Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Thursday 10 May 2018 (afternoon)

1 hour 15 minutes

Candidate session number

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]**.

1 98
2 95
4 90
5 88
6 86
8 81
10 76
11 74
16 62

12 pages

2218–6511

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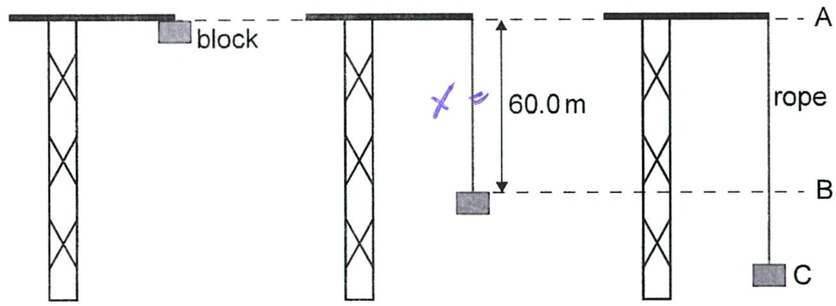
Answer **all** questions. Answers must be written within the answer boxes provided.

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]

$PE_{top A} = KE_{B}$ @ 60 m   or $v_f^2 = v_i^2 + 2ad$

$m(10)(60\,m) = \frac{1}{2} m v^2$ $v_f^2 = 0\,m/s + 2(10)(60\,m)$

$2(600) = v^2$

$v = 34.6\,m/s$ $v_f = 34.6\,m/s$

(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]

$J = \Delta p$

$Ft = m\Delta v$

$F(.759\,s) = 80\,kg\,(34.6\,m/s)$

$F_{net} = 3646\,N$

or $a = \frac{\Delta v}{t}$, $F_{net} = ma$, $\frac{80\,kg\,(34.6\,m/s)}{.759\,m/s}$

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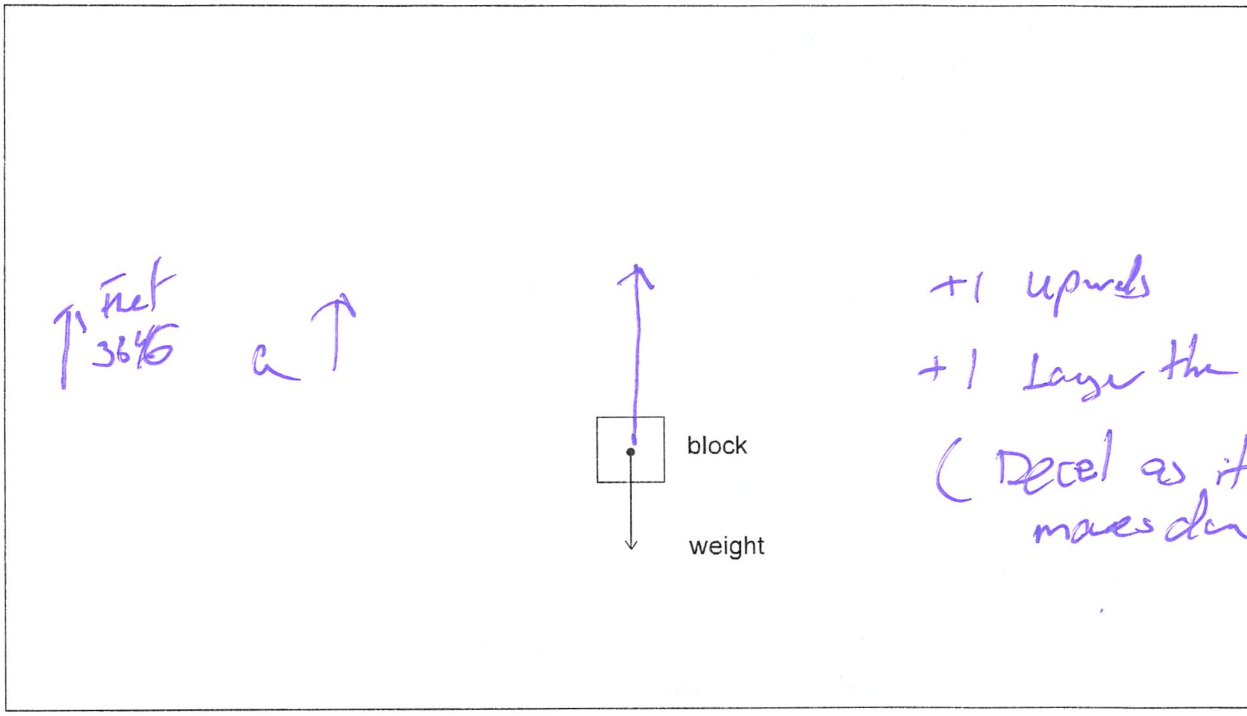
(Question 1 continued)

