M18/4/PHYSI/SP2/ENG/TZ1/XX

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Jamie

Thursday 10 May 2018 (afternoon)

1 hour 15 minutes

Candidate session number

18	M	TZ	1	P	2	P	H	S	L

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

$\boxed{35/50 \quad 70\%}$ (If marking harshly according to marking rubric)

But, you might get a mark for 1) c) ii) or 6) c) ii)

1 mark 2 marks

12 pages

2218–6511

12EP01

International Baccalaureate
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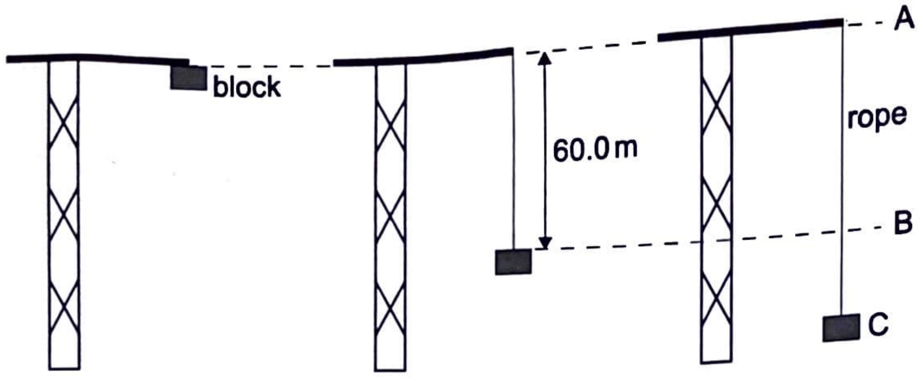
Answer **all** questions. Answers must be written within the answer boxes provided.

elastic: ability to return to original shape. Plastic opposite

1. An elastic climbing rope is tested by fixing one end of the rope to the top of a crane. The other end of the rope is connected to a block which is initially at position A. The block is released from rest. The mass of the rope is negligible.



The unextended length of the rope is 60.0 m. From position A to position B, the block falls freely.

(a) At position B the rope starts to extend. Calculate the speed of the block at position B. [2]

$v^2 = u^2 + 2as$ ✓

$\therefore v = \sqrt{0 + 2(-9.81)(-60)}$

$= 34.31 \text{ ms}^{-1}$

$= 34.3 \text{ ms}^{-1}$ ✓ (3 s.f)

DATA
$u = 0 \text{ ms}^{-1}$
$v = ?$
$a = -9.81 \text{ ms}^{-2}$
$s = -60.0 \text{ m}$

(b) At position C the speed of the block reaches zero. The time taken for the block to fall between B and C is 0.759 s. The mass of the block is 80.0 kg.

(i) Determine the magnitude of the average resultant force acting on the block between B and C. [2]

$\Delta p = (mv)_f - (mv)_i$

$= (80.0)(0) - (80)(34.31) = 2744.8 \text{ Ns}$

$F_{net} = \Delta p / \Delta t = 2744.8 / 0.759$ ✓

$\therefore F_{net} = 3616.337 \text{ N} = 3620 \text{ N}$ (3sf) ✓

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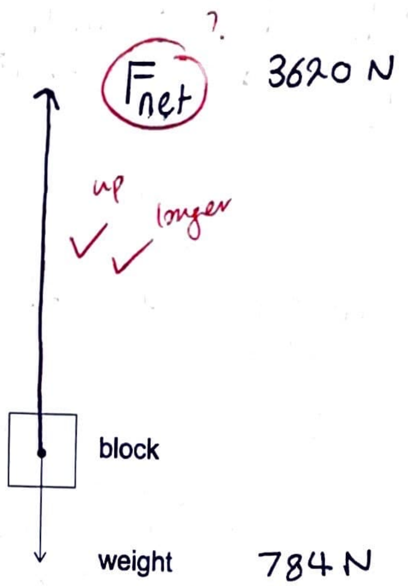
(Question 1 continued)

(ii) Sketch on the diagram the average resultant force acting on the block between B and C. The arrow on the diagram represents the weight of the block. **[2]**



(iii) Calculate the magnitude of the average force exerted by the rope on the block between B and C. **[2]**

$F_{net} = T - W$

$\therefore T = F_{net} + W = 3616 + 9.81 \times 80 = 4400.8\text{ N}$

~~= 3620 + 784 9.81 × 80.0~~

$\therefore T = 4.40 \times 10^3\text{ N}$ (3 s.f)

4/4

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(Question 1 continued)

