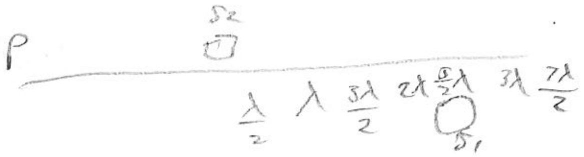
$\cancel{x_n = \frac{n\lambda D}{a}}$ $\quad$ $x = 1.7 \times 4$

$\qquad = 6.8 m$ $\qquad$ 0

$\cancel{= (4)(1.7)(}$

$\lambda = 1.7 m$

At 4th min, $\Delta\phi_P = \frac{7}{2}\lambda$



$= x$

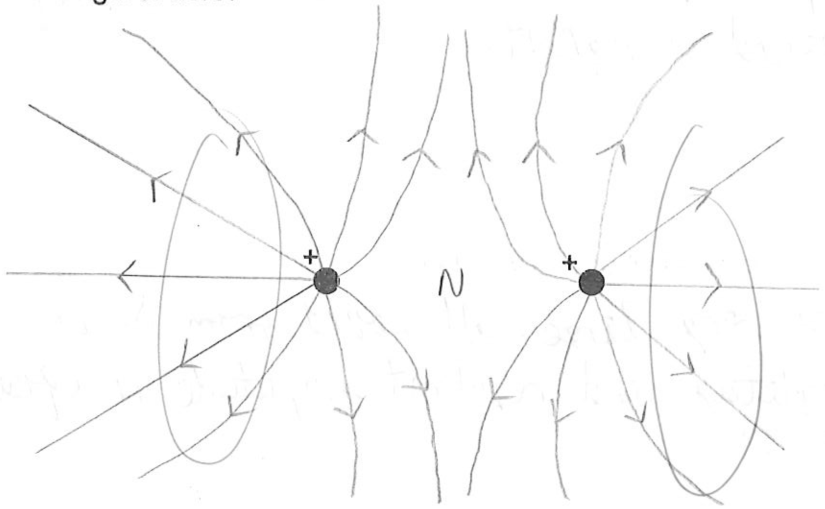
$x = 3.5 \times 1.7$

$= 5.95 m$

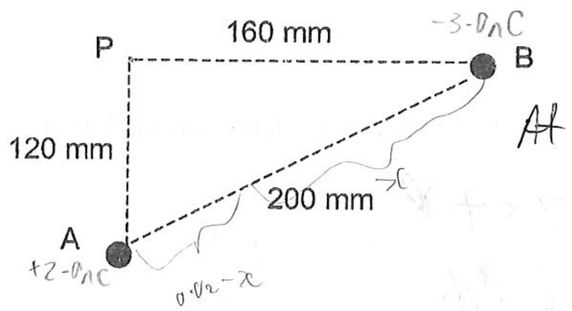
3 (a) (i) Define electric field strength at a point. [1]

Electric field strength at a point is the electric force acting exerted on a unit positive charge placed at that point.

(ii) Complete the diagram below to show the electric field lines in the region around two equal positive charges. Mark with a letter "**N**" the position of any point where the field strength is zero. [2]



(b) Point charges A, of +2.0 nC, and B, of -3.0 nC, are 200 mm apart in a vacuum, as shown by the figure. The point P is 120 mm from A and 160 mm from B.
Calculate the resultant electric field strength at P. [4]



$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

At P, $E_A = \frac{2.0\times10^{-9}}{4\pi(8.85\times10^{-12})(0.012)^2}$ 0.12

$= \cancel{1498.63}\ \cancel{11}\ 1500\ NC^{-1}$

$E_B = \frac{-3.0\times10^{-9}}{4\pi(8.85\times10^{-12})(0.016)^2}$ 0.16²

$= -1690\ NC^{-1}$

Resultant $|E| = \sqrt{(1499)^2 + (-1686)^2}$

$= 2260\ NC^{-1}$ (3 s.f)

