Coimisiún na Scrúduithe Stáit
State Examinations Commission

Scéimeanna Marcála	Scrúduithe Ardteistiméireachta, 2007
Fisic	**Ardleibhéal**

Marking Scheme	Leaving Certificate Examination, 2007
Physics	**Higher Level**

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Scéim Mharcála	*Scrúdú na hArdteistiméireachta 2007*
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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 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 are awarded for the **three** best answers.

Question 1

A student investigated the laws of equilibrium for a set of co-planar forces acting on a metre stick. The student found that the centre of gravity of the metre stick was at the 50.4 cm mark and its weight was 1.2 N.

How did the student find:

(i) **the centre of gravity,**

metre stick on a pivot (e.g. wedge, thread support, bench edge, etc.) / correct diagram 6

(ii) **the weight, of the metre stick?**

place on a newton balance / weighing scales **(-1 if no reference to weight / N / *g*)** 6

Why is the centre of gravity of the metre stick not at the 50.0 cm mark?

non-uniform / chipped / worn, etc. // zero mark / 100 cm not (exactly) at one end 3

The student applied vertical forces to the metre stick and adjusted them until the metre stick was in equilibrium.

How did the student know that the metre stick was in equilibrium?

(metre stick was) at rest / stationary / balanced / horizontal / level // "the forces and the moments both balance" 4

The student recorded the following data.

position on metre stick / cm	11.5	26.2	38.3	70.4	80.2
magnitude of force / N	2.0	4.5	3.0	5.7	4.0
direction of force	down	up	down	up	down

Calculate:

(i) **the net force acting on the metre stick**

F_{up} = 4.5 + 5.7 = 10.2 and F_{down} = 2 + 3 +1.2 +4 = 10.2 N / net force = 0 3

(ii) **the total clockwise moment about a vertical axis of the metre stick**

(For any axis e.g. through zero:)

C.T.M. = 2(0.115) + 3(0.383) +1.2(0.504) +4.0(0.802)

or 0.23+1.149+0.6048+3.208 **or** 5.1918 N m **or** 5.2 N m 6

(iii) **the total anti-clockwise moment about a vertical axis of the metre stick.**

(for same axis), A.C.T.M. = 4.5(0.262) +5.7(0.704) **or** 5.1918 N m **or** 5.2 N m 6

(For (ii) and (iii), penalise once only: **-1 for omission of or incorrect units)**

[State/imply: turning moment = force x (perp) distance …. award 6 marks if zero credit gained for (ii) and (iii) above]

Use these results to verify the laws of equilibrium.

net force is zero / F_{up} = F_{down} // net turning moment is zero / C.(T.) M = A.C.(T.).M

any one law 6

(final 6 marks awarded only for verification of laws arising from preceding calculations)

Question 2

The specific heat capacity of water was found by adding hot copper to water in a copper calorimeter. The following data was recorded.

mass of calorimeter	55.7 g
mass of calorimeter + water	101.2 g
mass of copper + calorimeter + water	131.4 g
initial temperature of water	16.5 ^{o}C
temperature of hot copper	99.5 ^{o}C
final temperature of water	21.0 ^{o}C

Describe how the copper was heated and how its temperature was measured.

any source of energy 6

thermometer **/** temperature sensor (or probe) **/** reference to 100 ^{o}C (if copper in boiling water) / temperature of (boiling) water 3

Using the data, calculate:

(i) the energy lost by the hot copper

$E = m\,c\,\Delta\theta$ 4

$E =$ (3.02 x 10^{-2})(390)(78.5) or 924.57 or 924.6 J 3

(-1 for omission of or incorrect units)

(ii) the specific heat capacity of water.

Heat lost by hot copper = heat gained by calorimeter + water **(stated or implied)** 3

924.57 = (0.0557)(390)(4.5) + (0.0455)(c_w)(4.5) **or** 924.57 = 97.75 + 0.2048 c_w 3

c_W = 4.038 x 10^{3} ≈ 4.04 x 10^{3} J kg^{-1} K^{-1} 3

(-1 for omission of or incorrect units)

accept range: (4.03 ↔ 4.04)10^{3} J kg^{-1} K^{-1} **(-1 if outside range)**

Give two precautions that were taken to minimise heat loss to the surroundings.

insulate calorimeter /use lid /transfer copper(pieces) quickly / use cold water (below room temperature) /avoid splashing / polish calorimeter / low heat capacity thermometer, etc. **any two** …. 6 + 6

Explain why adding a larger mass of copper would improve the accuracy of the experiment.

smaller % error **(-1 if % omitted)** / greater rise (or change) in (water) temperature 3

(specific heat capacity of copper = 390 J kg^{-1} K^{-1})

Question 3
In an experiment to measure the focal length of a concave mirror, an approximate value for the focal length was found. The image distance *v* was then found for a range of values of the object distance *u*. The following data was recorded.

u/cm	15.0	20.0	25.0	30.0	35.0	40.0
v/cm	60.5	30.0	23.0	20.5	18.0	16.5

How was an approximate value for the focal length found?

