Coimisiún na Scrúduithe Stáit
State Examinations Commission

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Fisic	*Ardleibhéal*

Marking Scheme	*Leaving Certificate Examination, 2005*
Physics	*Higher Level*

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Leaving Certificate Examination

2005

Physics

Higher Level

General Guidelines

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 as appropriate which are separated by a solidus, /, are alternatives which are equally acceptable. Words which are separated by a solidus and which are underlined must appear in the correct context by including the rest of the statement to merit the assigned mark.

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 also 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 omission of appropriate 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)

Each question carries 40 marks. Marks awarded for the **three** best answers.

Question 1

In an experiment to verify the principle of conservation of momentum, a body A was set in motion with a constant velocity. It was then allowed to collide with a second body B, which was initially at rest and the bodies moved off together at constant velocity.

The following data was recorded.

Mass of body A = 520.1 g

Mass of body B = 490.0 g

Distance travelled by A for 0.2 s before the collision = 10.1 cm

Distance travelled by A and B together for 0.2 s after the collision = 5.1 cm

Draw a diagram of the apparatus used in the experiment. (9)

air track // (smooth) runway 3

two riders // two trolleys 3

cork-pin or velcro etc. for coalescing 3

Describe how the time interval of 0.2 s was measured. (6)

use ticker tape timer / 0.2 s is time taken for a 10 dot interval // two light gates and card (on trolley) 3

time interval between dots = 0.02 s (= 1/50 sec) // read time(s) 3

Calculate the velocity of the body A (i) before, (ii) after, the collision. (6)

velocity **before:** ($v = s/t = 0.101/0.2$)

v (= 0.505 m s^{-1}) $\approx 0.51 \text{ m s}^{-1}$ 3

velocity **after:** ($v = 0.051/0.2$)

v (= 0.255 m s^{-1}) $\approx 0.26 \text{ m s}^{-1}$ 3

(-1 for omission of or incorrect unit)

Show how the experiment verifies the principle of conservation of momentum. (12)

momentum **before**

$p = mv$ or $p = (0.5201)(0.505)$ 3

p (= 0.263) $\approx 0.26 \text{ kg m s}^{-1}$ 3

momentum **after**

[p = (0.5201 + 0.4900)(0.255)]

$p = 0.258 \approx 0.26 \text{ kg m s}^{-1}$ 3

momentum before ≈ momentum after 3

(-1 for omission of or incorrect unit)

How were the effects of friction and gravity minimised in the experiment? (7)

air (cushion) to separate surfaces // sloped runway // oil wheels or clean track 4

horizontal (track) // frictional force equal and opposite to gravitational force // tilt track so that trolley moves with constant velocity 3

Question 2

In an experiment to measure the specific latent heat of vaporisation of water, cool water was placed in an insulated copper calorimeter. Dry steam was added to the calorimeter. The following data was recorded.

Mass of calorimeter	=	50.5 g
Mass of calorimeter + water	=	91.2 g
Initial temperature of water	=	10 ^{o}C
Temperature of steam	=	100 ^{o}C
Mass of calorimeter + water + steam	=	92.3 g
Final temperature of water	=	25 ^{o}C

Calculate a value for the specific latent heat of vaporisation of water. (24)

[specific heat capacity of copper is 390 J kg^{-1} K^{-1} and the specific heat capacity of water is 4200 J kg^{-1} K^{-1}.]

$m_s l_w + m_s c_w \Delta\theta_s = m_w c_w \Delta\theta_w + m_c c_c \Delta\theta_c$ (or equivalent composite subscripts) 3×3

(each term omitted or incorrectly represented … –3)

$\Delta\theta_s$ = 75 (^{o}C) and $\Delta\theta_w$ (= $\Delta\theta_c$) = 15 (^{o}C) 3

(0.0011) l_w + (0.0011)(4200)(75) = (0.0407)(4200)(15) + (0.0505)(390)(15) 3×3

(each incorrectly substituted value … –3)

[(0.0011) l_w + 346.5 = 2564.1 + 295.425]

