Neap

Trial Examination 2022

QCE Physics Units 3&4
Paper 1

Student's Name: _____

Teacher's Name: _____

Time allowed
- Perusal time – 10 minutes
- Working time – 90 minutes

General instructions
- Answer all questions in this question and response booklet.
- QCAA-approved calculator permitted.
- Formula and data booklet provided.
- Planning paper will not be marked.

Section 1 (20 marks)
- 20 multiple choice questions

Section 2 (25 marks)
- 8 short response questions

SECTION 1

Instructions

- Choose the best answer for Questions 1–20.
- This section has 20 questions and is worth 20 marks.
- Use a 2B pencil to fill in the A, B, C or D answer bubble completely.
- If you change your mind or make a mistake, use an eraser to remove your response and fill in the new answer bubble completely.

	A	B	C	D
Example:	●	○	○	○

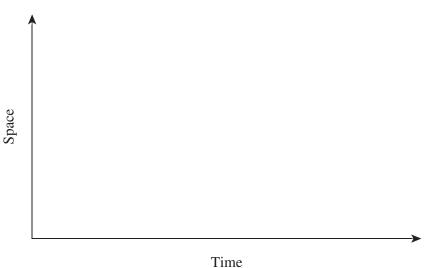|	A	B	C	D
1.	○	○	○	○
2.	○	○	○	○
3.	○	○	○	○
4.	○	○	○	○
5.	○	○	○	○
6.	○	○	○	○
7.	○	○	○	○
8.	○	○	○	○
9.	○	○	○	○
10.	○	○	○	○
11.	○	○	○	○
12.	○	○	○	○
13.	○	○	○	○
14.	○	○	○	○
15.	○	○	○	○
16.	○	○	○	○
17.	○	○	○	○
18.	○	○	○	○
19.	○	○	○	○
20.	○	○	○	○

SECTION 2

Instructions

- Write using black or blue pen.
- If you need more space for a response, use the additional pages at the back of this booklet.
  - On the additional pages, write the question number you are responding to.
  - Cancel any incorrect response by ruling a single diagonal line through your work.
  - Write the page number of your alternative/additional response, i.e. See page …
  - If you do not do this, your original response will be marked.
- This section has eight questions and is worth 25 marks.

QUESTION 21   (1 mark)

List the six types of quarks.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

QUESTION 22   (2 marks)

An astronaut is in a spacecraft travelling away from the Sun at $0.75c$.

At what speed will the light from the Sun pass the astronaut? Justify your response.

_____

_____

_____

_____

_____

QUESTION 23   (3 marks)

Define and explain electromagnetic radiation in terms of electric fields and magnetic fields. You may use a diagram to support your response.

_____

_____

_____

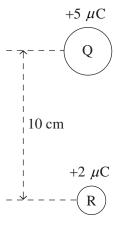_____

_____

_____

_____

QUESTION 24   (3 marks)

Complete the Feynman diagram below to show an annihilation interaction between an electron and a positron and the production of another electron and positron pair after the annihilation interaction. Label each particle.

QUESTION 25   (3 marks)

A scientist on a space station oversees interstellar traffic in a remote region of space. As a spacecraft is flying past, the scientist measures the length of the spacecraft to be 26 m using a laser light device. However, a passenger on the spacecraft measures the length of the spacecraft to be 30 m.

Determine the speed of the spacecraft relative to the scientist. Express your answer in terms of c.

_____

_____

_____

_____

_____

_____

_____

_____

_____

Speed = _____ c (to 1 decimal place)

QUESTION 26   (6 marks)

Charge Q is +5 μC and charge R is +2 μC. The charges are positioned with their centres 10 cm apart, as shown in the diagram.

+5 μC

Q

10 cm

+2 μC

R

Not to scale

Calculate the magnitude and direction of the electric field strength at the midpoint between charges *Q* and *R*. Express your answer in scientific notation.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Magnitude = _____ N C^{-1} (to 2 significant figures)

Direction = _____

QUESTION 27   (3 marks)

Describe three characteristics of a photon.

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

QUESTION 27   (3 marks)

QUESTION 28   (4 marks)

When repairing the International Space Station (ISS), astronauts wear spacesuits to protect them from the harsh environment of space. The ISS orbits the Earth at an altitude of 4.0×10^2 km above the Earth's surface. The combined mass of an astronaut and their spacesuit is 100 kg.