<u>image of</u> / <u>light from</u> a distant object (e.g. window) focused on a screen 6
measure distance from screen to mirror 2

What was the advantage of finding the approximate value for the focal length?

to avoid placing object inside (or near) *f* (during experiment) / to make it easier to find the image (later)
to confirm (or to indicate magnitude of) final answer 2

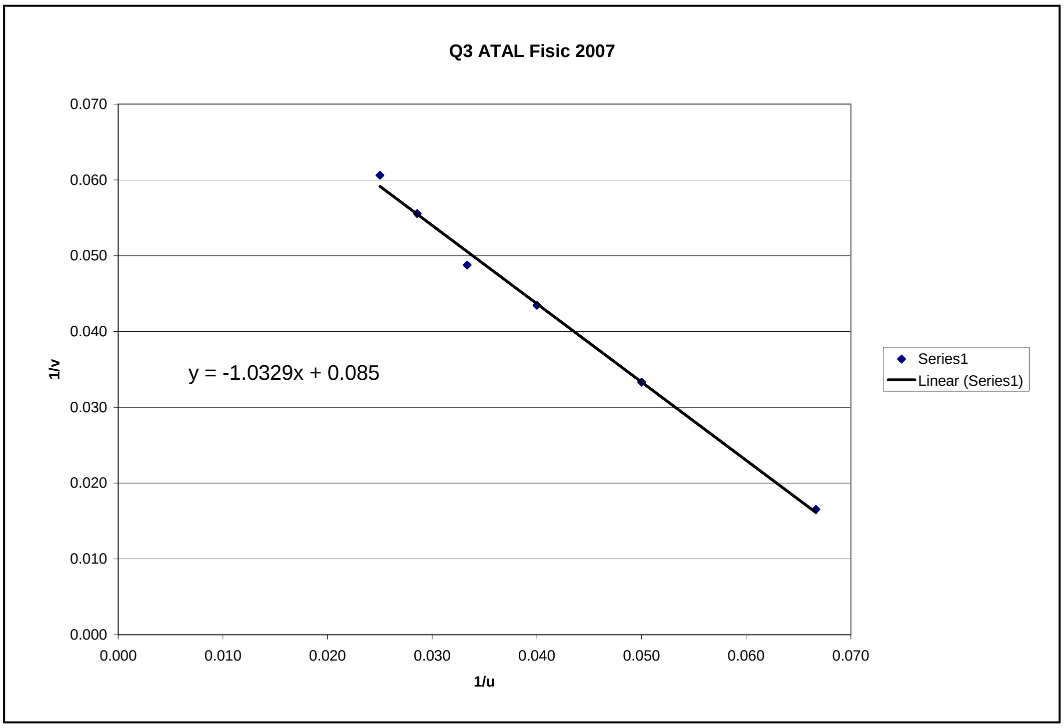
Describe, with the aid of a labelled diagram, how the position of the image was found.
apparatus: object, concave mirror, screen 6
arrangement: correct arrangement with object and screen on same side of mirror and with image on screen 6
(-1 if no diagram; -1 if no reference to image)

Calculate the focal length of the concave mirror by drawing a suitable graph based on the recorded data.

calculate $^1/u$ and $^1/v$ values	label axes *u* and *v*	3
label axes	plot at least five points	3
plot at least five points	draw smooth curve	3
straight line	locate point where $u = v$	3
extrapolate to cut axis (or axes) / read axis (or axes) value = (0.085 ± 0.003)	read coordinate(s)	3
focal length = 12.0 ± 1.0 (cm)	focal length = 12.0 ± 0.3 (cm)	3

(no unit required)

For use of data table rather than graphical work: formula: $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ (3)
correct substitution (3)
one correct *f* value (3)
f average (2 x 3)



Question 4

The following is part of a student's report of an experiment to investigate the variation of current I with potential difference V for a semiconductor diode.

I put the diode in forward bias as shown in the circuit diagram. I increased the potential difference across the diode until a current flowed. I measured the current flowing for different values of the potential difference. I recorded the following data.

V / V	0.60	0.64	0.68	0.72	0.76	0.80
I / mA	2	4	10	18	35	120

Draw a circuit diagram used by the student.

circuit showing battery (or p.s.u.), diode in forward bias, mA or A or current sensor in series, (protective R) 3 x 3

(-3 for any incorrect insertion or omission e.g. diode in reverse bias)

How did the student vary and measure the potential difference?