$l_w = 2.28 \times 10^6$ J kg^{-1} [accept range: (2.28 ~ 2.30)10^6] 3

(-1 for omission of or incorrect unit)

Why was dry steam used? (6)

condensed steam would already have lost its (s).l.h. (outside calorimeter) / calculations assume that <u>only steam</u> /<u>no water</u> is added / would not be possible to measure mass of any water added with steam 6

How was the steam dried? (4)

water trap / steam trap / insulated delivery tube / sloped delivery tube / allow steam to issue freely (initially) 4

A thermometer with a low heat capacity was used to ensure accuracy. Explain why. (6)

absorbs <u>no</u>/<u>less</u> heat from <u>system</u>/<u>water</u> (in calorimeter) / calculations assume that no energy is transferred to the thermometer 6

Question 3

In an experiment to verify Snell's law, a student measured the angle of incidence *i* and the angle of refraction *r* for a ray of light entering a substance. This was repeated for different values of the angle of incidence. The following data was recorded.

i / degrees	20	30	40	50	60	70
r / degrees	14	19	26	30	36	40

Describe, with the aid of a diagram, how the student obtained the angle of refraction. (9)

pins / ray box (to obtain incident and refracted rays) 3

diagram to show: outline of block, incident and refracted ray, normal 3

measure angle between refracted ray and normal (using a protractor / trig.) 3

sin *i*	0.34	0.50	0.64	0.77	0.87	0.94
sin *r*	0.24	0.33	0.44	0.50	0.59	0.64

Draw a suitable graph on graph paper and explain how your graph verifies Snell's law. (18)

sin *i* and sin *r* correct values (-1 for each incorrect value) 3

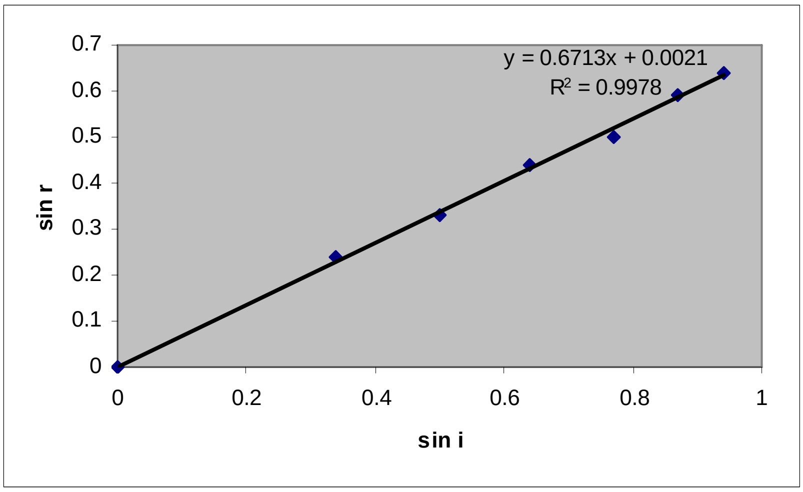
labelled axes 3

at least 5 points plotted correctly 3

straight line drawn 3

good distribution 3

conclusion e.g. sin *i* proportional to sin *r* / straight line through the origin 3



From your graph, calculate the refractive index of the substance. (9)

correct method for slope e.g. ($m =$) $y_2 - y_1 / x_2 - x_1$ 3

substitute coordinates of two points on the graph 3

$n = 1.49$ **(accept range: 1.44 – 1.50)** 3

The smallest angle of incidence chosen was 20°. Why would smaller values lead to a less accurate result? (4)

greater percentage error (in these readings) 4

Question 4

A student investigated the variation of the current *I* flowing through a filament bulb for a range of different values of potential difference *V*.