Calculate the gravitational force, F_g, acting on the combined mass.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

$F_g =$ _____ N (to 2 significant figures)

END OF PAPER

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

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Neap

QCE Physics Units 3&4

FORMULAS

Processing of data
Percentage uncertainty (%) $= \dfrac{\text{absolute uncertainty}}{\text{measurement}} \times 100$
Percentage error (%) $= \left\| \dfrac{\text{measured value} - \text{true value}}{\text{true value}} \right\| \times 100$

Heating processes	
$T_K = T_C + 273$	$Q = mL$
$Q = mc\Delta T$	$\Delta U = Q + W$
$\eta = \dfrac{\text{energy output}}{\text{energy input}} \times \dfrac{100}{1}\%$	

Ionising radiation and nuclear reactions	
$N = N_0 \left(\dfrac{1}{2}\right)^n$	$\Delta E = \Delta mc^2$

Electrical circuits	
$I = \dfrac{q}{t}$	$P = I^2 R$
$V = \dfrac{W}{q}$	$V_t = V_1 + V_2 + \ldots V_n$
$P = \dfrac{W}{t}$	$R_t = R_1 + R_2 + \ldots R_n$
$R = \dfrac{V}{I}$	$I_t = I_1 + I_2 + \ldots I_n$
$P = VI$	$\dfrac{1}{R_t} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots \dfrac{1}{R_n}$

Linear motion and force

$v = u + at$	$W = \Delta E$
$s = ut + \dfrac{1}{2}at^2$	$W = Fs$
$v^2 = u^2 + 2as$	$E_k = \dfrac{1}{2}mv^2$
$a = \dfrac{F_{net}}{m}$	$\Delta E_p = mg\Delta h$
$p = mv$	$\sum \dfrac{1}{2}mv^2_{before} = \sum \dfrac{1}{2}mv^2_{after}$
$\sum mv_{before} = \sum mv_{after}$	

Waves

$v = f\lambda$	$L = (2n-1)\dfrac{\lambda}{4}$
$f = \dfrac{1}{T}$	$\dfrac{\sin i}{\sin r} = \dfrac{v_1}{v_2} = \dfrac{\lambda_1}{\lambda_2} = \dfrac{n_2}{n_1}$
$L = n\dfrac{\lambda}{2}$	$I \propto \dfrac{1}{r^2}$

Gravity and motion

$v_y = gt + u_y$	$v = \dfrac{2\pi r}{T}$
$s_y = \dfrac{1}{2}gt^2 + u_y t$	$a_c = \dfrac{v^2}{r}$
$v_y^2 = 2gs_y + u_y^2$	$F_{net} = \dfrac{mv^2}{r}$
$v_x = u_x$	$F = \dfrac{GMm}{r^2}$
$s_x = u_x t$	$g = \dfrac{F}{m} = \dfrac{GM}{r^2}$
$F_g = mg$	$\dfrac{T^2}{r^3} = \dfrac{4\pi^2}{GM}$

Electromagnetism

$F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Qq}{r^2}$	$F = qvB\sin\theta$
$E = \dfrac{F}{q} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{r^2}$	$\phi = BA\cos\theta$
$V = \dfrac{\Delta U}{q}$	$\text{emf} = -\dfrac{n\Delta(BA_\perp)}{\Delta t}$
$B = \dfrac{\mu_0 I}{2\pi r}$	$\text{emf} = -n\dfrac{\Delta\phi}{\Delta t}$
$B = \mu_0 nI$	$I_p V_p = I_s V_s$
$F = BIL\sin\theta$	$\dfrac{V_p}{V_s} = \dfrac{n_p}{n_s}$

Special relativity

$t = \dfrac{t_0}{\sqrt{\left(1-\dfrac{v^2}{c^2}\right)}}$	$p_v = \dfrac{m_0 v}{\sqrt{\left(1-\dfrac{v^2}{c^2}\right)}}$
$L = L_0\sqrt{\left(1-\dfrac{v^2}{c^2}\right)}$	$\Delta E = \Delta m c^2$

Quantum theory

$\lambda_{\max} = \dfrac{b}{T}$	$\lambda = \dfrac{h}{p}$
$E = hf$	$n\lambda = 2\pi r$
$E_k = hf - W$	$mvr = \dfrac{nh}{2\pi}$
$\dfrac{1}{\lambda} = R\left(\dfrac{1}{n_f^2} - \dfrac{1}{n_i^2}\right)$	

PHYSICAL CONSTANTS AND UNIT CONVERSIONS

Heating processes	
Latent heat of fusion for water	$L_f = 3.34 \times 10^5$ J kg^{-1}
Latent heat of vaporisation for water	$L_v = 2.26 \times 10^6$ J kg^{-1}
Specific heat capacity of ice	$c_i = 2.05 \times 10^3$ J kg^{-1} K^{-1}
Specific heat capacity of steam	$c_s = 2.00 \times 10^3$ J kg^{-1} K^{-1}
Specific heat capacity of water	$c_w = 4.18 \times 10^3$ J kg^{-1} K^{-1}