(c) For the rope and block, describe the energy changes that take place

(i) between A and B. [1]

gravitational potential energy → kinetic energy : $E_p \rightarrow E_k$ ✓

(ii) between B and C. [1]

kinetic energy → elastic potential energy ?
and (loss in) grav potential energy

(d) The length reached by the rope at C is 77.4 m. Suggest how energy considerations could be used to determine the elastic constant of the rope. [2]

$E_p = E_k = \frac{1}{2} k x^2$

$\therefore \frac{1}{2}(80.0)(34.3)^2 = \frac{1}{2}(k)(77.4-60.0)^2$

$\therefore k = 310.87 \text{ J m}^{-2} = 311 \text{ J m}^{-2}$

~~k (elast) can be used to describ (hooke's constant)~~ ✗

k can be determined using Elastic PE $= \frac{1}{2}kx^2$

GPE at A = EPE at C

or

(GPE + KE) at B = EPE at C

1 ? /4

2. A closed box of fixed volume $0.15\,m^3$ contains 3.0 mol of an ideal monatomic gas. The temperature of the gas is 290 K.

(a) Calculate the pressure of the gas. [1]

$PV = nRT \rightarrow P = nRT/V = \frac{(3)(8.31)(290)}{(0.15)}$ ~~um~~

$= 48198\ Pa$

$= 48\ kPa$ ✓ (2 s.f)

$V = 0.15\ m^3$
$n = 3.0\ mol$
$T = 290\ K$

(b) When the gas is supplied with 0.86 kJ of energy, its temperature increases by 23 K. The specific heat capacity of the gas is $3.1\,kJ\,kg^{-1}\,K^{-1}$.

(i) Calculate, in kg, the mass of the gas. [1]

$Q = mc\Delta T \rightarrow m = Q/c\Delta T$

$= 0.86 \times 10^{+3} / 3100 \times 23$

$= 0.012\ kg$ ✓ (2 s.f)

$c = 3.1 \times 10^3\ kg^{-1}K^{-1}$
$Q = 0.86 \times 10^3\ J$
$\Delta T = 23\ K$

(ii) Calculate the average kinetic energy of the particles of the gas. [1]

$\bar{E}_k = \frac{3}{2} k_B T = \frac{3}{2}(1.38 \times 10^{-23})(290 + 23)$

$= 6.479 \times 10^{-21}\ J = 6.5 \times 10^{-21}\ J$ (2 s.f) ✓

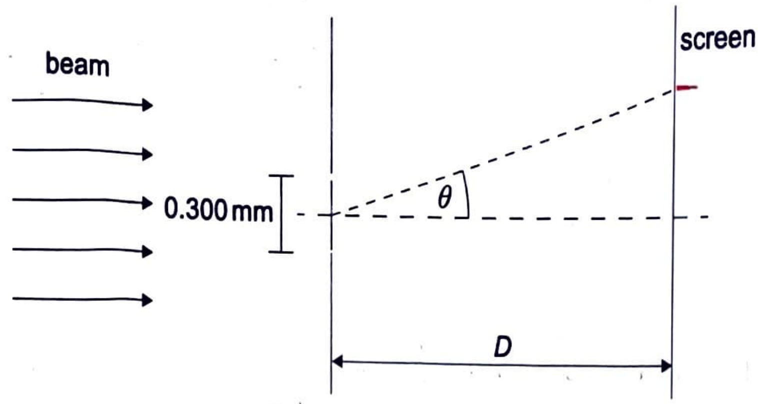
(c) Explain, with reference to the kinetic model of an ideal gas, how an increase in temperature of the gas leads to an increase in pressure. [3]

when the temperature of an ideal gas increases, the average kinetic energy will too ✓. Hence, each particle will travel at increased velocity, and exert greater impulse (momentum transfer) on the boundary of the container ✓. As $P = F/A$, the pressure will increase ✓ (area constant)

6/6

3. A beam of coherent monochromatic light from a distant galaxy is used in an optics experiment on Earth.

(a) The beam is incident normally on a double slit. The distance between the slits is 0.300 mm. A screen is at a distance D from the slits. The diffraction angle θ is labelled.