Draw a suitable circuit diagram used by the student. (12)

correct arrangement showing power supply, bulb, and means of varying voltage 2 x 3

(each item omitted or incorrectly located … -3)

ammeter in series with filament bulb 3

voltmeter in parallel with filament bulb 3

Describe how the student varied the potential difference. (4)

adjust rheostat / potentiometer / voltage on (variable) p.s.u. 4

With reference to the graph,
(i) explain why the current is not proportional to the potential difference (3)

not a straight-line graph 3

(ii) calculate the change in resistance of the filament bulb as the potential difference increases from 1 V to 5 V. (15)

At 1 V: $R = V/I$ 3

$= 1/0.028$ 3

$= 35.7\ \Omega$ 3

At 5 V: $R = (5/0.091) = 54.9\ \Omega$ 3

change in resistance (= 54.9 – 35.7) = 19.2 Ω **(-1 for omission of or incorrect unit)** 3

(Accept range: 17 ~ 20 Ω for change in resistance. **Zero** for any attempt using 'slope of graph' method.)

Give a reason why the resistance of the filament bulb changes. (6)

(as current increases) temperature of filament increases / filament gets hotter 3

more difficult for electrons /charge to pass through (due to increased vibrations of metal atoms) / *R* (of filament) increases with temperature 3

Section B (280 marks)

Each question carries 56 marks. Marks awarded for the best **five** answers.

Question 5 Marks awarded for the **eight** best answers.

(a) A container contains 5.0 kg of water. If the area of the base of the container is 0.5 m^2 calculate the pressure at the base of the container due to the water. (7) (g = 9.8 m s^{-2})

$P = F/A$ = [(5.0)(9.8)/(0.5)] 4

P = 98 Pa **(-1 for omission of or incorrect unit)** 3

(b) State Boyle's law. (7)

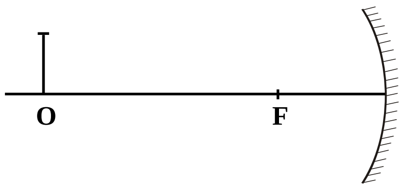
pressure is inversely proportional to volume / $p \propto 1/V$ / $pV = k$ 4

for a definite mass of gas at constant temperature 3

(c) What is the thermometric property of a thermocouple? (7)

emf / E / voltage / V / p.d. 7

(d) An object O is placed 30 cm in front of a concave mirror of focal length 10 cm. How far from the mirror is the image formed? (7)



$1/u + 1/v = 1/f$ / $1/30 + 1/v = 1/10$ 4

v = 15 (cm) = 0.15 (m) 3

(e) A capacitor of capacitance 100 μF is charged to a p.d. of 20 V. What is the energy stored in the capacitor? (7)

$E = ½CV^2$ / $E = ½(100 \times 10^{-6})(20)^2$ / $E = ½(100)(20)^2$ 4

E = 0.02 J **(-1 for omission of or incorrect unit)** 3

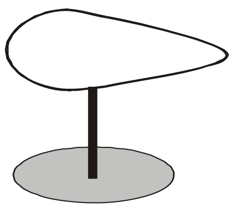
(f) Draw a sketch of the magnetic field due to a long straight current-carrying conductor. (7)

(concentric) circles with arrows (indicating correct direction of field) 4

conductor with arrow (indicating direction of current in the conductor) 3

(no direction for field … -1. no direction for current … -1.)

(g) A pear-shaped conductor is placed on an insulated stand is shown. Copy the diagram and show how the charge is distributed over the conductor when it is positively charged. (7)



concentration of charge at pointed end 4

charge indicated throughout the conductor 3

(h) Explain why high voltages are used in the transmission of electrical energy. (7)

high voltages ➔ smaller currents (required for equivalent power transmission) 4

less <u>power</u> / <u>heat</u> / <u>energy</u> losses 3

(i) How are electrons produced in an X-ray tube? (7)

at the (heated) cathode / filament 4

thermionic emission occurs 3

(j) Name the fundamental force of nature that holds the nucleus together.
Or
Draw the truth table for the AND gate. (7)

strong // 0-1; 1-0; 0-0 gives 0 (output) 4

nuclear // 1-1 gives 1 (output) 3

Question 6

Define (i) angular velocity, (ii) centripetal force. (12)

