



# Coimisiún na Scrúduithe Stáit State Examinations Commission

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*Scrúduithe Ardteistiméireachta, 2003*

*Fisic*

*Ardleibhéal*

*Marking Scheme*

*Leaving Certificate Examination, 2003*

*Physics*

*Higher Level*

Coimisiún na Scrúduithe Stáit  
**State Examinations Commission**

**LEAVING CERTIFICATE EXAMINATION**

**2003**

Physics

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Marking scheme

**In considering this marking scheme the following points should be noted:**

1. In many instances only key words are given, words that must appear in the **correct context** in the candidate's answer in order to merit the assigned marks.
2. Words, expressions or statements separated by a solidus, /, are alternatives which are equally acceptable.
3. Answers that are separated by a double solidus, //, are answers which are mutually exclusive. A partial answer from one side of the // may not be taken in conjunction with a partial answer from the other side.
4. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.
5. The detail required in any answer is determined by the context and manner in which the question is asked and by the number of marks assigned to the answer in the examination paper. Therefore, in any instance, it may vary from year to year.
6. For lack of units, or incorrect units, one mark is deducted, when indicated.
7. Each time an arithmetical slip occurs in a calculation one mark is deducted.

## Section A 120 Marks

Marks awarded for the THREE best answers

### Question 1

Describe with the aid of a diagram how the student obtained this data. (12)

<b>trapped gas (labelled / indicated)</b>	<b>3</b>
<b>reference to pressure gauge</b>	<b>3</b>
<b>method of varying pressure / volume</b>	<b>3</b>
<b>method of reading volume</b>	<b>3</b>
<b>(no diagram deduct 3)</b>	

Draw a suitable graph on graph paper to show the relationship between the pressure of the gas and its volume. (15)

$p/\text{kPa}$	120	180	220	280	320	380	440
$V/\text{cm}^3$	9.0	6.0	5.0	4.0	3.5	3.0	2.5
$1/V/\text{cm}^{-3}$	<b>0.111</b>	<b>0.167</b>	<b>0.200</b>	<b>0.250</b>	<b>0.286</b>	<b>0.333</b>	<b>0.400</b>

<b>calculation of <math>1/V</math></b>	<b>3</b>
<b>axes labelled</b>	<b>3</b>
<b>6 points plotted correctly</b>	<b>3</b>
<b>straight line</b>	<b>3</b>
<b>good fit</b>	<b>3</b>
<b>(-3 if not drawn on graph paper)</b>	

Explain how your graph verifies Boyle's law. (6)

<b>straight line through the origin</b>	<b>3</b>
<b>pressure is inversely proportional to volume</b>	<b>3</b>

Describe how the student ensured that the temperature of the gas was kept constant. (7)

<b>allowed time between readings / allow to settle / release gas pressure slowly</b>	<b>7</b>
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## Question 2

Describe how the mass of the steam was found. (9)

<b>final mass (of calorimeter + water + condensed steam)</b>	<b>3</b>
<b>mass of calorimeter + water</b>	<b>3</b>
<b>subtract / difference</b>	<b>3</b>

Calculate a value for the specific latent heat of vaporisation of water. (18)

<i>ml</i>	<b>(3)</b>
$(ml)_{steam} + (mc\Delta\theta)_{steam} = (mc\Delta\theta)_{water} + (mc\Delta\theta)_{cal}$	<b>9</b>
<b>(ml missing or incorrect 0 any other factor missing or incorrect -3)</b>	
<b>9°C</b>	<b>3</b>
<b>81°C</b>	<b>3</b>
<b>2.2 MJ kg<sup>-1</sup></b>	<b>3</b>

**(-1 for lack of units or incorrect units)**

Why is the rise in temperature the least accurate value? Give two ways of improving the accuracy of this value. (13)

<b>read only to one significant figure</b>	<b>3</b>
<b>more sensitive / digital thermometer / to 0.1 degree</b>	<b>7</b>
<b>more steam / less water / insulation / cover / stirring / steam trap / midway temperature</b>	<b>3</b>

### Question 3

How did the student find an approximate value for the focal length of the lens? (6)

**focus image of distant object on a “screen”** 3  
**distance from lens to screen (= focal length)** 3

Describe, with the aid of a labelled diagram, how the student found the position of the image.(10)

**lens + (illuminated ) object** 3  
**screen** 3  
**move object / lens / screen until sharp image is seen** 4  
**( -4 for lack of diagram -1 for lack of labels)**