(i) A series of dark and bright fringes appears on the screen. Explain how a dark fringe is formed. **[3]**

- Dark fringes are formed by destructive interference of the superimposed waves diffracted from each slit.
- The destructive interference occurs at the locations where the superimposed waves are 90° out of phase.
- The same concept applies to bright fringes, however they occur ~~are~~ in phase.

any odd multiple of π

180°

(ii) The wavelength of the beam as observed on Earth is 633.0 nm. The separation between a dark and a bright fringe on the screen is 4.50 mm. Calculate D. **[2]**

$s = \lambda D/d \rightarrow D = sd/\lambda$

$\therefore D = (2\times4.50\times10^{-3})(0.300\times10^{-3})/(633\times10^{-9})$

$= \cancel{4.2654\ m = 4.27\ m\ (3\ s.f)}$

$= 4.27\ m$ (3 s.f)

DATA

$\lambda = 633\times10^{-9}\ m$

$s = 2\times4.50\times10^{-3}\ m$

$d = 0.300\times10^{-3}\ m$

(This question continues on the following page)

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(Question 3 continued)

(b) The air between the slits and the screen is replaced with water. The refractive index of water is 1.33.

(i) Calculate the wavelength of the light in water. [1]

$\lambda_2 = \lambda_1 / 1.33 = \frac{633 \times 10^{-9}}{1.33} = 4.7594 \times 10^{-7}$ m
$= 4.76 \times 10^{-7}$ m
$= 476$ nm ✓

(ii) State **two** ways in which the intensity pattern on the screen changes. [2]

- fringe spacing will ~~reduce~~ decrease (become more frequent) ✓
- ~~the intensity of the fringes will be reduced?~~
- the brightest fringe will be offset due to the speed decrease, hence θ increases. ✗

intensity decreases

(eg in pool, n is higher than in air – note denser mediums have the higher n for sound but lower for light.

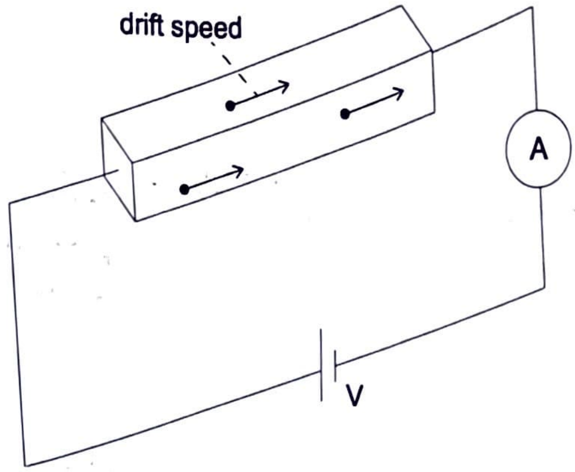
no ✗

n higher, and room clicking is louder, intensity
So ~~[illegible]~~ n ∝ intensity

When a wave hits a new medium, some of it is transmitted and some of it is reflected.

2/3

4. An ohmic conductor is connected to an ideal ammeter and to a power supply of output voltage V.



The following data are available for the conductor:

density of free electrons	$= 8.5 \times 10^{22}\,\text{cm}^{-3}$
resistivity	$\rho = 1.7 \times 10^{-8}\,\Omega\text{m}$
dimensions	$w \times h \times l = 0.020\,\text{cm} \times 0.020\,\text{cm} \times 10\,\text{cm}$.

The ammeter reading is 2.0A.

(a) Calculate the resistance of the conductor. [2]

cross-sectional area $A = W \times h = 4 \times 10^{-8}\,m^2$

$R = \rho L / A = \dfrac{(1.7\times10^{-8})(0.1)}{(4\times10^{-8})}$ ✓

$= 0.0425\ \Omega$

$= 4.3 \times 10^{-2}\ \Omega$ (2s.f) ✓

DATA

$\rho = 1.7\times10^{-8}\ \Omega m$

$L = 0.1\ m$

$W = 2\times10^{-4}\ m$

$h = 2\times10^{-4}\ m$

(b) Calculate the drift speed v of the electrons in the conductor in $\text{cm}\,\text{s}^{-1}$. State your answer to an appropriate number of significant figures. [3]

cross-section, $A = 4\times10^{-8}\,m^2$ (from above)

$q = 1.60\times10^{-19}$ J

$I = 2.0$ A

~~density = 8.5×10^22 ... 8.5×10^28 m^-3~~

$\therefore\ n = 8.5\times10^{22} \times \text{Volume} = 8.5\times10^{22} \times (0.02\times0.02\times10)$ ✓ $= 3.4\times10^{20}$

$\therefore\ V = \dfrac{2.0}{4\times10^{-8}\times3.4\times10^{20}\times1.6\times10^{-19}}$ ✓ ✗ 0.37 cms^{-1}

$=$ RIP ✗

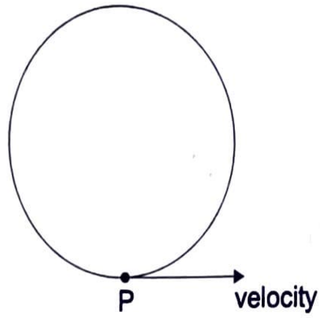
0.368 cm s^{-1} =

XX

correct formula

3/5

5. An electron moves in circular motion in a uniform magnetic field.



The velocity of the electron at point P is $6.8 \times 10^5\,\text{m s}^{-1}$ in the direction shown.
The magnitude of the magnetic field is 8.5 T.