Ionising radiation and nuclear reactions	
Atomic mass unit	1 amu $= 1.66 \times 10^{-27}$ kg
Electron volt	1 eV $= 1.60 \times 10^{-19}$ J
Mass of an alpha particle	$m_\alpha = 6.6446572 \times 10^{-27}$ kg
Mass of an electron	$m_e = 9.1093835 \times 10^{-31}$ kg
Mass of a neutron	$m_n = 1.6749275 \times 10^{-27}$ kg
Mass of a proton	$m_p = 1.6726219 \times 10^{-27}$ kg
Speed of light in a vacuum	$c = 3 \times 10^8$ m s^{-1}

Electrical circuits	
Charge on an electron	$e = -1.60 \times 10^{-19}$ C

Linear motion and force	
Mean acceleration due to gravity on Earth	$g = 9.8$ m s^{-2}

Waves	
Speed of sound in air at 25°C	$v_s = 346$ m s^{-1}

Gravity and motion	
Gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
Mass of the Earth	$m_E = 5.97 \times 10^{24}$ kg

Electromagnetism	
Coulomb's constant	$\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}
Magnetic constant	$\mu_0 = 4\pi \times 10^{-7}$ $T\,A^{-1}$ m

Quantum theory	
Wien's displacement constant	$b = 2.898 \times 10^{-3}$ m K
Planck's constant	$h = 6.626 \times 10^{-34}$ J s
Rydberg's constant	$R = 1.097 \times 10^7$ m^{-1}

SCIENTIFIC NOTATION

Ratio to basic unit	Prefix	Abbreviation
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10	deca	da
10^2	hecto	h
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T

LIST OF ELEMENTS

Name	Atomic no.	Symbol		Name	Atomic no.	Symbol
Hydrogen	1	H		Krypton	36	Kr
Helium	2	He		Rubidium	37	Rb
Lithium	3	Li		Strontium	38	Sr
Beryllium	4	Be		Yttrium	39	Y
Boron	5	B		Zirconium	40	Zr
Carbon	6	C		Niobium	41	Nb
Nitrogen	7	N		Molybdenum	42	Mo
Oxygen	8	O		Technetium	43	Tc
Fluorine	9	F		Ruthenium	44	Ru
Neon	10	Ne		Rhodium	45	Rh
Sodium	11	Na		Palladium	46	Pd
Magnesium	12	Mg		Silver	47	Ag
Aluminium	13	Al		Cadmium	48	Cd
Silicon	14	Si		Indium	49	In
Phosphorus	15	P		Tin	50	Sn
Sulfur	16	S		Antimony	51	Sb
Chlorine	17	Cl		Tellurium	52	Te
Argon	18	Ar		Iodine	53	I
Potassium	19	K		Xenon	54	Xe
Calcium	20	Ca		Cesium	55	Cs
Scandium	21	Sc		Barium	56	Ba
Titanium	22	Ti		Lanthanum	57	La
Vanadium	23	V		Cerium	58	Ce
Chromium	24	Cr		Praseodymium	59	Pr
Manganese	25	Mn		Neodymium	60	Nd
Iron	26	Fe		Promethium	61	Pm
Cobalt	27	Co		Samarium	62	Sm
Nickel	28	Ni		Europium	63	Eu
Copper	29	Cu		Gadolinium	64	Gd
Zinc	30	Zn		Terbium	65	Tb
Gallium	31	Ga		Dysprosium	66	Dy
Germanium	32	Ge		Holmium	67	Ho
Arsenic	33	As		Erbium	68	Er
Selenium	34	Se		Thulium	69	Tm
Bromine	35	Br		Ytterbium	70	Yb

LIST OF ELEMENTS

LIST OF ELEMENTS (CONTINUED)