<i>u/cm</i>	20.0	25.0	35.0	45.0
<i>v/cm</i>	66.4	40.6	27.6	23.2
<b><i>f/cm</i></b>	<b>15.4</b>	<b>15.5</b>	<b>15.4</b>	<b>15.3</b>

Using the data in the table, find an average value for the focal length of the lens. (15)

$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$  3  
**one correct value for *f* /  $1/f$**  3  
**2 other correct values** 3  
**get average** 3  
**15.4 cm / 0.154 m** 3  
**(if no correct value for *f*, then marks may only be awarded for formula)**

Give two sources of error in measuring the image distance and state how one of these errors can be reduced. (9)

**image not sharp / parallax error in reading distance /**  
**not measuring to centre of lens / zero error in metre stick** 2x3  
**how to reduce error** 3

## Question 4

Describe, with the aid of a labelled diagram, how the apparatus was arranged in this experiment. (12)

<b>power source and heating coil</b>	<b>3</b>
<b>ammeter in series, labelled</b>	<b>3</b>
<b>labelled thermometer in container of water</b>	<b>3</b>
<b>method of varying current</b>	<b>3</b>

Using the given data, draw a suitable graph on graph paper and explain how your graph verifies Joule's law. (18)

$I/A$	1.5	2.0	2.5	3.0	3.5	4.0	4.5
$\Delta\theta/^\circ\text{C}$	3.5	7.0	10.8	15.0	21.2	27.5	33.0
$I^2/A^2$	<b>2.25</b>	<b>4.0</b>	<b>6.25</b>	<b>9.0</b>	<b>12.25</b>	<b>16.0</b>	<b>20.25</b>

<b>label axes</b>	<b>3</b>
<b>at least 6 correct points</b>	<b>3</b>
<b>straight line</b>	<b>3</b>
<b>good fit</b>	<b>3</b>

<b>straight line through origin</b>	<b>3</b>
$\Delta\theta \propto I^2$	<b>3</b>

Explain why the current was allowed to flow for a fixed length of time in each case. (5)

<b>idea of only 2 variables / <math>H \propto t</math> / compare like with like</b>	<b>5</b>
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Apart from using insulation, give one other way of reducing heat losses in the experiment. (5)

<b>start with cold water / change the water for each run use a lid / shorter time interval / polish calorimeter</b>	<b>5</b>
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## Question 5

### MARKS AWARDED FOR THE EIGHT BEST ANSWERS

- (a) State Hooke's law.  
 **$F = -ks$**  // restoring force is proportional to // force  $\alpha$  4  
**explain notation** // displacement // extension 3
- (b) What is the relationship between the acceleration due to gravity  $g$  and the distance from the centre of the earth?  
 **$g$  is inversely proportional** 4  
**distance squared** 3
- (c) The diagram shows forces of 5 N applied to a water tap. Calculate the moment of the couple (torque) on the tap.  
**moment = force by distance** (4)  
**0.3 N m** 7  
**(-1 for lack of units or incorrect units)**
- (d) Which wave phenomenon can be used to distinguish between transverse waves and longitudinal waves?  
**polarisation** 7
- (e) Sound intensity level can be measured in dB or dB(A). What is the difference between the two scales?  
**idea of dB(A) being adapted to human ear** 4  
**frequency** 3
- (f) Calculate the critical angle for diamond. The refractive index of diamond is 2.4.  
 **$1/\sin C$**  (4)  
 **$24.6^\circ$**  7
- (g) What is the purpose of a miniature circuit breaker (MCB) in an electric circuit?  
**behaves as a fuse / to break the circuit // safety device** 4  
**when too large a current flows // prevents too large a current** 3
- (h) What is the photoelectric effect?  
**emission of electrons (from a metal)** 4  
**by light / electromagnetic radiation / photons** 3
- (i) What is meant by nuclear fusion?  
**combining of two (small) nuclei** 4  
**release of energy / large nucleus** 3
- (j) Give one contribution made to Physics by either Paul Dirac or Nicholas Callan. (7)  
**Dirac; (predicted) positrons / antiparticles / antimatter**  
**operator theory / quantum algebra**  
**Callan: induction coil / batteries / prevent rusting** any one 7

## Question 6

Give the difference between vector quantities and scalar quantities and give one example of each. (8)

**a vector has a direction** 3  
**examples (must indicate vector or scalar)** 3 + 2

Describe an experiment to find the resultant of two vectors. (18)

**3 (Newton) balances // 3 weights** 6  
**joined by string // joined over pulleys** 3  
**adjust until the system is at rest** 3  
**read each force / balance** 3  
**vector sum of two forces = third force (stated or implied)** 3