$1630\ Vm^{-1}$

$\tan\theta = \frac{E_A}{E_B}$

$\theta = 49.8°$

3 (c) (i) Explain why there is a point X on the line AB in part **(b)** at which the electric potential is zero. [1]

~~A test charge placed at x will not experience a resultant force, since $|E|$ from both sources cancel out each other.~~

Potential due to + charge A & − charge B. Thus, there is pt x on line at which electric potential is 0

0

(ii) Calculate the distance of the point X from A. [2]

$$\frac{2.0\times10^{-9}}{4\pi\varepsilon_0 x} + \frac{3.0\times10^{-9}}{4\pi\varepsilon_0(0.02-x)} = 0$$

$$\frac{2.0\times10^{-9}}{4\pi\varepsilon_0 x^2} = \frac{3.0\times10^{-9}}{4\pi\varepsilon_0(0.02-x)^2}$$

$$\frac{(0.02-x)^2}{x^2} = \frac{3.0\times10^{-9}}{2.0\times10^{-9}}$$

$$\frac{0.02-x}{x} = \sqrt{\frac{3}{2}}$$

$$0.02-x = \sqrt{\frac{3}{2}}\,x$$

$$\sqrt{\frac{3}{2}}\,x + x = 0.02$$

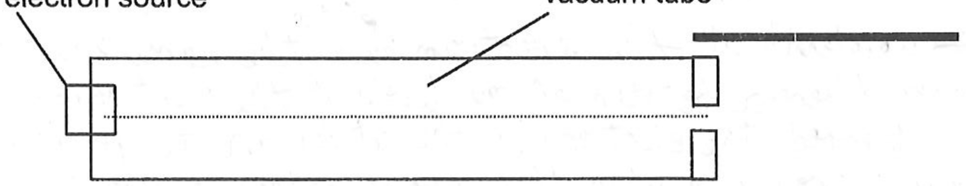
$$x = \cancel{8.98} \; 8.99\times10^{-3}\ \text{m (3 s.f)}$$

0

4 A beam of electrons is emitted from a source. They are accelerated from rest through a potential difference of 500 V in a vacuum tube as shown below.

$E = (1.6\times10^{-19}C)(500)$ $qE = V$

eV



(a) Calculate the velocity of the electron, v when it just emerges from the tube. [2]

~~Velocity = 500V~~

WD by field = ↑ in KE of e

$$KE = (1.6\times10^{-19})(500)$$
$$= 8.00\times10^{-17}\ \text{J}$$
$$\tfrac{1}{2}mv^2 = 8.00\times10^{-17}$$
$$v = \sqrt{\frac{2\times8.00\times10^{-17}}{9.11\times10^{-31}}}$$
$$= 1.33\times10^{7}\ \text{ms}^{-1}\ \text{(3 s.f)}$$

4 **(b)** The electrons emerge from the tube into a region of upward directed uniform electric field, E of 1.00 x 10^4 NC^{-1}. A magnetic field is applied in the region to enable the electron to continue to move horizontally. Determine the magnitude and direction of the smallest uniform magnetic field that will cause the electron to continue to move horizontally? [3]

$F = 1.00 \times 10^4 \times 1.60 \times 10^{-19}$

$= 1.60 \times 10^{-15} N$ (3 s.f)

$F = Bqv \sin\theta$

$B = \frac{F}{qv} = \frac{1.60 \times 10^{-15}}{1.60 \times 10^{-19} \times 1.33 \times 10^7} = \cancel{7.54}\ 7.55 \times 10^{-4}$ T (3 s.f)

2

The magnetic field must point outwards. ?

out of the plane of the paper

(c) The source is replaced by one emitting protons. Describe and explain how the path of the proton would differ, if any, through this combination of fields. [3]

The proton will move in the same direction as the forces exerted by the electric and magnetic field will both ~~reverse cause it to move in direction opposite to electron.~~ reverse in direction.