(i) $\omega = \theta/t$ // angle traced out / angular displacement // rate of change 3

correct notation // per unit time / sec // of angle 3

(ii) $F = mv^2/r$ or mw^2r // force on body in circular motion 3

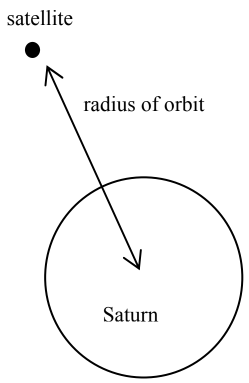
correct notation // towards the centre (of orbit) 3

State Newton's Universal Law of Gravitation. (6)

$F = \dfrac{Gm_1m_2}{d^2}$ / $F \propto \dfrac{m_1m_2}{d^2}$ // force proportional to product of masses 3

correct notation // inversely proportional to distance squared 3

A satellite is in a circular orbit around the planet Saturn. Derive the relationship between the period of the satellite, the mass of Saturn and the radius of the orbit. (15)



Gravitational force = centripetal force 3

$v^2 = GM/r$ or $w^2 = GM/r^3$ 3

$T = 2\pi r/v$ or $T = 2\pi/w$ 3

$T^2 = 4\pi^2r^2/v^2$ or $T^2 = 4\pi^2/w^2$ 3

$T^2 = 4\pi^2r^3/GM$ 3

(**final formula presented without derivation .. 3 marks only**)

The period of the satellite is 380 hours. Calculate the radius of the satellite's orbit around Saturn. (9)

T = <u>380 × 60 × 60</u> / <u>1.368 × 10^6</u> / <u>1.37 × 10^6</u> (s) 3

$(380 \times 3600)^2 = 4\pi^2r^3/(6.7 \times 10^{-11})(5.7 \times 10^{26})$ 3

$r = 1.2 \times 10^9$ m **(-1 for omission of or incorrect unit)** 3

The satellite transmits radio signals to earth. At a particular time the satellite is 1.2×10^{12} m from earth. How long does it take the signal to travel to earth? (9)

$v = s/t$ 3

$(3.0 \times 10^8) = (1.2 \times 10^{12})/t$ 3

t = <u>4000 s</u> / <u>1.1 h</u> **(-1 for omission of or incorrect unit)** 3

It is noticed that the frequency of the received radio signal changes as the satellite orbits Saturn. Explain why. (5)

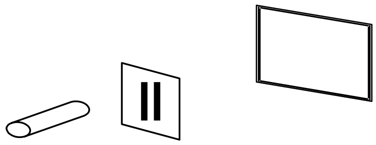
Doppler effect // satellite moves towards (earth) 3

due to relative motion between source (of signal) and detector // and away from <u>earth</u> / <u>detector</u> 2

(universal gravitational constant = 6.7×10^{-11} N m^2 kg^{-2} mass of Saturn = 5.7×10^{26} kg; speed of light = 3.0×10^8 m s^{-1})

Question 7
A student used a laser, as shown, to demonstrate that light is a wave motion.

(i) Name the two phenomena that occur when light passes through the pair of narrow slits. (6)



diffraction 3
interference 3

(ii) A pattern is formed on the screen. Explain how the pattern is formed. (12)

slits act as coherent sources 3

waves <u>overlap</u> / <u>meet</u> / path difference between waves (or shown on diagram) 3

constructive interference gives <u>brightness</u> / <u>bright lines</u> / <u>bright fringes</u> 3

destructive interference gives <u>darkness</u> / <u>dark lines</u> / <u>dark fringes</u> 3

(iii) What is the effect on the pattern when

(a) the wavelength of the light is increased. (4)

distance between <u>fringes</u> / <u>lines</u> / <u>spots</u> increases // pattern more spread out 4

(b) the distance between the slits is increased. (4)

distance between <u>fringes</u> / <u>lines</u> / <u>spots</u> decreases // pattern less spread out 4

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

two loudspeakers connected to signal generator // rotate vibrating (tuning) fork 3

walk in front of and parallel to speakers // near ear 3

observation: (e.g. sound <u>loud and low</u> / <u>waxes and wanes</u>) 3

conclusion: interference occurs showing that sound is a wave motion 3

Sound travels as longitudinal waves while light travels as transverse waves. Explain the difference between longitudinal and transverse waves. (9)

longitudinal waves: the direction of the vibrations (of medium) 3

is parallel to the direction of (propagation) of the wave 3

transverse wave: the direction (of the vibrations) is perpendicular to the (direction of the) wave 3

Describe an experiment to demonstrate that light waves are transverse waves. (9)

light source and two pieces of polaroid 3

rotate one polaroid relative to the other and light (intensity)decreases (to zero) 3

<u>polarization</u> indicates transverse waves 3

Question 8

Nuclear disintegrations occur in radioactivity and in fission.