A cyclist travels from A to B along the arc of a circle of radius 25 m as shown. Calculate (i) the distance travelled, (ii) the displacement undergone by the cyclist...(12)

**(i) reference to  $2\pi r$**  3  
 **$39(.3) \text{ m} / 12.5\pi \text{ m}$**  3  
**(-1 for lack of units or incorrect units)**

**(ii)  $35(.3) \text{ m} / 25\sqrt{2}$**  4  
**NW /  $45^\circ$**  3  
**(-1 for lack of units or incorrect units)**

A person in a wheelchair is moving up a ramp at a constant speed. Their total weight is 900 N. The ramp makes an angle of  $10^\circ$  with the horizontal. Calculate the force required to keep the wheelchair moving at a constant speed up the ramp. (9)

**$mg\sin\theta / F\sin\theta$**  3  
 **$900 \sin 10^\circ$**  3  
 **$156(.3) \text{ N}$**  3  
**(-1 for lack of units or incorrect units)**

The ramp is 5 m long. Calculate the power exerted by the person in the wheelchair if it takes her 10 s to travel up the ramp. (9)

**$(P =) W/t$**  (3)  
 **$W = Fs / mgh$**  (3)  
**78 W** 9  
**(-1 for lack of units or incorrect units)**

## Question 7

Describe an experiment to show that sound is a wave motion. (12)

**tuning fork // 2 speakers // microphone and CRO 3**  
**set vibrating // attach to same frequency source // sound source 3**  
**rotate by ear // walk in front of speakers // observe pattern on screen 3**  
**increase and decrease of sound // wave pattern 3**

What is the Doppler effect? Explain, with the aid of labelled diagrams, how this phenomenon occurs. (14)

**change in frequency 3**  
**motion of source / observer 3**

**non concentric circles, stated or implied as waves 3**  
**close parts of circles show high frequency / short wavelength 3**  
**centres show direction of movement of source 2**

Bats use high frequency waves to detect obstacles. A bat emits a wave of frequency 68 kHz and wavelength 5.0 mm towards the wall of a cave. It detects the reflected wave 20 ms later.

Calculate the speed of the wave and the distance of the bat from the wall. (12)

$v = f\lambda$  3  
340 m s<sup>-1</sup> 3  
(-1 for lack of units or incorrect units)

$v = s/t$  /  $vt = s$  3  
3.4 m 3  
(-1 for lack of units or incorrect units)

If the frequency of the reflected wave is 70 kHz, what is the speed of the bat towards the wall? (12)

$f' = \frac{fc}{c \pm u}$  6  
substitution 3  
9.7 m s<sup>-1</sup> 3  
(-1 for lack of units or incorrect units)

Give two other applications of the Doppler effect. (6)

**speed traps / speed of stars (red shift) / landing aircraft**  
**/ ultrasound (blood movement or heartbeat of foetus) /**  
**measure temperature / weather forecasting. 4 + 2**

## Question 8

Define the unit of current, i.e. the ampere. (9)

**two (infinitely) long parallel wires (of negligible cross section) 3**  
**1 metre apart in vacuum 3**  
**(force of)  $2 \times 10^{-7} \text{ N m}^{-1}$  3**

Describe an experiment to demonstrate the principle on which the definition of the ampere is based. (15)

**(aluminium) foil / wires 3**  
**parallel strips 3**  
**a circuit 3**  
**when current is switched on 3**  
**foil moves 3**

Various materials conduct electricity. Draw a graph to show the relationship between current and voltage for each of the following conductors:

- (i) a metal at constant temperature
- (ii) an ionic solution with inactive electrodes
- (iii) a gas (18)

**(i) axes and straight line 3**  
**through origin 3**  
**(ii) axes and straight line 3**  
**starting at  $v > 0$  3**  
**(iii) axes and curve 3**  
**curve and plateau 3**

How would the graph for the metal differ if its temperature were increasing? (7)

**non linear / curve 7**  
**resistance increases (3)**

How would the graph for the ionic solution differ if its concentration were reduced? (7)

**slope of graph is less (stated or shown) 7**  
**resistance increases / less ions / less charge carriers (3)**

## Question 9

List two properties of the electron. (6)

**negative charge, mass = 1/1836 amu (approx = 0), orbits nucleus, deflected by electric / magnetic field etc.** 2 x 3

Name the Irishman who gave the electron its name in the nineteenth century. (6)

**(G. J.) Stoney** 6

Give an expression for the force acting on a charge  $q$  moving at a velocity  $v$  at right angles to a magnetic field of flux density  $B$ . (6)

**$qvB$**  6  
 **$evB$**  (3)

An electron is emitted from the cathode and accelerated through a potential difference of 4 kV in a cathode ray tube (CRT) as shown in the diagram.

