UNIVERSITY OF KWAZULU-NATAL

FIRST SEMESTER MAIN EXAMINATION

NOVEMBER 2014

SUBJECT AND COURSE: PHYSICS 133

TIME: 2 hours **TOTAL MARKS: 120**

Internal Examiners: Prof. D. Wang

Moderator: Dr. M. Cavero (Pietermaritzburg Campus)

GENERAL INSTRUCTIONS:

- This exam must be answered on the MCQ sheet provided. It is the responsibility of the candidate to ensure that **all the details** are filled in on the MCQ answer sheet. **Failure to do so** will result in a mark of zero for this examination.
  - Use only an HB pencil to fill in the MCQ sheet.
  - Use numbers 1- 40 only.

- **It is the candidate's responsibility to ensure that this paper has 12 numbered pages, which includes the information sheet.**

- Do your rough work for a question on the question paper provided. Rough work will not be marked.

- The last page of this exam, which is printed separately, is an information sheet.

- No part of this exam paper may be torn off.

- Marks have been allocated in such a way that 1 mark corresponds approximately to one minute of time. Candidates are advised not to spend a disproportionate amount of time on any question.

Rule 9 (1)(e) **WARNING: CANDIDATES WILL BE DISQUALIFIED IF:**

(a) they introduce, or attempt to introduce, into any place where an examination is about to be conducted or is being conducted, any paper, book, note, document or instrument, the use of which is not authorized by the examiner or the examination officer.
(b) they possess, use, or attempt to use during an examination, any paper, book, note, document or instrument the use of which is not authorized by the examiner or the examination officer.
(c) they remove or attempt to remove from the examination room, any examination book or writing paper supplied by the University for the purposes of answering an examination.
(d) they communicate or attempt to communicate any information relating to the examination to another candidate while the examination is in progress.
(e) they use a false name or identity number in an examination.
(f) they commit any other fraudulent, deceitful or dishonest practice which would mislead or deceive the examiner or examination officer.

IF A STUDENT IS FOUND GUILTY BY A STUDENT DISCIPLINE COURT OF CONTRAVENING THE ABOVE RULE –9(1)(e) – SHE/HE WILL SUFFER ONE OR MORE OF THE FOLLOWING CONSEQUENCES:

(i) Disqualification from entry to any examination.
(ii) Cancellation or forfeiture of examination results.
(iii) Deprivation of a degree, diploma or certificate obtained as a result of the offence.

SECTION A: Electricity and Magnetism (18 Questions, 54 Marks)

QUESTION 1

A charged particle in an electric field of 3.00×10^5 NC^{-1} experiences a force of 10.3 N. The magnitude of the electric charge on the particle is

a) 2.91×10^4 C
b) 3.09 μC
c) 3.09×10^6 C
d) 34.3 μC.

QUESTION 2

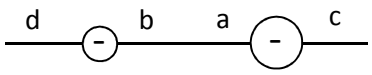
A particle with charge 8.00 μC is placed 10 cm from another particle. It is subject to a Coulomb force of 17.0 N. The charge on the second particle is

a) 4.24 μC
b) 2.36 μC
c) 15.1 C
d) 15.1 μC.

QUESTION 3

A relatively large negative charge is situated near a smaller negative charge. The combined electric field which they produce has a neutral point situated on the line joining the charges at a point which lies

a) between the charges, nearer the larger charge;
b) between the charges, nearer the smaller charge;
c) on the side nearer the larger charge;
d) on the side nearer the smaller charge.



QUESTION 4

The electric potential at point A is higher than that at point B by 100 V. When a charge of 2.0 nC is moved from point A to point B, the amount of energy given out is

a) 2.0×10^{-7} J
b) 2.0×10^{11} J
c) 5.0×10^{-11} J
d) -2.0×10^{-11} J.

QUESTION 5

A particle is initially at rest. After it has been accelerated across an electric potential difference of 14.3 V, its energy is 28.6 eV. The charge on the particle is

a) 1.60×10^{-19} C
b) 3.20×10^{-19} C
c) 1.00 C
d) 2.00 C.