Name	Atomic no.	Symbol	Name	Atomic no.	Symbol
Lutetium	71	Lu	Americium	95	Am
Hafnium	72	Hf	Curium	96	Cm
Tantalum	73	Ta	Berkelium	97	Bk
Tungsten	74	W	Californium	98	Cf
Rhenium	75	Re	Einsteinium	99	Es
Osmium	76	Os	Fermium	100	Fm
Iridium	77	Ir	Mendelevium	101	Md
Platinum	78	Pt	Nobelium	102	No
Gold	79	Au	Lawrencium	103	Lr
Mercury	80	Hg	Rutherfordium	104	Rf
Thallium	81	Tl	Dubnium	105	Db
Lead	82	Pb	Seaborgium	106	Sg
Bismuth	83	Bi	Bohrium	107	Bh
Polonium	84	Po	Hassium	108	Hs
Astatine	85	At	Meitnerium	109	Mt
Radon	86	Rn	Darmstadtium	110	Ds
Francium	87	Fr	Roentgenium	111	Rg
Radium	88	Ra	Copernicium	112	Cn
Actinium	89	Ac	Nihonium	113	Nh
Thorium	90	Th	Flerovium	114	Fl
Protactinium	91	Pa	Moscovium	115	Mc
Uranium	92	U	Livermorium	116	Lv
Neptunium	93	Np	Tennessine	117	Ts
Plutonium	94	Pu	Oganesson	118	Og

PERIODIC TABLE OF THE ELEMENTS

KEY

1	atomic number
H	symbol
1.01	relative atomic mass*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01																	**2 He** 4.00
3 Li 6.94	**4 Be** 9.01											**5 B** 10.81	**6 C** 12.01	**7 N** 14.01	**8 O** 16.00	**9 F** 19.00	**10 Ne** 20.18
11 Na 22.99	**12 Mg** 24.31											**13 Al** 26.98	**14 Si** 28.09	**15 P** 30.97	**16 S** 32.06	**17 Cl** 35.45	**18 Ar** 39.95
19 K 39.10	**20 Ca** 40.08	**21 Sc** 44.96	**22 Ti** 47.87	**23 V** 50.94	**24 Cr** 52.00	**25 Mn** 54.94	**26 Fe** 55.85	**27 Co** 58.93	**28 Ni** 58.69	**29 Cu** 63.55	**30 Zn** 65.38	**31 Ga** 69.72	**32 Ge** 72.63	**33 As** 74.92	**34 Se** 78.97	**35 Br** 79.90	**36 Kr** 83.80
37 Rb 85.47	**38 Sr** 87.62	**39 Y** 88.91	**40 Zr** 91.22	**41 Nb** 92.91	**42 Mo** 95.95	**43 Tc** (98.91)	**44 Ru** 101.07	**45 Rh** 102.91	**46 Pd** 106.42	**47 Ag** 107.87	**48 Cd** 112.41	**49 In** 114.82	**50 Sn** 118.71	**51 Sb** 121.76	**52 Te** 127.60	**53 I** 126.90	**54 Xe** 131.29
55 Cs 132.91	**56 Ba** 137.33	57–71 Lanthanoids	**72 Hf** 178.49	**73 Ta** 180.95	**74 W** 183.84	**75 Re** 186.21	**76 Os** 190.23	**77 Ir** 192.22	**78 Pt** 195.08	**79 Au** 196.97	**80 Hg** 200.59	**81 Tl** 204.38	**82 Pb** 207.2	**83 Bi** 208.98	**84 Po** (210.0)	**85 At** (210.0)	**86 Rn** (222.0)
87 Fr (223.0)	**88 Ra** (226.1)	89–103 Actinoids	**104 Rf** (261.1)	**105 Db** (262.1)	**106 Sg** (263.1)	**107 Bh** (264.1)	**108 Hs** (265.1)	**109 Mt** (268)	**110 Ds** (281)	**111 Rg** (272)	**112 Cn** (285)	**113 Nh** (284)	**114 Fl** (289)	**115 Mc** (288)	**116 Lv** (293)	**117 Ts** (294)	**118 Og** (294)

Lanthanoids

57 La 138.91	**58 Ce** 140.12	**59 Pr** 140.91	**60 Nd** 144.24	**61 Pm** (146.9)	**62 Sm** 150.36	**63 Eu** 151.96	**64 Gd** 157.25	**65 Tb** 158.93	**66 Dy** 162.50	**67 Ho** 164.93	**68 Er** 167.26	**69 Tm** 168.93	**70 Yb** 173.05	**71 Lu** 174.97

Actinoids

89 Ac (227.0)	**90 Th** 232.0	**91 Pa** 231.0	**92 U** 238.0	**93 Np** (237.0)	**94 Pu** (239.1)	**95 Am** (241.1)	**96 Cm** (244.1)	**97 Bk** (249.1)	**98 Cf** (252.1)	**99 Es** (252.1)	**100 Fm** (252.1)	**101 Md** (258.1)	**102 No** (259.1)	**103 Lr** (262.1)

Groups are numbered according to IUPAC convention 1–18.
*Values in brackets are for the isotope with the longest half-life.