How much energy does the electron gain? What is the speed of the electron at the anode. (18)

**4 keV /  $6.4 \times 10^{-16}$  J** 6  
**(-1 for lack of units or incorrect units)**

$$E = \frac{1}{2}mv^2 \quad 3$$

$$6.4 \times 10^{-16} = \frac{1}{2} \times 9.1 \times 10^{-31} v^2 \quad 6$$

$$3.7(5) \times 10^7 \text{ m s}^{-1} \quad 3$$

**(-1 for lack of units or incorrect units)**

After leaving the anode, the electron travels at a constant speed and enters a magnetic field at right angles, where it is deflected. The flux density of the magnetic field is  $5 \times 10^{-2}$  T.

Calculate (i) the force acting on the electron, (ii) the radius of the circular path followed by the electron, in the magnetic field. (15)

(i)  $F = evB$  3

substitute 3

$$3.0 \times 10^{-13} \text{ N} \quad 3$$

**(-1 for lack of units or incorrect units)**

(ii)  $F = \frac{mv^2}{r}$  3

$$4.3 \times 10^{-3} \text{ m} \quad 3$$

**(-1 for lack of units or incorrect units)**

What happens to the energy of the electron when it hits the screen of the CRT? (5)

**converted to light / heat / does not hit screen / fluorescence** 5

### Question 10(a)

Leptons, baryons and mesons belong to the “particle zoo”.

Give (i) an example, (ii) a property, of each of these particles. (18)

**LEPTONS; electron / positron / muon / tau / neutrino** 3

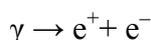
**not subject to strong force / any individual property** 3

**BARYONS; proton / neutron** 3

**subject to all forces / three quarks / any individual property** 3

**MESONS pi(on) / kaon** 3

**subject to all forces / mass between electron and proton  
quark and antiquark / any correct charge** 3



Calculate the minimum frequency of the  $\gamma$ -ray photon required for this reaction to occur. (15)

$$E = (2)mc^2 \quad 3$$

**substitution** 3

$$E = hf \quad 3$$

$$(2)mc^2 = hf \quad 3$$

$$2.5 \times 10^{20} \text{ Hz} \quad 3$$

(-1 for lack of units or incorrect units)

What is the effect on the products of the reaction if the frequency of the  $\gamma$ -ray photon exceeds the minimum value? (5)

**kinetic energy / speed / moving / more particles** 5

The reverse of the above reaction is known as pair annihilation. Write a reaction that represents pair annihilation. (6)



(-3 per missing item)

Explain how the principle of conservation of charge and the principle of conservation of momentum apply in pair annihilation. (12)

**total charge on both sides is zero** 6

**electron and positron have opposite charges** (3)

**photons in opposite directions /**

**momentum of positron + electron = momentum of photons** 6

**momentum before = momentum after = zero** (3)

## Question 10 (b)

Explain the difference between intrinsic and extrinsic conduction in semiconductors. (12)

**intrinsic conduction is in a pure semiconductor** 6

**extrinsic conduction is in an impure semiconductor** 6

Draw a labelled diagram of a p-n junction. (9)

**2 layers** 3

**label p and n** 3

**reference to depletion layer** 3

Explain how a p-n diode can be used to convert a.c. to d.c. (9)

**a.c. to diode** 3

**conducts in forward bias / voltage** 3

**no conduction in reverse bias** 3

**(award 3 for *allows current to flow in one direction only*  
if no reference to bias.)**

Draw a diagram of a circuit used to get a smooth d.c. output from an a.c. source. (9)

**4 diodes / bridge rectifier** 3

**capacitor** 3

**full circuit including a.c. in and d.c. out** 3

Explain why a light-emitting diode (LED) emits light when a suitable forward bias is applied to it. (9)

**current flows** 3

**electrical energy to light energy** 3

**junction near surface** 3

Give two ways in which a photodiode differs from a LED and give a use for a photodiode. (8)

**photodiode requires light** 3

**LED is operated in forward bias but photodiode in reverse bias** 3

**light meter / burglar alarms / optic fibre / counters / checkout  
/ automatic door / bar-coding /oil-burner** 2

## Question 11

(a) What is radioactive decay? (7)

**breakup of a nucleus** 4

**release of radiation /  $\alpha$  /  $\beta$  /  $\gamma$**  3

(b) What is an isotope? (7)

**same atomic number / same number of protons** 4

**different atomic mass / different number of neutrons** 3

(c) Apart from “carbon dating”, give two other uses of radioactive isotopes. (7)