(adjust or change or slide) rheostat / potential divider // adjust or use variable power supply unit 3

(to measure p.d.) voltmeter or voltage sensor (placed across diode) 3

Draw a graph to show how the current varies with the potential difference.

axes labelled I and V 3

plot 5 points (at least) 3

correct shape **(see graph at page end)** 3

Estimate from your graph the junction voltage of the diode.

junction voltage = 0.60 ↔0.78 (V) **(unit not required)** 3

The student then put the diode in reverse bias and repeated the experiment. What changes did the student make to the initial circuit?

reverse p.s.u / reverse voltmeter / reverse ammeter / replace mA with µA
/ place voltmeter in parallel with the series combination of diode and milliammeter (or µA or A)

any two 2 x 3

Alternatively:

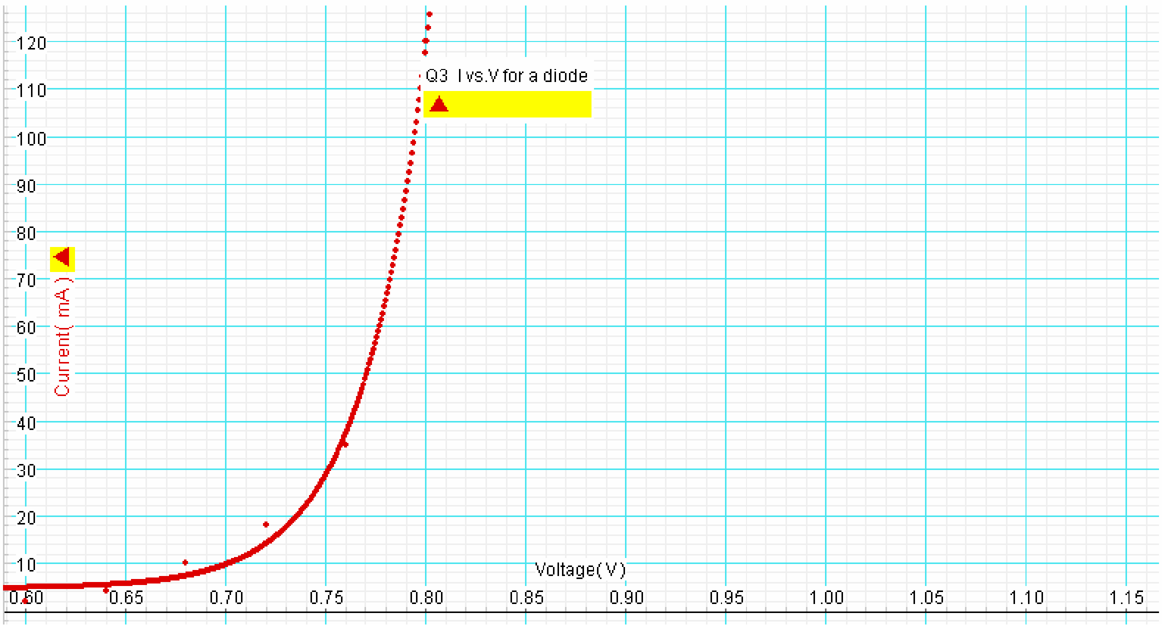
reverse the diode / replace mA with a µA / place voltmeter in parallel with the series combination of diode and milliammeter (or µA or A) [**any two** 2 x 3]

Draw a sketch of the graph obtained for the diode in reverse bias.

axes labelled I and V 3

correct shape (i.e. showing little or no current as V is increased negatively and maybe indicating a breakdown voltage) 4

[No graph drawn but statement: "no current flows in reverse bias" …. 4 marks]



SECTION B (280 marks)

Answer **five** questions from this section. Each question carries 56 marks.

Question 5

Answer any **eight** of the following parts *(a), (b), (c),* etc.

(a) **State Archimedes' principle.**

upthrust / buoyancy / (apparent) loss in weight (in fluid) equals 4

weight of fluid/ liquid/water displaced 3

(b) **Why is a filament light bulb not an efficient source of light?**

any reference to the production of: *heat* (*energy*) 7

["The output / light energy is only a small percentage / fraction of the input / electrical energy". … 7 marks]

(c) **Why does the temperature of an athlete reduce when she perspires?**

(latent) heat / energy taken from body 4

as perspiration / water evaporates // as water / liquid changes into steam / vapour /gas 3

(d) **How is infra-red radiation detected?**

thermometer / temperature sensor(or probe) / photographic film(or plate) / (by its) heating effect, etc. **(any one)** 7

(e) **The refractive index of a liquid is 1.35, what is the critical angle of the liquid?**

$n_g = {}^1/ \sin i_c$ ..… (4 marks)

$i_c = 47.8^o$ (-1 penalty for answer 53.1^o …. gradian mode used) 7

(f) **Calculate the energy stored in a 5 μF capacitor when a potential difference of 20 V is applied to it.**

$E = \frac{1}{2}CV^2$ 4

$E = ½ (5 \times 10^{-6})(20)^2$ **or** 1.0×10^{-3} J **or** 1.0 mJ 3

(g) **Why does a magnet that is free to rotate point towards the North?**

any reference to (earth's) magnetic field / like poles repel / unlike poles attract 7