Distinguish between radioactivity and fission. (12)

radioactivity is the disintegration of an (unstable) nucleus 3

with the emission of α / β / γ / radiation 3

fission is the splitting of a (large) nucleus 3

into two <u>similar sized</u> / <u>smaller</u> nuclei with the release of energy and neutrons 3

Give an application of (i) radioactivity, (ii) fission. (6)

(i) smoke detectors, carbon dating, tracing leaks, medical (cancer treatment, sterilising), etc. 3

(ii) generating electrical <u>energy</u> / <u>power</u>, bombs 3

Radioactivity causes ionisation in materials. What is ionisation? (3)

the charging of a (neutral) atom / (when) atom loses (or gains) electron(s)

/ atom (formed) with unequal number of + and - (charges) 3

Describe an experiment to demonstrate the ionising effect of radioactivity. (12)

apparatus // radioactive source and charged (gold leaf) electroscope 3

procedure // bring radioactive source close to the cap 3

observation // leaves collapse 3

conclusion //as charge leaks away through ionised air / electroscope neutralised by ionised air 3

Cobalt–60 is a radioactive isotope with a half-life of 5.26 years and emits beta particles.

(i) Write an equation to represent the decay of cobalt–60. (9)

$^{60}_{27}Co \rightarrow ^{0}_{-1}e + ^{60}_{28}Ni$ **(each incorrect item .. –3)** 3×3

(numbers consistently inverted or placed to the left, right or alternate side of symbol, acceptable.)

(ii) Calculate the decay constant of cobalt–60. (8)

formula: $\lambda T_{½} = \ln 2$ 3

correct substitution (i.e. $T_{1/2}$ = 5.26 y / 1.66×10^8 s and ln 2 = 0.693) 3

answer: $\lambda = 4.18 \times 10^{-9}\ s^{-1}$ / 3.61×10^{-4} days^{-1} / 0.132 y^{-1} 2

(-1 for omission of or incorrect unit)

(iii) Calculate the rate of decay of a sample of cobalt–60 when it has 2.5×10^{21} atoms. (6)

<u>activity</u> / <u>*A*</u> / <u>*dN/dt*</u> = (-)λN 3

= 1.04 (5) × 10^{13} Bq (or s^{-1}) **(-1 for omission of or incorrect unit)** 3

(decay w.r.t. years => 3.30×10^{20} y^{-1})

Question 9

Define (i) potential difference. (6)

work done // $V = W / Q$ 3

moving unit charge between two points // notation 3

(ii) resistance. (6)

$R = V/I$ // voltage per 3

notation // unit current 3

Two resistors, of resistance R_1 and R_2 respectively, are connected in parallel. Derive an expression for the effective resistance of the two resistors in terms of R_1 and R_2. (12)

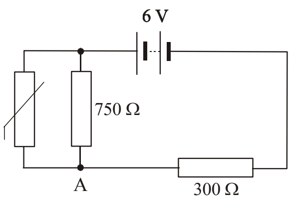
$I_T = I_1 + I_2$ 3

(apply Ohm's law) $V = IR$ 3

$V/R_T = V/R_1 + V/R_2$ 3

$1/R_T = 1/R_1 + 1/R_2$ 3

In the circuit diagram, the resistance of the thermistor at room temperature is 500 Ω.
At room temperature, calculate:



(i) the total resistance of the circuit. (9)

$1/R_p = 1/500 + 1/750$ 3

$R_p = 300\ \Omega$ 3

$R_{cct} = 600\ \Omega$ 3

(no penalty incurred here re units)