**medical imaging, (battery of) heart pacemakers, sterilization,  
tracers, irradiation of food, killing cancer cells,  
measuring thickness, smoke detectors, nuclear fuel** 4 + 3

(d) How many neutrons are in a  $^{14}\text{C}$  nucleus? (7)

**eight** 7

(e)  $^{14}\text{C}$  decays to  $^{14}\text{N}$ . Write an equation to represent this nuclear reaction. (7)

$^{14}_6\text{C} \longrightarrow ^{14}_7\text{N} + ^0_{-1}\text{e}$  (or  $^0_{-1}\beta$ ) 7

( if atomic numbers are missing award a maximum of 4)

(f) How much of a  $^{14}\text{C}$  sample remains after 11 460 years? (7)

**2 half lives** (4)

**quarter / 25%** 7

(g) Calculate the decay constant of  $^{14}\text{C}$ . (7)

$\lambda T_{1/2} = \ln 2$  (0.693) (4)

$3.8 \times 10^{-12} \text{ s}^{-1}$  /  $1.2(1) \times 10^{-4} \text{ y}^{-1}$  7

(-1 for lack of units or incorrect units)

(h) Why does the  $^{12}\text{C}$  in dead tissue remain “undisturbed”? (7)

**It is not radioactive / it is not exchanging with the atmosphere /  
it is stable** 7

## Marks are awarded for the best TWO parts

### Question 12 (a)

State Newton's second law of motion. (6)

**Force is proportional to** //  $F \propto \frac{mv - mu}{t}$  **3**

**rate of change of momentum** // **notation** **3**

Calculate the average vertical acceleration of the skydiver.

If the mass of the skydiver is 90 kg, what is the magnitude and direction of the average resultant force acting on him? (10)

$v^2 = u^2 + 2as$  **3**

**0.83 m s<sup>-2</sup>** (-1 for lack of units or incorrect units) **3**

**75 N** (-1 for lack of units or incorrect units) **3**

**down** **1**

Use a diagram to show the forces acting on the skydiver and explain why he reaches a constant speed. (12)

**weight acting down on diagram** **3**

**air resistance / friction / buoyancy acting up on diagram** **3**

**resultant force = 0** // **air resistance = weight** **3**

**therefore acceleration = 0** **3**

### Question 12 (b)

What is the difference between heat and temperature? (6)

**heat is a form of energy** **3**

**temperature is a measure of hotness (or coldness)** **3**

**(heat in Joules and temperature in Kelvin 3)**

The emf of a thermocouple can be used as a thermometric property.

Explain the underlined terms. (10)

**a voltage / pd** **4**

**a property that changes** **3**

**measurably / continuously / regularly / uniformly, with temperature** **3**

Name a thermometric property other than emf. Explain why it is necessary to have a standard thermometer. (12)

**length / pressure / volume / resistance / colour** **3**

**different thermometers** **3**

**different readings** **3**

**at same temperature / different thermometric properties** **3**

### Question 12 (c)

State Coulomb's law of force between electric charges. (6)

$$F \propto \frac{Q_1 Q_2}{d^2} \quad // \quad F \propto \text{product of charges} \quad 3$$

**explain Q and d** // **inversely proportional to distance squared** 3

Define electric field strength and give its unit. (9)

**force** //  $\frac{F}{Q}$  /  $\frac{Q}{4\pi\epsilon d^2}$  3

**per unit charge** // **explain symbols** 3

**N C<sup>-1</sup> / V m<sup>-1</sup>** 3

How would you demonstrate an electric field pattern? (9)

**oil and semolina or seeds** 3

**high tension / high voltage** 3

**lines of semolina show field** 3

show direction of the electric field strength. (4)

**Arrow towards X** 4

### Question 12 (d)

State the laws of electromagnetic induction. (12)

**induced emf is** //  $E = (-) \frac{d\Phi}{dt}$  3

**proportional to rate of change of flux** // **explain  $\Phi$  and  $t$**  3

**direction of induced current / e.m.f.** // **minus sign included above** 3

**opposes change producing it** // **significance of minus** 3

A small magnet is attached to a spring as shown in the diagram. The magnet is set oscillating up and down. Describe the current flowing in the circuit. (6)

**alternating** // **a.c.** 6

**changing in magnitude** (3)

**changing in direction** (3)

If the switch at A is open, the magnet will take longer to come to rest. Explain why. (10)

**no (induced) current** 4

**no (induced) magnetic field (in coil)** 3

**no opposing force / resistance** 3