QUESTION 6

After charging a capacitor with an electric potential difference of 5.00 V, the charge on the capacitor is found to be 4.36 μC. The capacitance of the capacitor is

a) 4.4 μF
b) 1.15×10^{6} F
c) 0.87 μF
d) 21.8 μF.

QUESTION 7

Two capacitors of capacitance 3.20 nF and 5.62 nF are connected in **series**. After charging, the smaller capacitor has a charge of 1.37 μC. The charge on the larger capacitor is

a) 2.41 μC
b) 1.37 μC
c) 0.78 μC
d) 0.00 μC.

QUESTION 8

Two capacitors of capacitance 3.20 nF and 5.62 nF are connected in **parallel**. After charging, the larger capacitor has a charge of 1.37 μC. The electrical potential difference across the smaller capacitor is

a) 780 V
b) 244 V
c) 400 V
d) 208 V.

QUESTION 9

When an electric potential difference of 160 V is applied across two parallel plates which are 2.00 mm apart, the electric field between them will be

a) 1.25×10^{-5} NC^{-1}
b) 3.13 NC^{-1}
c) 3.20 NC^{-1}
d) 8.00×10^{4} NC^{-1} .

QUESTION 10

Three identical electrical resistors with resistance R each are connected in parallel. The equivalent resistance is

a) R
b) 3R
c) ⅓R
d) $(3R)^{-1}$.

QUESTION 11

Two wires made from the same metal have the same length. The electrical resistance of the fatter wire is half that of the thinner wire. The diameter of the fatter wire divided by that of the thinner wire is

a) 2
b) √2
c) 4
d) 1/√2.

QUESTION 12

A kettle is designed to produce 1000 W when connected to a 220 V supply. When it is connected to a 110 V supply it will generate

a) 2000 W
b) 1000 W
c) 500 W
d) 250 W.

QUESTION 13

A light bulb is powered by a 12.0 V battery rated at 200 Ah. If the battery lasts for 1.90 days, power generated by the light bulb is

a) 30.3 kW
b) 1.26 kW
c) 105.2 W
d) 52.6 W.

QUESTION 14

A 12.0 V battery has an internal resistance of 0.10 Ω. When the battery is delivering a current of 4.00 A to an external load, the terminal voltage will be

a) 0.40 V
b) 8.00 V
c) 11.6 V
d) 12.4 V.

QUESTION 15

A conductor 5.00 cm long carries a current of 2.00 A. It lies at right angles to a magnetic field of 10.0 T. The magnitude of the force exerted on the conductor by the magnetic field is

a) 100 N
b) 25 N
c) 1.00 N
d) 0 N.

QUESTION 16

Two long straight wires each carry the same current, in the same direction. They are separated by 1 m. The force between them is

a) attractive and equal to 1.0 N
b) repulsive and equal to 1.0 N
c) attractive and dependent on the magnitude of the current
d) repulsive and dependent on the magnitude of the current.

QUESTION 17

A conductor carries a current normally out of the plane of the paper. Use the right hand rule to determine the direction of the magnetic field lines generated by the current. The magnetic field lines are directed

a) in a clockwise direction in the plane of the paper
b) in an anti-clockwise direction in the plane of the paper
c) into the plane of the paper
d) out of the plane of the paper.

QUESTION 18

A transformer converts a 220 V_{rms} supply to 6.0 V_{rms} for an electronic power supply. If the electrical current in the primary coil is 4.2 A, the current in the secondary coil will be

a) 5544 A
b) 154 A
c) 0.15 A
d) 3.18×10^{-3} A.

SECTION B: Physical Optics (10 Questions, 30 Marks)

QUESTION 19

If unpolarised light falling on a glass surface produces a completely polarised reflected beam when the angle of incidence of the light on the surface (Brewster's angle) is 55.4°, the refractive index of the glass is

a) 0.57
b) 0.82
c) 1.21
d) 1.45.

QUESTION 20

A solution of sugar of concentration 2.43 gcm^{-3} rotates an incident beam of plane polarised light by 6.0° when contained in a cell 15.0 cm long. The specific rotation the optically active sugar is

a) 42.3 $°cm^2g^{-1}$
b) 6.1 $°cm^2g^{-1}$
c) 0.16 $°cm^2g^{-1}$
d) 2.2×10^2 $°cm^2g^{-1}$.