(ii) the current flowing through the 750 Ω resistor. (9)

$I_{cct} = \underline{(V / R)_{cct}}$ / $= \underline{6 \div 600}$ / $= \underline{0.01}$ A 3

($V_{branch} =$) $V_{300} = \underline{(0.01)(300)}$ / $\underline{3\ V}$ 3

I_{750} (= 3 ÷ 750) = $\underline{4 \times 10^{-3}\ A}$ / $\underline{4\ mA}$ 3

(-1 for omission of or incorrect unit)

As the temperature of the room increases, explain why:

(iii) the resistance of the thermistor decreases (7)

more energy added to the thermistor / temperature of Th3 increases 3

(more) electrons <u>produced</u> / <u>released</u> 2

(resistance is reduced because) more <u>electrons</u> /<u>charge carriers</u> are available for conduction 2

(iv) the potential at A increases. (7)

resistance of thermistor (and 750 Ω combination) decreases 3

potential difference across thermistor and 750 Ω combination decreases 2

potential at A increases 2

Question 10

Define electric field strength. (6)

$E = F/Q$ // force per 3

notation // unit charge 3

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

force proportional to product of charges // $F = Q_1Q_2/4\pi\varepsilon r^2$ // $F \propto Q_1Q_2/r^2$ 3

inversely proportional to square of distance // notation // notation 3

Why is Coulomb's law an example of an inverse square law? (6)

(because) F is proportional to $1/d^2$ / as distance is doubled force decreases by a factor of 4 6

Give two differences between the gravitational force and the electrostatic force between two electrons. (6)

gravitational force is much smaller (than the electrostatic force) 3

gravitational force is attractive, electrostatic force is repulsive 3

Describe an experiment to show an electric field pattern. (12)

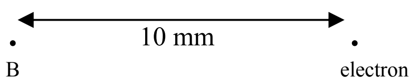
high voltage /H.T / E.H.T. and two metal plates /electrodes 3

semolina and oil in container 3

connect a (high) voltage to the plates (in container) 3

semolina lines up in the field 3

Calculate the electric field strength at the point B, which is 10 mm from an electron. (9)



E *or* $F = Q/4\pi\varepsilon d^2$ 3

$= (1.6 \times 10^{-19})/4\pi(8.9 \times 10^{-12})(0.01)^2$ 3

$E = 1.4 \times 10^{-5}$ N C^{-1} 3

(-1 for omission of or incorrect unit)

What is the direction of the electric field strength at B? (3)

towards the electron / to the right 3

A charge of 5 μC is placed at B. Calculate the electrostatic force exerted on this charge. (8)

(permittivity of free space = 8.9×10^{-12} F m^{-1}; charge on the electron = 1.6×10^{-19} C)

$F = Eq$ or $F = (1.4 \times 10^{-5})(5 \times 10^{-6})$ 3

$= 7.2 \times 10^{-11}$ N {accept range: $(7.1 \sim 7.2)10^{-11}$ N} **(-1 for omission of or incorrect unit)** 3

towards the electron 2

Question 11 (a) Answer **either** part (a) or part (b).

(a) Read the following passage and answer the accompanying questions.

Ernest Rutherford made the following point:

If the particles that come out naturally from radium are no longer adequate for my purposes in the laboratory, then maybe the time had come to look at ways of producing streams of fast particles artificially. High voltages should be employed for the task. A machine producing millions of alpha particles or protons would be required. These projectiles would be released close to a high voltage and would reel away at high speed. It would be an artificial particle accelerator. Potentially such apparatus might allow physicists to break up all atomic nuclei at will.

(Adapted from "The Fly in the Cathedral" Brian Cathcart; 2004)

(i) What is the structure of an alpha particle? (7)

Two protons // helium 4

two neutrons // nucleus (in context) 3

(ii) Rutherford had bombarded gold foil with alpha particles. What conclusion did he form about the structure of the atom? (7)

(dense) positive core / nucleus 4

(atom) mostly empty space / radius of nucleus ≈ 10^{-15} m / radius of atom ≈ 10^{-10} m 3

(iii) High voltages can be used to accelerate alpha particles and protons but not neutrons. Explain why. (7)

alpha particles and protons are charged 4

neutrons are not charged 3

(iv) Cockcroft and Walton, under the guidance of Rutherford, used a linear particle accelerator to artificially split a lithium nucleus by bombarding it with high-speed protons.