- $m_p > m_e$ – $V_p < V_e$ upon entering cross field region
- magentic force will be smaller $F_B = qvB$
- electric force ($F_E = qE$) remain unchanged
- thus resulting in proton deflecting upward

5 White light is shone through atoms in a cool vapour. The light which emerges is found to have the continuous spectrum of white light, but with dark lines crossing the spectrum.

(a) State briefly how the dark lines are caused, and what happens to the atoms in the process. [2]

The ~~the d~~ dark lines occur as the ~~wavelengths~~ of light in ~~that spectrum~~ wavelength of the spectrum photons have the same energy as the energy difference between energy levels of the electrons of the atoms and are absorbed. The electrons in the atoms are temporarily excited to a higher energy level when they absorb photons of suitable energy. ~~and wavelength~~

(b) The wavelengths of the most prominent dark lines are 657 nm and 423 nm. Find the photon energy corresponding to these wavelengths. [2]

$E = hf$

$= \frac{hc}{\lambda}$

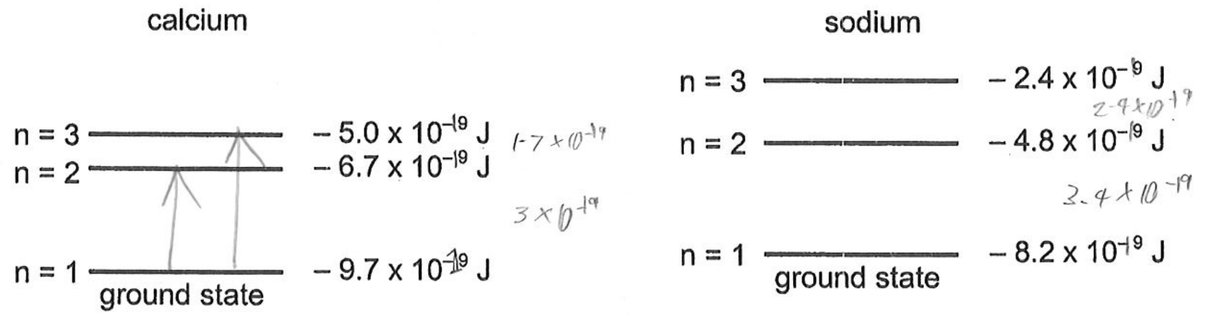
Energy $= \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{657 \times 10^{-9}}$

$= 3.03 \times 10^{-19}$ J (3 s.f)

Energy $= \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{423 \times 10^{-9}}$

$= 4.70 \times 10^{-19}$ J (3 s.f)

5 **(c)** The vapour is known to consist of calcium atoms only **or** sodium atoms only **or** mixture of calcium and sodium atoms. Simplified energy level diagrams for the two types of atoms are given below.



By considering transitions between levels within each atom, decide whether calcium atoms only **or** sodium atoms only **or** mixture of calcium and sodium atoms are likely to be present. Indicate on the above energy level diagrams, the transitions that give rise to the two dark lines described in part **(b)**. [3]

~~A mixture of~~ calcium ~~and sodium~~ atoms are likely to be present since the energy differences of $n=1$ and $n=2$ of 3×10^{-19} J and energy difference of $n=1$ and $n=3$ of 4.7×10^{-19} J correspond to photons of same energy absorbed.

2

(d) A beam of electrons is directed at the sodium vapour to excite the sodium atoms. Determine whether if the bombarding electrons are able to cause ionisation from the ground state if they have a de Broglie wavelength of 1.5×10^{-10} m. [3]

$IE = E_\infty - E_1$

$= 8.2\times10^{-19}$ J

$E = \frac{\lambda}{p}$

$\lambda = \frac{h}{p}$

$= \frac{1.5\times10^{-10}}{\cancel{9.31\times10}(9.11\times10^{-31})(3\times10^{8})}$

$p = \frac{h}{\lambda}$

$= 5.49\times10^{-41}$ J

$= 4.42\times10^{-24}$

$E_k =$

The energy of the electrons are different from the energy ~~of~~ ~~levels~~ difference ~~between~~ the different energy levels, hence they cannot cause ionisation from ground state.