(h) **State the principle on which the definition of the ampere is based.**

force between (two) conductors // current-carrying conductor experiences a force 4

carrying current // in a magnetic field 3

[correct formula … 7 marks]

(i) **How are electrons accelerated in a cathode ray tube?**

(by a large) p.d /voltage / H.T / E.H.T./ electric field 7

(j) **A kaon consists of a strange quark and an up anti-quark. What type of hadron is a kaon?**

a meson 7

or

Draw the basic structure of a bi-polar transistor.

three layers 4

emitter, base and collector (or e, b, c) connections correctly labelled 3

Question 6

State Hooke's law.

restoring force proportional to // $F = (-)\,ks$ 3

extension/displacement // correct notation 3

A stretched spring obeys Hooke's law. When a small sphere of mass 300 g is attached to a spring of length 200 mm, its length increases to 285 mm.

Calculate its spring constant.

$(F =)\ mg = ks$ 3

$(0.30)(9.8) = (k)(0.085)$ 3

$k = 34.588 \approx 34.6\ \text{N m}^{-1}$ **(-1 for omission of or incorrect units)** 3

The sphere is pulled down until the length of the spring is 310 mm. The sphere is then released and oscillates about a fixed point.

Derive the relationship between the acceleration of the sphere and its displacement from the fixed point.

$F = m\,a$ 3

$ma = -\,ks$ 2 x 3

$\Rightarrow\ a = -(k/m)s$ **or** $a \propto -s$ **or** $a = -(\text{constant})s$ (**penalty of -1 if negative sign omitted**) 3

Why does the sphere oscillate with simple harmonic motion?

its acceleration is proportional to // $a = -\omega^2 s$ **or** $a \propto -s$ (**penalty of -1 , once only, if negative sign omitted**) 3

its displacement (from a fixed point and always directed towards that point) // correct notation 3

(2 x 3 for conventional definition of S.H.M)

Calculate:

(i) the period of oscillation of the sphere

$T = \dfrac{2\pi}{\omega}$ 3

From above: $\omega^2 = \dfrac{k}{m}$ **or** $\omega^2 = \dfrac{34.6}{0.30}$ **(-1 if 300 g used)** 3

$\omega = 10.7$ 3

$T(= \dfrac{2\pi}{\omega} = \dfrac{2\pi}{10.7}) = 0.58 \approx 0.6$ ➔ $T = 0.6$ s **(-1 for omission of or incorrect units)** 3

(ii) the maximum acceleration of the sphere

(this occurs when s is a maximum, i.e. when s = amplitude = 0.310 – 0.285 = 0.025 m)

$a = -\omega^2 s$ 3

$a = -(10.7)^2(0.025)$ 3

$a = (-)2.89\ \text{m s}^{-2}$ **(-1 for omission of or incorrect units)** 3

(iii) the length of the spring when the acceleration of the sphere is zero.

(this occurs at the fixed point when) $l = 0.285$ m 2

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

Question 7

What is the Doppler effect?

apparent change in <u>frequency</u> / <u>wavelength</u> 3
due to relative motion between source and observer (state/imply: e.g. either S or O moving) 3

Explain, with the aid of labelled diagrams, how this phenomenon occurs.

non-concentric circles (-1 if not labelled as *waves*) 3
source and direction of motion (stated/implied) 3
position of observer indicated 3
<u>shorter wavelength</u> / <u>higher frequency</u> on approaching observer (or vice versa) 3

The emission line spectrum of a star was analysed using the Doppler effect. Describe how an emission line spectrum is produced.

(monatomic) gas (or atoms) 3
is heated / is excited /receives energy 3
electron(s) <u>move</u>/<u>jump</u> to higher <u>level</u>/<u>state</u> 3
<u>electromagnetic radiation</u>/<u>energy</u>/<u>photon</u>/<u>quantum</u> emitted on return 3

appropriate diagram may merit full marks (4 x 3)

Alternatively:

(monatomic) gas discharge tube / example, e.g. *Na* lamp (2 x 3)
spectrometer + <u>prism</u>/<u>grating</u> // a direct vision spectroscope // (diffraction) grating (3)
observation (e.g. a number of bright lines are seen) (3)

The red line emitted by a hydrogen discharge tube in the laboratory has a wavelength of 656 nm. The same red line in the hydrogen spectrum of a moving star has a wavelength of 720 nm.
Is the star approaching the earth? Justify your answer.

no 3
wavelength has increased // frequency has decreased 5

Calculate:

(i) the frequency of the red line in the star's spectrum

$f' = \frac{c}{\lambda'}$ or $c = f\lambda$ 3

$f' = \frac{3 \times 10^8}{720 \times 10^{-9}}$ **or** $f' = 4.17 \times 10^{14}$ Hz **(-1 for omission of or incorrect units)** 3

(no penalty here for use of 656 nm rather than 720 nm.