QUESTION 21

Blue light of wavelength 450 nm from a point source passes through two narrow parallel slits onto a screen 2.00 m away. If the distance bewteen adjacent fringes on the screen is 1.30 mm, the distance between the parallel slits is

a) 0.29 mm
b) 0.69 mm
c) 1.17 mm
d) 1.30 mm.

QUESTION 22

In any given arrangement of Young's double slit experiment, the spacing of the interference fringes will be decreased if

a) the distance between the slits is decreased;
b) the wavelength of the light is decreased;
c) the distance between the screen and the slits is increased;
d) wavelength of the light is increased.

QUESTION 23

When the air gap between two glass plates is one quarter of the wavelength of the illuminating light ($\lambda/4$), the reflected light will

a) interfere constructively
b) interfere destructively
c) be unchanged
d) change in an unpredictable way.

QUESTION 24

A mixture of red light (λ = 640 nm) and yellow light (λ = 580 nm) falls normally on an air film between two glass plates that is 2.90×10^{-4} mm thick. The reflected light will be

a) yellow and red
b) yellow
c) blue
d) red.

QUESTION 25

In a measurement on Newton's rings, the radius of the 5^{th} dark ring is found to be 1.10 mm. The radius of the 10^{th} dark ring is

a) 0.550 mm
b) 0.692 mm
c) 1.10 mm
d) 1.56 mm.

QUESTION 26

The wavelength of the light falling on a single slit is doubled. The corresponding width of the central maximum of the diffraction pattern will be

a) quadrupled (multiplied by 4)
b) doubled
c) halved
d) quartered.

QUESTION 27

Yellow light (λ = 580 nm) falls normally on a diffraction grating with 5000 lines per cm. The angle between the first order beam and the beam passing straight through the grating will be

a) 47.2^o
b) 35.4^o
c) 23.6^o
d) 16.9^o.

QUESTION 28

White light falls on a diffraction grating. In the spectrum formed for each order,

a) blue light is deviated more than red light
b) red light is deviated more than blue light
c) red and blue light are not separated
d) no red light passes through the grating.

SECTION C Atomic and Nuclear (12 Questions, 36 Marks)

QUESTION 29

In the Rutherford scattering experiment, most of a beam of positively charged alpha particles pass straight through a thin metal film, while a few are scattered through large angles. Rutherford concluded that the metal film consists of

a) mostly empty space with some massive positively charged particles
b) mostly empty space with some massive negatively charged particles
c) a continuous sheet of mixed positive and negative charges
d) negative charges in a sea of positive charge.

QUESTION 30

The element ${}^{p}_{q}E$ has a nucleus which consists of

a) q protons and p neutrons
b) p protons and q electrons
c) q protons and p – q neutrons
d) p – q protons and q neutrons.

QUESTION 31

The nucleus of the carbon 12 isotope of carbon has a mass of 12 u, by definition. This means that 1 u is

a) 1.99×10^{-28} kg
b) 1.66×10^{-27} kg
c) 12.0 g
d) 12.0 kg.

QUESTION 32

Copper has an atomic number of 64. The number of copper atoms in a copper pellet of mass 10 g is

a) 2.59×10^{-25}
b) 9.41×10^{22}
c) 3.80×10^{24}
d) 3.80×10^{26}.

QUESTION 33

The first atomic bomb released energy equivalent to about 20 kilotons of TNT or 10^{14} J. The net mass decrease which generated this energy was

a) 2 x 107 kg
b) 3.3 x 107 kg
c) 1.11 kg
d) 1.11 g

QUESTION 34

The cut-off wavelength of the X-rays produced in an X-ray tube is $\lambda = 4.0 \times 10^{-11}$ m. The electrons producing the X-rays are accelerated across an electrical potential difference of

a) 31.1 kV
b) 5.00×10^{-16} V
c) 3.11 kV
d) 5.00×10^{13} kV

QUESTION 35

X-rays with a cut-off wavelength $\lambda = 1.5 \times 10^{-11}$ m fall on a crystal in which the spacing between the atomic planes is 1.6 angstrom. The Bragg angle of the second order diffraction maxima is

a) 2.7°
b) 5.4°
c) 10.8°
d) 22.0°.