0

(e) Would you expect the bombarding electrons in part **(d)** to be diffracted by crystals in which the atom spacing is 0.20 nm? Explain your answer. [2]

$0.20\,nm = 0.20\times10^{-9}$ m $\quad 2.0\times10^{-10}$ m

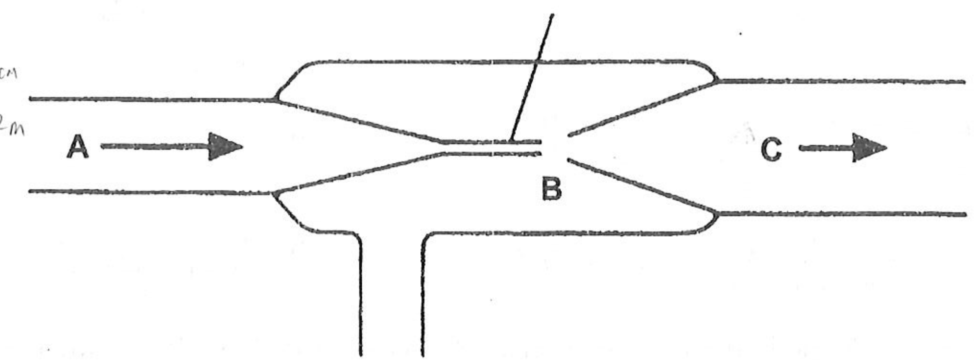
No. The atom spacing is to ~~narrow~~ wide for diffraction to occur. For diffraction to occur, spacing must be approximately equal to wavelength.

Atom spacing is comparable to de Broglie wavelength of electron ∴ diffraction significant.

6 **(a)** The figure below shows a cross-section through a simple laboratory filter pump.

2 mm

0.002 m



The pressure at **B** is 45 kPa. The nozzle has a diameter of 2.0 mm.
The pressure at **C** is atmospheric pressure (100 kPa) and the water at **C** is moving **very slowly**.
[Density of water is 1000 kg m^{-3}]

(i) Explain how a flow of water from **A** to **C** through the pump produces a partial vacuum at **B**. [3]

speed of water at B is much faster than A & C

By Bernoulli's eq, P in & around B will be ↓ atmospheric P, create partial vacuum at B.

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$

$A_1 V_1 = A_2 V_2$

The cross-sectional area of C is wider than B. This causes the velocity of water at C to be lower than B. When velocity is low, pressure is high. The low velocity of water at C compared to B causes the pressure at C to be ~~lower~~ higher than pressure at B, creating a partial vacuum at B.

(ii) Water can be considered as an ideal, incompressible fluid and the flow in part **(i)** is laminar, non-viscous and horizontal. Calculate the velocity of the water emerging from the nozzle at **B**. State any **other** assumptions made in your working. [3]

~~$A_B V_B = A_C V_C$~~

~~$\pi\left(\frac{2\times10^{-3}}{2}\right)^2 V$~~

$P_B + \frac{1}{2}\rho V_B^2 = P_C + \frac{1}{2}\rho V_C^2$

$45\times10^3 + \frac{1}{2}(1000)V_B^2 = 100\times10^3$

$V_B^2 = \frac{100000 - 45000}{\frac{1}{2}(1000)}$

$V_B = 10.5 \text{ ms}^{-1}$ (3s.f)

All water from B enters C

Assumption: Velocity of water in C is 0 ms^{-1}

~~Assumption: Same mass of water emerging from B and going through C is same.~~

(iii) Calculate the rate, in m^3 s^{-1}, at which water flows through the pump. [1]

Rate $= 10.49 \times \pi(0.002)^2$

$= 1.32\times10^{-4} \text{ m}^3\text{s}^{-1}$ (3s.f)

AV

$\frac{\pi}{4}(2\times10^{-3})^2(10.5)$

$= 3.3\times10^{-5} \text{ m}^3\text{s}^{-1}$

6 (b) The drag force F on an object of mass 0.50 kg falling with velocity v through a viscous fluid under turbulent conditions is given by

$$F = kv^2$$

where k is a constant having the value 36 N m^{-2} s^2.