(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 Fn AtA + Fg = mg

= 3646 80Kg (9.8)

Fg = 4400N

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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]

↓PE_{grav} → ↑KE
(mgh)

(ii) between B and C. [1]

↓PE_{grav} + ↓KE → ↑PE_s

(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]

@A $v=0$ $E_T = PE_g = mgh$
@C $v=0$ $E_T = PE_s = \frac{1}{2}kx^2$
@A @C
$mgh = \frac{1}{2}kx^2$

3.2 (Modeling a gas)

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]

$PV = nRT$ $\quad P = \frac{nRT}{V}$ $\quad P = \frac{3.0\,mol\,(8.31)\,290K}{0.15\,m^3}$ $\quad P = 48\,KPa$

(T in Kelvin)

(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]

$Q = mC\Delta T$ $\quad m = \frac{Q}{C\Delta T}$ $\quad m = \frac{860\,J}{3100\,\frac{J}{kgK}\,(23K)}$ $= .012\,kg$

(Can leave in KJ)

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

From Ref. Book

$E_K = \frac{3}{2} K_B T$ $\quad E_K = \frac{3}{2}(1.38 \times 10^{-23})(313K)$

$E_K = 6.5 \times 10^{-21}\,J$

K_B = Boltzmann Constant ~~C = K + 273~~ 290 Temp initial +23 = 313K

(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]

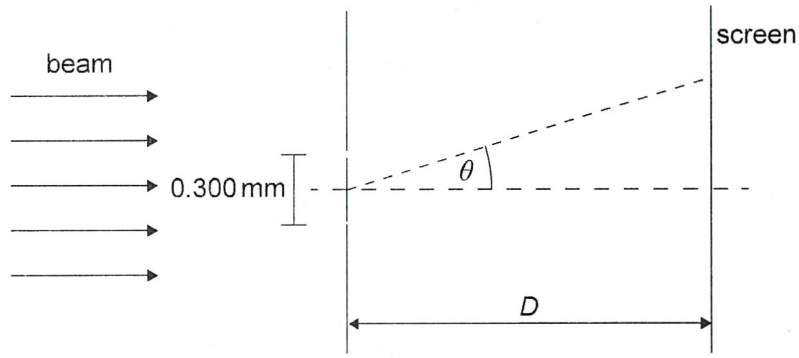
↑ Temp → ↑ v → KE of gas molecules

↑ Force/momentum (↑ v) transferred to walls & more freq collisions with wall

↑ Force → ↑ Pressure $\quad P = \frac{F}{Area\ (const)}$

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]

Superposition of light from each slit or
Constructive / Destructive interference from both slits
Dark band appears @ any half odd multiple of wavelength

(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]

4.4 Wave Behavior from IB Data Booklet

$s = \frac{\lambda D}{d}$ or $D = \frac{s d}{\lambda}$ $D = \frac{(4.5\times10^{-3}\,m)(.300\times10^{-3}\,m)}{(6.33\times10^{-9}\,m)}$

s = Fringe Spacing = 4.5 mm
D = Distance to Screen = $= 4.27\,m$
d = Slit Spacing = .300 mm
λ = Wavelength = 633 nm

(This question continues on the following page)

(Question 3 continued)

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

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

4.4 like Before

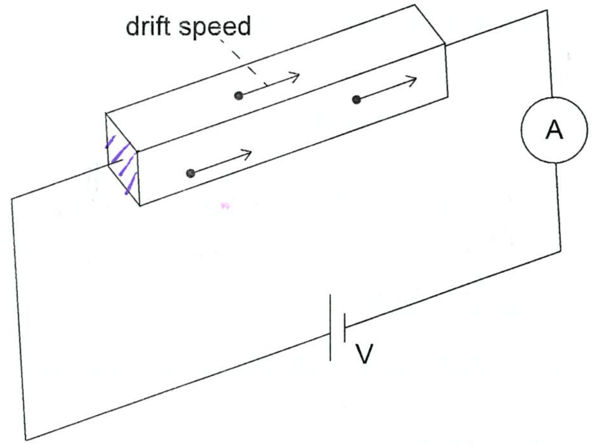
$\frac{n_1}{n_2} = \frac{v_2}{v_1}$ $\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1}$ $\frac{1}{1.33} = \frac{\lambda_2}{633 nm}$ $\lambda_2 = 476 nm$

$v = f\lambda$ Freq. Fixed e Same

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

- Intensity Decrease
- Distance between peaks decreases

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:

n = 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. Area = .02 cm × .02 cm = .0004 cm² (cross sectn)