Accept answer: 4.57 x 10^{14} Hz)

(ii) the speed of the moving star.

(Similarly) $f = 4.57 \times 10^{14}$ Hz

formula: $f' = \frac{fc}{c + u}$ 3

substitution: $4.17 \times 10^{14} = \frac{(4.57 \times 10^{14})(3.00 \times 10^{8})}{3.00 \times 10^{8} + u}$ **(-3 for incorrect substitution)** 2 x 3

answer: $u = 2.92 \times 10^7$ m s^{-1} **(-1 for omission of or incorrect units)** 3

(speed of light = 3.00×10^8 m s^{-1})

Question 8

Define electric field strength and give its unit of measurement.

force // $(E =)F / q$ 3

per unit charge // correct notation 3

N C^{-1} or V m^{-1} 3

Describe how an electric field pattern may be demonstrated in the laboratory.

apparatus oil, metal plates, container, semolina, H.T. **(-1 for each omission)** 3

arrangement correct arrangement 3

procedure switch on power (state or imply) 3

observation semolina particles line up (to show field pattern) 3

The dome of a Van de Graff generator is charged. The dome has a diameter of 30 cm and its charge is 4 C.
A 5 μC point charge is placed 7 cm from the surface of the dome.

Calculate:

(i) the electric field strength at a point 7 cm from the dome

(For +1 C at point P):

formula: $(E =)F = \dfrac{q_1 q_2}{4\pi\varepsilon d^2}$ 3

substitution: $(E =)F = \dfrac{(1)(4)}{4\pi(8.9 \times 10^{-12})(0.22)^2}$ **(-1 if 0.07 used instead of 0.22 m)** 3

answer: $E = 7.39 \times 10^{11}$ N C^{-1} **(-1 for omission of or incorrect units)** 3

[Candidates may work with *E* or *F* initially but must conclude with answer showing *E* … otherwise -1]

(ii) the electrostatic force exerted on the 5 μC point charge.

formula: $F = E\ q$ 3

answer: $F = (7.39 \times 10^{11})(5 \times 10^{-6})$ or $F = 3.69 \times 10^{6}$ N **(-1 for omission of or incorrect units)** 3

All the charge resides on the surface of a Van de Graff generator's dome. Explain why.

like charges repel 3

charges are a maximum distance apart (on <u>outside</u>/<u>surface</u> of dome) 3

Describe an experiment to demonstrate that total charge resides on the outside of a conductor.

apparatus: metal can, gold leaf electroscope, proof plane **(-1 for each omission)** 3

procedure: charge metal can and use proof plane to test inside and outside 3

observation: leaves on g.l.e. deflect for outside sample only 3

conclusion: charge resides on outside only 3

(experiment could also be performed using a butterfly net)

Give an application of this effect.

electrostatic shielding / co-axial cable / TV (signal) cable
/ to protect persons or equipment, enclose them in hollow conductors
/Faraday cages (there is no electric field inside a closed conductor), etc.

any relevant application 2

(permittivity of free space = 8.9×10^{-12} F m^{-1})

Question 9

Define (i) resistance

voltage // V/I or P/I^2 3

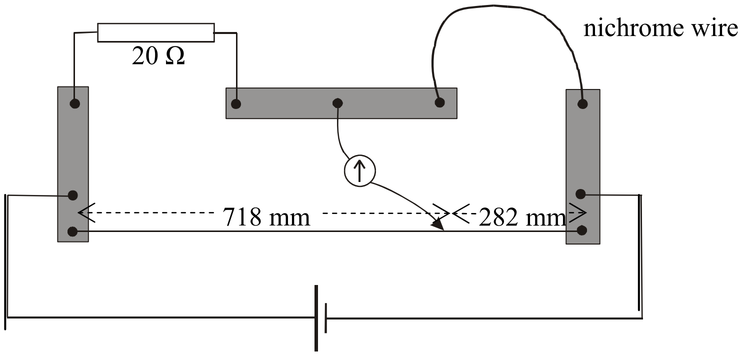
divided by current /per unit current // correct notation 3

(ii) resistivity.

the resistance // RA/L 3

of a cube of material of side 1 m // correct notation 3

A metre bridge was used to measure the resistance of a sample of nichrome wire. The diagram indicates the readings taken when the metre bridge was balanced. The nichrome wire has a length of 220 mm and a radius of 0.11 mm.