(i) Explain what is meant by *turbulent conditions*. [1]

The flow is not laminar and paths of fluid particles cross each other.

The streamlines (or layers) of fluid around the object is irregular (unsteady, non-laminar, whirlpool etc.)

(ii) Calculate the acceleration of the object when it is falling with velocity 0.20 m s^{-1}. [2]

$F_R = ma$

$F_R = W - U$

$= (0.50)(9.81) - (36)(0.20)^2$

$= 3.465\,N$

$a = \frac{F}{m}$

$= \frac{3.465}{0.50}$

$= 6.93\ ms^{-1}$ (3s.f)

2

$F_{net} = ma$

$mg - kv^2 = ma$

$a = g - \frac{kv^2}{m}$

$= 9.81 - \frac{(36)(0.20)^2}{0.50}$

$= 6.93\ ms^{-2}$

7 Read the following passage and then answer the questions that follow.
(You are advised to spend 25 min on this question.)

Nuclear fusion is the joining together, or 'fusing', of the nuclei of light atoms to make nuclei of heavier atoms. There are many possible reactions, but one, which is the subject of extensive research for peaceful power production, is:

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

$^{2}_{1}H$ is an isotope of hydrogen, called deuterium, and occurs naturally in the hydrogen in sea water, though only to the extent of 1 part in 45 000. $^{3}_{1}H$ is another isotope of hydrogen called tritium. This is too rare to be extracted from natural hydrogen, but can be made by bombarding lithium-6 with neutrons:

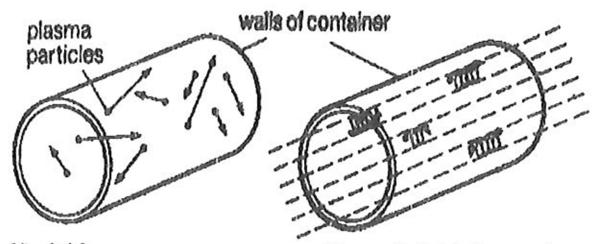
$$^{6}_{3}Li + ^{0}_{1}n \rightarrow ^{3}_{1}H + ^{4}_{2}He \text{ ----------(2)}$$

The neutrons to bombard the lithium could be provided by the fusion reaction once it has been started, so the basic fuels would be deuterium and lithium. Enough of these are available to give ample energy for millions of years! Another advantage is that none of the final products is radioactive, although tritium is mildly radioactive, with a half-life of 12.4 years.

Unfortunately there are many very difficult engineering problems to be solved before getting any useful energy. The main difficulty is that nuclei of any atoms are positively charged and repel each other very strongly, and so have to be travelling at enormous speeds before they collide strongly enough for the short range "strong nuclear force' to make them fuse.

If the nuclei were at an extremely high temperature, say 1 x 10^9 K, the collisions between them would cause enough nuclei to fuse to provide enough energy to maintain the high temperature and give out useful extra energy.

At this temperature the gas cannot be contained by any known material! Instead it has to be kept from touching the walls of the container by using a magnetic field. The particles of a gas at this temperature consist of electrons and nuclei separated from each other, properly called a plasma, and these charged particles moving at high speed are deflected by the magnetic field as shown in the diagrams.