Copy and complete the following nuclear equation for this reaction. (7)

$^{4}_{2}He$ 4

$^{4}_{2}He$ 3

(v) Circular particle accelerators were later developed. Give an advantage of circular accelerators over linear accelerators. (7)

(progressively) increasing (or more) energy/speed attainable

/ more compact / occupy less space any one 7

(vi) In an accelerator, two high-speed protons collide and a series of new particles are produced, in addition to the two original protons. Explain why new particles are produced. (7)

(kinetic) energy (of the protons) 4

converted into mass (of new particles) 3

(vii) A huge collection of new particles was produced using circular accelerators. The quark model was proposed to put order on the new particles. List the six flavours of quark. (7)

Up, down, charm, strange, top, bottom (6 × 1) + 1

(viii) Give the quark composition of the proton. (7)

Up, up, down h/m 7

Question 11 (b)

(b) Read the following passage and answer the accompanying questions.

The scientist whose research would unite electricity and magnetism was Michael Faraday. He developed the first electric motor in 1821, showing that a current- carrying conductor could be made to revolve around a magnet. He went on to expand on Oersted's observation that an electric current produces a magnetic effect. Perhaps, Faraday thought, the opposite was also true: a moving magnetic field could generate an electric current. This was to be called electromagnetic induction. Soon he had created the first electric generator, and everyday life would never be the same again. His experiments with induced currents produced the transformer.

(Adapted from Milestones of Science; Curt Supple; 2000)

(i) List three factors that affect the force on a current-carrying conductor placed near a magnet. (7)

magnetic flux density (B), current (I), length (l), sin θ — any three — 3 + 2 + 2

(ii) What energy transformation takes place in an electric motor? (7)

electrical energy — 4

to kinetic energy — 3

(iii) What is the function of a commutator in a dc motor? (7)

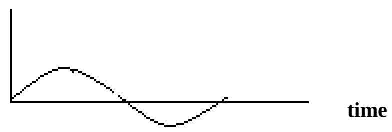
allows current to always flow // so that torque — 4

into the same end of the coil (and out the other end) // is always in the same direction — 3

(iv) Draw a sketch of the output voltage from an ac generator. (7)

varying (voltage) wrt time — 4

sinusoidal shape — 3



(v) How are the slip rings connected to an external circuit in an ac generator? (7)

brushes — 4

springs / carbon / metal — 3

(vi) A transformer and an induction coil can both be used to change a small voltage into a larger voltage. What is the basic difference in the operation of these two devices? (7)

transformer: a.c. input // a.c. output // current flows through secondary — 4

induction coil: d.c.input // (adjusted for) d.c. output // sparks across gap in secondary — 3

(vii) Name the Irish physicist who invented the induction coil. (7)

(Dr. Nicholas) Callan — 7

(viii) Give two factors that affect the efficiency of a transformer. (7)

(I^2R) heat losses in coils / eddy currents (in core) / poor flux linkage / poor core design / hysteresis losses / coil resistance — any two — 4 + 3

Question 12 Answer any **two** parts.

Question 12 (a)

State the principle of conservation of energy. (6)

energy cannot be created or destroyed // total energy of an <u>isolated</u> /<u>closed</u> system 3

it can be changed from one form into another // remains constant 3

A basketball of mass 600 g which was resting on a hoop falls to the ground 3.05 m below. What is the maximum kinetic energy of the ball as it falls? (9)

(max) KE = PE (at height of 3.05 m) // $v^2 = u^2 + 2as$ / $v^2 = 0 + 2(9.8)(3.05)$ 3