Calculate:

(i) the resistance of the nichrome wire

$$\frac{R_1}{R_2} = \frac{L_1}{L_2}\left(= \frac{R_3}{R_4}\right)$$ 3

$$\frac{R}{20} = \frac{282}{718}$$ 3

$\Rightarrow$ $R = 7.86\ \Omega$ **(-1 for omission of or incorrect units)** 3

(ii) **the resistivity of nichrome.**

$$\rho = \frac{RA}{L}$$ state or imply 3

$$\rho = \frac{(7.855)(3.801\times10^{-8})}{0.220}$$ **(-1 if incorrect *A*)** 3

$\Rightarrow$ $\rho = 1.36 \times 10^{-6}\ \Omega$ m **(-1 for omission of or incorrect units)** 3

Sketch a graph to show the relationship between the temperature and the resistance of the nichrome wire as its temperature is increased.

axes labelled R and T (or θ) 3

correct linear graph with intercept showing R greater than zero **(-1 if line passes through origin)** 3

What happens to the resistance of the wire:

(i) as its temperature falls below 0°C ?

R decreases 3

(ii) as its length is increased ?

R increases 4

(iii) **if its diameter is increased ?**

R decreases 4

Name another device, apart from a metre bridge, that can be used to measure resistance.

ohmmeter / wheatstone bridge / /multimeter / DMM / ammeter + voltmeter any one 6

Give one advantage and one disadvantage of using this device instead of a metre bridge.

ohmmeter:	compact, portable, faster method, etc.	less accurate, fragile, difficult to calibrate/check,
wheatstone bridge:	compact, portable, more accurate etc.	'black box' difficult to comprehend, expensive,
ammeter +voltmeter:	easy to use, easy to understand, etc.	range selection difficult, fragile, less accurate

one advantage + one disadvantage of the chosen device 2 + 1

Question 10 (a) Answer **either** part *(a)* **or** part *(b)*.

Read the following passage and answer the accompanying questions.

Ernest Walton was one of the legendary pioneers who made 1932 the *annus mirabilis* of experimental nuclear physics. In that year James Chadwick discovered the neutron; Carl Anderson discovered the positron; Fermi articulated his theory of radioactive decay; and Ernest Walton and John Cockcroft split the nucleus by artificial means. In their pioneering experiment Cockcroft and Walton bombarded lithium nuclei with high-energy protons linearly accelerated across a high potential difference (*c.* 700 kV). The subsequent disintegration of each lithium nucleus yielded two helium nuclei and energy. Their work gained them the Nobel Prize in 1951.

(Adapted from "Ernest Thomas Sinton Walton 1903 –1995 The Irish Scientist" McBrierty; 2003)

(i) Draw a labelled diagram to show how Cockcroft and Walton accelerated the protons.

anode and cathode (in tube) / (lithium) target / two helium nuclei 3

p.d / V / H.T 3

What is the velocity of a proton when it is accelerated from rest through a potential difference of 700 kV?

$W = qV$ 3

$W = \frac{1}{2}mv^2$ 3

$v^2 = \dfrac{2(1.6022\times10^{-19})(7.00\times10^{5})}{1.6726\times10^{-27}}$ 3

$\Rightarrow v = 1.16 \times 10^7$ m s^{-1} **(-1 for omission of or incorrect units)** 3

Write a nuclear equation to represent the disintegration of a lithium nucleus when bombarded with a proton.

${}^{7}_{3}Li + {}^{1}_{1}H \rightarrow 2\,{}^{4}_{2}He$ **(accept *p* for *H* and α for *He* ; -1 for each error)** 3 x 3

Calculate the energy released in this disintegration.

mass of reactants = $1.1646 \times 10^{-26} + 1.6726 \times 10^{-27}$ **or** 1.33186×10^{-26} (kg) 3

mass of products = $2(6.6443 \times 10^{-27})$ **or** 1.32886×10^{-26} (kg) 3

$\Delta m = 3.00 \times 10^{-29}$ kg 3

$E = mc^2$ **or** $E = (3.00 \times 10^{-29})(9 \times 10^{16})$ **or** $E = 2.7 \times 10^{-12}$ J 3

(-1 for omission of or incorrect units)

(ii) Compare the properties of an electron with that of a positron.

(both have) equal mass / charges equal / charges opposite (in sign) / matter and anti-matter

any *one* direct comparison 5

What happens when an electron meets a positron?

(pair) annihilation / energy released(or produced) / γ-rays emitted 3

(iii) In beta decay it appeared that momentum was not conserved.
How did Fermi's theory of radioactive decay resolve this?

any reference to *neutrino* 6

(neutrino had the *missing*) momentum 3

(charge on electron = 1.6022×10^{-19} C; mass of proton = 1.6726×10^{-27} kg;
mass of lithium nucleus = 1.1646×10^{-26} kg; mass of helium nucleus = 6.6443×10^{-27} kg;
speed of light = 2.9979×10^{8} m s^{-1})

Question 10 (b)

State the principle of conservation of energy.

energy cannot be created or destroyed // total energy is constant **(-1 if *conserved* is used instead of *constant*)**	3
may change from one form to another // in a closed system	3

What is the main energy conversion that takes place in an electric motor?

electrical (energy)	3
to mechanical / kinetic (energy)	3

What is the function of :