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

$R = \frac{\rho L}{A}$ $R = \frac{(1.7\times10^{-8}\,\Omega m)(10\times10^{-2} m)}{(.02\times10^{-2})(.02\times10^{-2} m)}$ (w, h)

$R = .043\,\Omega$

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

$I = nAvq$
n - # of charges per unit volume (m^{-3})
A - cross section Area (m^2)
v - Drift velocity (m/s)
I - current (A)
q - charge (C)

$I = nAvq$

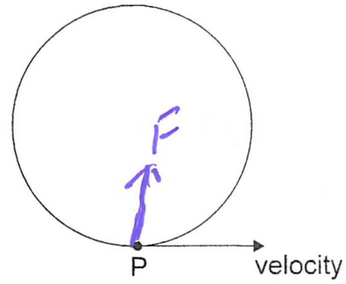
$\frac{I}{nAq} = v$

$\frac{2A}{(8.5\times10^{22}\,cm^{-3})(.0004\,cm^2)(1.6\times10^{-19}\,C)}$

$v = .368\,\frac{cm}{sec}$

Elect Drift - Avg velocity attained by charged particles

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]

Out of page

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

$F = qvB$
$(1.6 \times 10^{-19}\,C)(6.8 \times 10^{5}\,\frac{m}{s})(8.5\,T) = 9.2 \times 10^{-13}\,N$

(c) Explain why the electron moves

(i) at constant speed. [1]

- Magnetic Force / Accel is @ Rt. Angle to velocity
or
Mag Force does not do work to electron ⇒ No change in Electron KE

(ii) on a circular path. [2]

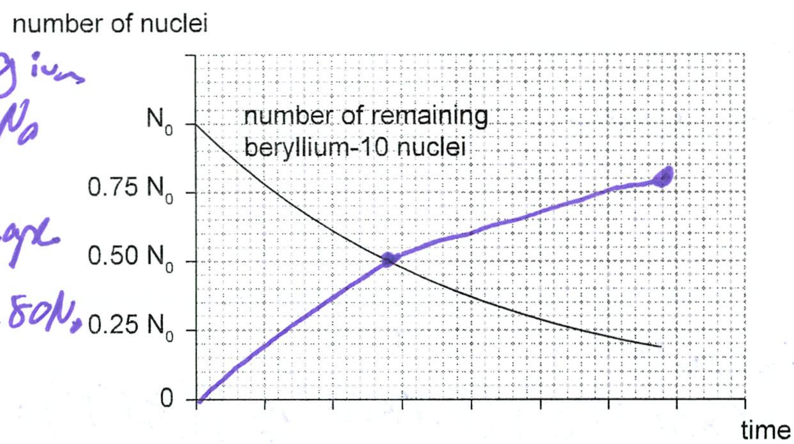
- The velocity of the Electron is ⊥ to the magnetic field
- There is centripetal Accel / Force acting on the charge

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

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

$$^{10}_{\square}\text{Be} \rightarrow {}^{\square}_{5}\text{B} + \beta + \bar{\upsilon}$$

(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.



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

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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]

Fraction of Be $= \frac{1}{8}$ or 12.5%

(This question continues on the following page)

(Question 6 continued)

(c) An ice sample is moved to a laboratory for analysis. The temperature of the sample is −20 °C.

(i) State what is meant by thermal radiation. [1]

Emission of electromagnetic / infrared energy

(ii) Discuss how the frequency of the radiation emitted by a black body can be used to estimate the temperature of the body. [2]

- From Wein's Law, peak wavelength emitted from Electromagnetic waves depends on the temperature of the emitter
- Since $v = f\lambda$ The Freq/Color depends on the temp

(iii) Calculate the peak wavelength in the intensity of the radiation emitted by the ice sample. [2]

8.2 - Thermal Energy Transfer Data Booklet

From Above -20°C ⇒ $T_K = T_C + 273$

$\lambda_{max}(\text{meters}) = \frac{2.90 \times 10^{-3}}{T\,(\text{Kelvin})}$ $\lambda = \frac{2.90 \times 10^{-3}}{253\,K} = 1.1 \times 10^{-5}\,m$

(iv) Derive the units of intensity in terms of fundamental SI units. [2]

8.2 - Databooklet

$P = \frac{W}{t} = \frac{F \cdot d}{t}$

$I = \frac{Pow}{Area}$ $I = \frac{watt}{m^2} = \frac{\left(\frac{kg\,m}{s^2/s}\right) \cdot m}{m^2} = \frac{\frac{kg\,m^2}{s^3}}{m^2} = kg\,s^{-3}$

The number of Joules transferred by the wave in 1 sec to an area $1m^2$