$E = mgh$ // $v^2 = 59.78$ 3

$E = 17.9(34)$ J // $[E_k = \frac{1}{2}mv^2 = \frac{1}{2}(0.60)(59.78)]$ ➔ $E_k = 17.9(34)$ J 3

(-1 for omission of or incorrect unit)

On bouncing from the ground the ball loses 6 joules of energy. What happens to the energy lost by the ball? (4)

changes into <u>sound</u> / <u>heat</u> /<u>other forms</u> 4

Calculate the height of the first bounce of the ball. (9)

(acceleration due to gravity = 9.8 m s^{-2})

[retained energy = E = 17.9 – 6] ➔ E = 11.9 J 3

$[h = E/mg]$ ➔ h = 11.9 / (0.600)(9.8) 3

h = 2.02 m accept range: (2.02 --- 2.03) m 3

(-1 for omission of or incorrect unit)

Question 12 (b)

Define magnetic flux. (6)

$\phi = BA$ 3

notation 3

State Faraday's law of electromagnetic induction. (6)

(magnitude of the) emf induced (in conductor) is proportional to // E (or e) $\propto$ (or $=$) 3

the rate of change of (magnetic) flux (cutting the conductor) // $\frac{d\phi}{dt}$ 3

A square coil of side 5 cm lies perpendicular to a magnetic field of flux density 4.0 T. The coil consists of 200 turns of wire.
What is the magnetic flux cutting the coil? (9)

$A = (0.05)^2 = 0.0025$ 3

ϕ $(= BA) = (4)(0.0025)$ 3

$\phi = 0.01$ Wb **(-1 for omission of or incorrect unit)** 3

The coil is rotated through an angle of 90^o in 0.2 seconds. Calculate the magnitude of the average e.m.f. induced in the coil while it is being rotated. (7)

$E = N(\Delta\phi/\Delta t)$ 3

$\Delta\phi/\Delta t = 0.01 - 0)/0.2$ or $= 0.05$ 2

[E= 200(0.05)] ➔ E = 10 V **(-1 for omission of or incorrect unit)** 2

Question 12 (c)

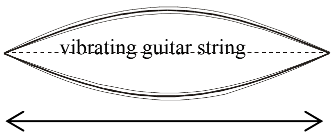
The frequency of a stretched string depends on its length.
Give two other factors that affect the frequency of a stretched string. (6)

tension 3

mass per unit length / mass per metre / linear density 3

The diagram shows a guitar string stretched between supports 0.65 m apart. The string is vibrating at its first harmonic.

The speed of sound in the string is 500 m s^{-1}. What is the frequency of vibration of the string? (9)



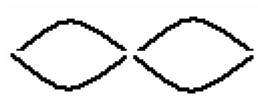
$\lambda = 2 \times 0.65$ or 1.3 m 3

$v = f\lambda$ 3

$[f = v/\lambda = 500 / 1.3] \Rightarrow f = 384.6$ Hz 3

(-1 for omission of or incorrect unit)

Draw a diagram of the string when it vibrates at its second harmonic. (7)



h/m 7

What is the frequency of the second harmonic? (6)

$f_{2nd} = 2f_{1st}$ 3

= 769.2 Hz **(-1 for omission of or incorrect unit**…. penalise ***once*** only for hertz unit**)** 3

Question 12 (d)

One hundred years ago, Albert Einstein explained the photoelectric effect.

What is the photoelectric effect? (6)

emission of electrons from the surface of a metal 3

when light of suitable <u>frequency</u> / <u>energy</u> shines on it 3

Write down an expression for Einstein's photoelectric law. (9)

$hf = \phi + \frac{1}{2}mv^2$ **(each incorrect item … -3)** 3×3

Summarise Einstein's explanation of the photoelectric effect. (9)

<u>photons</u> (of light) / <u>quanta</u> / <u>packets (or bundles) of energy</u> 3

<u>all of energy</u> from one photon is given to one electron 3

energy must be greater than work function of metal <u>for P.E.E. to occur</u> / <u>for electron to escape</u> 3

Give one application of the photoelectric effect. (4)

sound track in film, photography, counters, photocell, burglar alarm, automatic doors, etc. 4