No field *Magnetic field along axis*

Data		
Charge on electron,	e =	1.6×10^{-19} C
For nucleus at absolute temperature T,	KE =	kT
Boltzmann's constant,	k =	1.38×10^{-23} JK^{-1}
Radius of a deuterium nucleus	=	1.64×10^{-15} m
Radius of tritium nucleus	=	1.87×10^{-15} m
Mass of $^{6}_{3}Li$	=	6.017034 u

(a) Explain how equation (1) demonstrates the conservation of both nucleon number and charge.[2]

~~Atom~~ Total number of nucleons of particles on either side are the same. Proton number is also conserved.

M O

Nucleon no before & after reaction is 5

Charge before & after reaction is +2.

(b) By considering deuterium nucleus and tritium nucleus as charged spheres, calculate the minimum energy in MeV required to overcome their coulomb barrier and come in contact with each other. [3]

D nucleus = +e

T nucleus = +e

$r_1 = 1.64 \times 10^{-15}$ m

$r_2 = 1.87 \times 10^{-15}$ m

$x = r_1 + r_2 = 3.51 \times 10^{-15}$ m

Min energy $= \frac{Q_1 Q_2}{4\pi\varepsilon_0 x}$

$= \frac{(1.6\times10^{-19})(1.6\times10^{-19})}{4\pi(8.85\times10^{-12})(3.51\times10^{-15})} = 6.558\times10^{-14}$ J $= 0.410$ MeV

0

(c) Estimate the speed of a lithium nucleus at 1.0×10^{9} K. [2]

$\frac{1}{2}mv^2 = kT$ ~~Speed =~~ $KE = 1.38\times10^{-23} \times 1.0\times10^{9}$

$= 1.38\times10^{-14}$ J

$\frac{1}{2}mv^2 = 1.38\times10^{-14}$

$v = \sqrt{\frac{2\times1.38\times10^{-14}}{6.017034\times1.66\times10^{-27}}} = 1.66\times10^{6}$ ms^{-1} (3s.f.)

$KE = \frac{3}{2n}RT$

$= \frac{3}{2}NkT = \frac{1}{2}kT$

(d) (i) Define half-life for a radioactive substance. [1]

Half-life of a radioactive substance refers to the time taken for half the nuclei in the substance to decay.

of a radioactive element

1

(ii) Calculate the decay constant of tritium. [2]

$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

$= \frac{\ln 2}{12.4\times365\times24\times3600}$

$= 1.77\times10^{-9}$ s^{-1} (3s.f.)

2

(iii) If the initial number of tritium atoms is 5.0 x 10^{30}, calculate the number of atoms that would have decayed in 10 years. [2]

$N = N_0 e^{-\lambda t}$

$= (5.0 \times 10^{30})(e^{(-1.77\times10^{-9})(10\times365\times24\times3600)})$

$= 2.86 \times 10^{30}$ (3 s.f)

$5.0\times10^{30} - 2.86\times10^{30} = 2.14\times10^{30}$

(e) Describe the path taken by a nucleus in the magnetic field if it is travelling:

(i) along the field, [1]

Straight line.

No change in path as no magnetic force is experienced.

(ii) perpendicular to the field, and [1]

It will travel in a circle.

circular path

(iii) at other angles to the field [1]

It will travel in a helical path.

(f) Calculate the magnetic flux density of the magnetic field needed to keep a lithium nucleus contained within a diameter of 0.20 m. [3]

$T = BqV$

$=$

$F_B = \frac{mv^2}{r}$

$Bqv = \frac{mv^2}{r}$

$B = \frac{mv}{qr}$

$= \frac{(6\times1.66\times10^{-27})(1.66\times10^{6})}{(3\times1.6\times10^{-19})(\frac{0.2}{2})}$

$= 0.348\ T$

(g) What is meant by the term "plasma"? [1]

A gas consisting of electrons and nuclei separated from each other.

gas at ↑ T that has e separated from nucleus

(h) If the plasma is prevented from touching walls of the container, why will the container still get very hot? [1]

No. Since the gas ~~mole~~ particles does not bombard the walls of the container, they will not transfer any of their kinetic energy to the molecules of the walls, hence the walls do not become very hot.

transmitted by radiation

-- END --