QUESTION 36

A radioactive source emits 'radiation' which is capable of passing through several centimetres of most materials and which is undeviated by a magnetic field at right angles to its path. This radiation is most probably

a) α rays
b) β rays
c) γ rays
d) cosmic rays.

QUESTION 37

A radioactive isotope has a half-life of 31 s. The proportion of a sample left after 2 min 4 s is

a) ½
b) ¼
c) ⅛
d) 1/16.

QUESTION 38

The half-life for the decay of a certain isotope is 17.0 s. The decay constant λ for this decay is

a) $0.0408\ s^{-1}$
b) $0.0588\ s^{-1}$
c) $0.118\ s^{-1}$
d) $11.8\ s^{-1}$.

QUESTION 39

The relative biological effectiveness or quality factor for radiaton exposure is about 1 for γ-rays and about 10 for α-rays. This means that the typical biological danger from equivalent amounts of energy absorbed from α-rays compared with γ-rays is

a) 10 times
b) 1/10
c) 10^{10} times
d) ln10 times.

QUESTION 40

In reducing the exposure to radiation in the laboratory one should **not**

a) keep as far from any sources as possible
b) restrict the time spent in proximity to sources
c) reduce unnecessary ventilation
d) cover any open sores or wounds.

INFORMATION SHEET

PHYSICAL CONSTANTS

$g = 9.80\ \text{m s}^{-2}$ $c = 3.00\times10^{8}\ \text{m s}^{-1}$ $e = 1.60\times10^{-19}\ \text{C}$

$\frac{1}{4\pi\varepsilon_0} = 9.00\times10^{9}\ \text{N m}^2\ \text{C}^{-2}$ $\frac{\mu_0}{2\pi} = 2\times10^{-7}\ \text{T m A}^{-1}$ $n_{\text{air}} = 1.00$

$N_A = 6.02\times10^{23}\ \text{mol}^{-1}$ $h = 6.63\times10^{-34}\ \text{J s}$ $1\text{Ci} = 3.7\times10^{10}\ \text{Bq}$

$m_e = 9.11\times10^{-31}\ \text{kg} = 5.5\times10^{-4}\ \text{u}$ $m_p = 1.673\times10^{-27}\ \text{kg} = 1.00728\ \text{u}$

$m_n = 1.675\times10^{-27}\ \text{kg} = 1.00866\ \text{u}$

ELECTRICITY AND MAGNETISM

$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$ $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ $\text{V} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ $E = \frac{V}{d}$

$\text{Energy} = \frac{1}{2}qV$ $V = IR$ $R = \rho\frac{l}{A}$ $R_T = R_0(1+\alpha T)$

$P = VI$ $V = E - Ir$ $V = V_0\sin(2\pi ft)$ $E = \frac{F}{q}$

$F = BIl\sin\theta$ $B = \frac{\mu_0}{2\pi}\frac{I}{r}$ $\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{L}$ $\frac{V_s}{V_p} = \frac{n_s}{n_p}$

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$ $C_{eq} = C_1 + C_2 + C_3 + \ldots$

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$ $R_{eq} = R_1 + R_2 + R_3 + \ldots$ $V = \frac{W}{q}$

PHYSICAL OPTICS

$n_1\sin\theta_1 = n_2\sin\theta_2$ $n = \tan\theta_B$ $\theta = [\theta]cl$ $d\sin\theta_n = n\lambda$

$y_n = \frac{n\lambda x}{d}$ $2t = n\lambda$ $2t = \left(n + \frac{1}{2}\right)\lambda$ $2\mu t = n\lambda$

$r_n^2 = nR\lambda$ $a\sin\theta_n = n\lambda$ $\sin\theta = \frac{1.22\lambda}{D}$

ATOMIC PHYSICS

$N = N_0 e^{-\lambda t}$ $\text{A} = \lambda\text{N}$ $A = A_0 e^{-\lambda t}$ $\ln 2 = \lambda T$ $H = QD$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/T}$ $\frac{A}{A_0} = \left(\frac{1}{2}\right)^{t/T}$ $D = \frac{E}{m}$ $2d\sin\theta = n\lambda$ $eV = hf_{MAX} = \frac{hc}{\lambda_{CUT-OFF}}$