(i) the commutator,

so that coil rotates in one direction / (it) reverses current (every half-cycle) 5

(ii) the carbon brushes,

to link power supply to coil / to enable current to enter coil (as it rotates) 5

(iii) the magnet, in an electric motor?

to provide a magnetic field / to interact with the current-carrying coil / (to help) create the torque 5

Why does the motor turn when current flows through the coil?

a current-carrying <u>coil</u>/<u>conductor</u>	3
experiences a <u>force</u> /<u>torqu</u>e	3
in a magnetic field	3

The induction motor was invented by Nicholas Tesla. Give an advantage of an induction motor over a dc motor.

no brushes (to replace)
not affected by (minor) voltage fluctuations
<u>less</u>/ <u>no</u> electrical interference
<u>stabilised</u>/<u>smoother</u>/<u>constan</u>t rate of rotation, etc.
less friction
no sparking — any *one* advantage 5

Describe an experiment to demonstrate the principle on which the induction motor operates.

apparatus:	aluminum disc, magnet	**(3 marks each item: -1 if magnetic material used)**	2 x 3
arrangement:	place disc on (pointed) pivot		3
procedure:	rotate magnet over disc		3
observation:	disc rotates (in same direction as magnet)		3

Question 11
Read the following passage and answer the accompanying questions.

At present, nuclear fission reactors supply a sixth of the world's electricity. Along with hydroelectric stations they are the major source of 'carbon-free' energy today. Nuclear reactors have shown remarkable reliability and efficiency even though the development of nuclear technology was held back by the nuclear accidents at Chernobyl and Three Mile Island.
A nuclear revival is possible. The global reserves of uranium could support a much larger number of reactors than exist today. Nuclear power generation could increase from three hundred gigawatts today to one thousand gigawatts by the year 2050, saving the earth from 1.5 billion tonnes of carbon emissions a year. Already more than twenty gigawatts of nuclear capacity have come online since 2000. Nuclear power would significantly contribute to the stabilisation of greenhouse gas emissions.

The type of reactor that will continue to dominate for the next two decades is the light water reactor, which uses ordinary water (as opposed to heavy water, containing deuterium) as the coolant and moderator.

Solar cells, wind turbines and biofuels are becoming viable energy sources. Solar cells use semiconductor materials, such as silicon, to convert sunlight into electricity, but at the moment they provide only 0.15% of the world's energy needs. Yet sunlight could be harnessed to supply 5000 times as much energy as the world currently consumes.

(Adapted from "Scientific American; Energy's Future beyond Carbon"; September 2006)

(a) **What is nuclear fission?**
disintegration / break-up / splitting of a large nucleus 4
into two smaller nuclei (+ neutrons + energy) **(-1 if** *atoms* **used; -1 if no comparative term used)** 3

(b) **How much energy is generated worldwide every minute by nuclear power today?**
$(300 \times 10^9)(60)$ J **or** 18,000 gigajoule (per minute) **or** 1.8×10^{13} J **(-1 for omission of or incorrect units)** 7
[stated or implied : power x time … 4 marks,]

(c) **At present, why is a fission reactor a more viable source of energy than a fusion reactor?**
(fission) can be (more) easily controlled / easier to initiate reaction **or** *vice versa* 7

(d) **Deuterium is an isotope of hydrogen; what is an isotope?**
atoms of the same element // atoms having the same atomic number / number of protons 4
having a different number of neutrons / (atomic) mass (or weight) / mass number 3

(e) **What is the function of a moderator in a fission reactor?**
to slow down (fast)neutrons (to facilitate fission) 7

(f) **Why is silicon a semiconductor?**
it has a resistivity / resistance / conductivity 4
between that of a conductor and an insulator 3
("it's neither a good conductor nor a good insulator"….. 7 marks)
(*R* decreases with (increasing) *T* 7 marks)

(g) **A large number of solar cells are joined together in series and cover an area of 20 m^2. The efficiency of the solar cell is 20%. If the solar constant is 1400 W m^{-2}, what is the maximum power generated by the solar cells?**

[1400×20 **or** $1400 \times {}^1/_5$) ….. 4 marks]

$(1400 \times 20 \times {}^1/_5)$ W **or** 5600 J s^{-1} **or** 5600 W **(-1 for omission of or incorrect units)** 7

(h) **What is the source of the sun's energy?**
fusion (reaction) / hydrogen (gas) 7
("nuclear reaction" …. 4 marks)

Question 12 Answer any **two** of the following parts *(a), (b), (c), (d)*.

Question 12 (a)

***(a)* What is friction?**

a force — 3

that opposes motion / tries to prevent one surface sliding over another — 3

A car of mass 750 kg is travelling east on a level road. Its engine exerts a constant force of 2.0 kN causing the car to accelerate at 1.2 m s^{-2} until it reaches a speed of 25 m s^{-1}.
Calculate

(i) the net force,

$F_{\text{net}} = m a$ — 3

$F_{\text{net}} = (750)(1.2)$ **or** 900 N, (east) **(no penalty for units)** — 3

(ii) the force of friction, acting on the car.