(a) State the direction of the magnetic field. [1]

Into the page × out of the page plane / ⊙ (reverse direction as electron is −ve)

(b) Calculate, in N, the magnitude of the magnetic force acting on the electron. [1]

$F = qvB\sin\theta \rightarrow$ $F = qVB = 1.6\times10^{-19} \times 8.5 \times 6.8\times10^5$
$= 9.248\times10^{-13}$ N
$= 9.2\times10^{-13}$ N (2 s.f)

(c) Explain why the electron moves

(i) at constant speed. almost -- but not specific enough. [1]

continually accelerated inwards (velocity vector changes), but speed (scalar) remains the same ×
magnetic force/acceleration at right angles to velocity

(ii) on a circular path. [2]

Magnetic force always acts perpendicular to the velocity and the magnetic flux density. Hence, ~~as the~~ the electron will always ~~an~~ experience a force × towards the centre.

centripetal (acceleration/force)

2/5

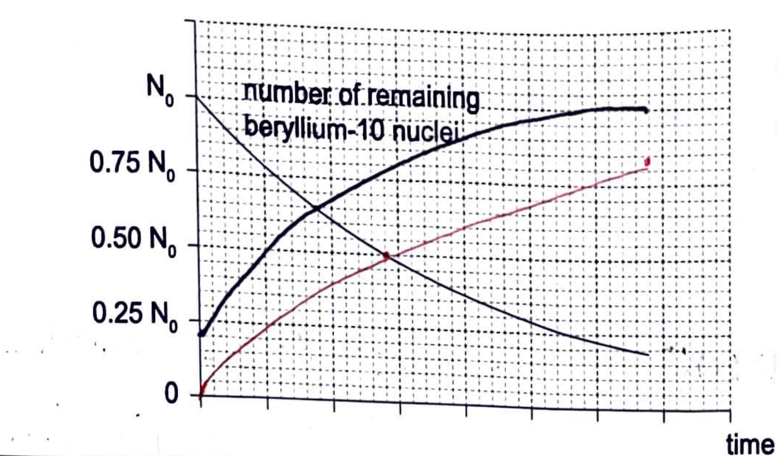
Turn over

6. The radioactive nuclide beryllium-10 (Be-10) undergoes beta minus (β–) decay to form a stable boron (B) nuclide.

(a) Identify the missing information for this decay. [1]

$$^{10}_{\boxed{4}}\text{Be} \rightarrow {}^{\boxed{10}}_{5}\text{B} + \beta + \bar{\nu}$$ ✓

(b) The initial number of nuclei in a pure sample of beryllium-10 is N_0. The graph shows how the number of remaining **beryllium** nuclei in the sample varies with time.



✗ Starts at 0, ends at ~0.8 N_0

✗ crosses at 0.50 N_0

(sorry)

(i) On the graph, sketch how the number of **boron** nuclei in the sample varies with time. 0. [2]

(ii) After 4.3×10^6 years,

$$\frac{\text{number of produced boron nuclei}}{\text{number of remaining beryllium nuclei}} = 7.$$

Show that the half-life of beryllium-10 is 1.4×10^6 years. [3]

~~$N = N_0 \times (\frac{1}{2})^T$~~ $\cancel{B/Be}$ $B + Be = N_0$

1 half life $\frac{B}{Be} = 1$

2 half lives $B/Be = 3$

3 half lives $B/Be = 7$ ✗ → Half life $= \frac{4.3\times10^6}{3}$

✓ $= 1.4 \times 10^6$ years ✓

fraction of Be $= \frac{1}{8}$, 12.5%, or 0.125

(This question continues on the following page)

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(Question 6 continued)

(iii) Beryllium-10 is used to investigate ice samples from Antarctica. A sample of ice initially contains 7.6×10^{11} atoms of beryllium-10. State the number of remaining beryllium-10 nuclei in the sample after 2.8×10^{6} years. [1]

2.8×10^5 years: half lives = ~~4 3x10~~ $(1.4 \times 10^6 / 2.8 \times 10^6)^{-1}$

$\Rightarrow$ number atoms $= 7.6 \times 10^{11} \times \frac{1}{4}$ $\leftarrow$ = 2 half lives

$= 1.9 \times 10^{11}$ atoms ✓

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1/1