$F_{\text{net}} = F_{car} - F_{friction}$ — 3

$900 = 2000 - F_{friction}$ **or** $F_{friction} = 1100$ N, (west) **(no penalty for units)** — 3

If the engine is then turned off, calculate how far the car will travel before coming to rest.

(Friction causes deceleration:) $a = F \div m$ (re-arrangement only) — 3

$a = (-1100) \div 750$ **or** -1.47 m s^{-2} — 2

$v^2 = u^2 + 2as$ — 3

$0 = 25^2 + 2(-1.47)\, s$ **or** $s = 213.07$ m ≈ 213 m **(-1 for omission of or incorrect units)** — 2

(b) **Define sound intensity.**

energy per sec / power / watt // ***P*** /***A*** — 3

per unit area / m^{-2} // correct notation — 3

A loudspeaker has a power rating of 25 mW. What is the sound intensity at a distance of 3 m from the loudspeaker?

surface area of sphere = $4\pi r^2$	surface area of hemisphere = $2\pi r^2$	3
S.I at 3 m = $(25 \times 10^{-3}) \div 4\pi(3)^2$	S.I at 3 m = $(25 \times 10^{-3}) \div 2\pi(3)^2$	3
S.I = 2.21×10^{-4} W m^{-2}	S.I = 4.42×10^{-4} W m^{-2} **(-1 for omission of or incorrect units)**	3

(accept either answer)

The loudspeaker is replaced by a speaker with a power rating of 50 mW.
What is the change:

(i) in the sound intensity?

increased by: 2.21×10^{-4} W m^{-2} ‖ 4.42×10^{-4} W m^{-2} — 6

(accept either answer: -1 if the new increased S.I value is given rather than the *change*)

('it is doubled' 3 marks)

(ii) in the sound intensity level?

increased by: 0.30 B or 3 dB — 3

The human ear is more sensitive to certain frequencies of sound. How is this taken into account when measuring sound intensity levels?

dBA / decibel adapted / a frequency weighted scale is used
// sound level meter (modified so that it) responds more to sounds between 2kHz and 4 kHz / just like the ear
any one — 4

Question 12 (c)

State Faraday's law of electromagnetic induction.

induced <u>e.m.f.</u> / <u>voltage</u> is proportional // $E \alpha d\phi / dt$ **or** $E = d\phi / dt$ (accept E or V) 3
to rate of <u>cutting</u> / <u>change of</u> (magnetic) flux // correct notation 3

Describe an experiment to demonstrate Faraday's law.

> -1 per missing item.
> A suitable diagram could merit 3 x 3
> *Observation* must be stated for final 3 marks

apparatus	coil, magnet, galvanometer or equivalent	3
arrangement	connect coil to G	3
procedure	move magnet towards coil	3
observation	the faster the movement, the greater the <u>deflection</u> / (induced) <u>voltage</u>	3

A resistor is connected in series with an ammeter and an ac power supply. A current flows in the circuit. The resistor is then replaced with a coil. The resistance of the circuit does not change.
What is the effect on the current flowing in the circuit?

current is reduced 4

Justify your answer.

back emf induced in coil **(-1 if *back* omitted)** // coil has a self-inductance **(-1 if *self* omitted) //** Lenz's law reference 6

Question 12 (d)

Explain the term half-life.

time // $\lambda T_{\frac{1}{2}} = 0.693 (= \ln 2)$ 3

for half (the radioactive nuclei in a sample) to decay / for activity (of a sample) to be halved // λ a constant 3

A sample of carbon is mainly carbon-12 which is not radioactive, and a small proportion of carbon-14 which is radioactive. When a tree is cut down the carbon-14 present in the wood at that time decays by beta emission.
Write a nuclear equation to represent the decay of carbon-14.

$${}^{14}_{6}C \rightarrow {}^{0}_{-1}\beta + {}^{14}_{7}N$$ 3 x 3

(accept e in lieu of β …. **–1 for each error**)

An ancient wooden cup from an archaeological site has an activity of 2.1 Bq. The corresponding activity for newly cut wood is 8.4 Bq. If the half-life of carbon-14 is 5730 years, estimate the age of the cup.

(8.4 Bq → 2.1 Bq requires) two half-lives. 3
11,460 years 3

Name an instrument used to measure the activity of a sample. What is the principle of operation of this instrument?

Geiger Counter / GM tube:	(gas is) ionised (and a pulse of charge/current flows)
ratemeter **:**	average <u>number of particles</u> / <u>current</u> detected **or** displayed
scaler:	total number of <u>particles</u> / <u>pulses of charge</u> is counted **or** displayed
solid state detector:	electron-hole pairs created
etc.	

(for any one instrument + principle) 6 + 1