Neap

Trial Examination 2023

Question and Response Booklet

QCE Physics Units 3&4

Paper 2

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.
- Write using black or blue pen.
- QCAA-approved calculator permitted.
- Formula and data booklet provided.
- Planning paper will not be marked.

Section 1 (50 marks)

- 11 short response questions

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2023 QCE Physics Units 3&4 Written Examination.

SECTION 1

Instructions

- 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.

DO NOT WRITE ON THIS PAGE

THIS PAGE WILL NOT BE MARKED

QUESTION 1 (4 marks)

A transformer's primary coil has 4800 turns and is supplied with a potential of 240 V. The secondary coil has 480 turns and powers a small electric motor that requires a current of 0.5 A.

Determine the current supplied to the primary coil of the transformer.

Current = _____ mA (to one significant figure)

QUESTION 2 (2 marks)

Calculate the wavelength of an electron travelling at 1.0×10^5 m s^{-1}.

Wavelength = _____ m (to two significant figures)

QUESTION 3 (4 marks)

Volcanic lava can often appear to glow different colours, especially red, orange and yellow. The wavelengths of these colours are shown in the table.

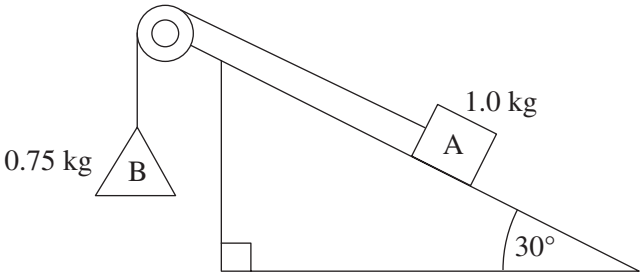
Colour	Wavelength (nm)
yellow	570–590
orange	590–620
red	620–750

Rhyolitic lava and basaltic lava have different chemical compositions. Rhyolitic lava has a high silicon content and often glows orange-red. Basaltic lava has a low silicon content and often glows yellow immediately after a volcanic eruption, then glows orange-red after some time has passed.

With reference to black-body radiation, chemical composition and the information in the table, explain why rhyolitic lava and basaltic lava glow differently.

QUESTION 4 (4 marks)

Consider the diagram.



Not to scale

The ramp applies friction to block A. Block B is a hanging mass attached to the other end of the pulley. The pulley is frictionless. The blocks are at rest.

a) Determine the magnitude of the frictional force being experienced by the system. *[3 marks]*

Frictional force = _____ N (to two significant figures)

b) Identify the direction that block B would move if the ramp were frictionless. *[1 mark]*

QUESTION 5 (5 marks)

The average distance between the proton and the electron in a hydrogen atom is 6.0×10^{-11} m.

Determine the factor (that is, how many times) by which the electrostatic force is greater than the gravitational force between the proton and the electron in a hydrogen atom.

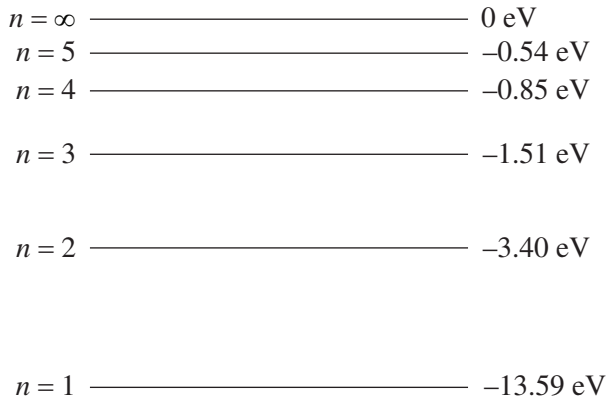
Factor = _____ (to two significant figures)

QUESTION 6 (3 marks)

Explain how Bohr's model of the atom addressed two limitations of Rutherford's model.

QUESTION 7 (5 marks)

An energy level diagram for hydrogen is shown.



a) The Lyman-α emission from a hydrogen atom is a photon with a wavelength of 121.6 nm.

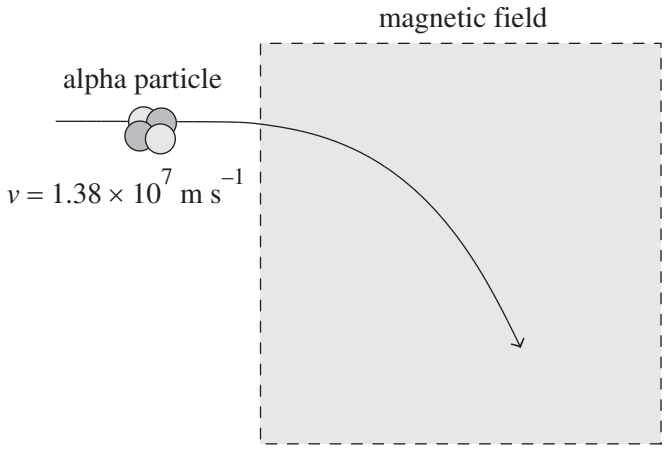
Determine which energy level transition the Lyman-α emission corresponds to. *[3 marks]*

Energy level transition = _____ to _____

b) Explain whether it is possible for a photon emitted from a hydrogen atom to have a shorter wavelength than that of the Lyman-α emission. *[2 marks]*

QUESTION 8 (7 marks)

An alpha particle with a velocity of 1.38×10^7 m s^{-1} enters a region with a uniform magnetic field, as shown in the diagram.



The motion of the alpha particle is perpendicular to the magnetic field until it enters the field, where it is deflected along a circular path with a radius of 78 cm.

a) Predict the direction of the magnetic field. *[1 mark]*

b) Determine the centripetal force acting on the alpha particle in the magnetic field. *[3 marks]*

Centripetal force = _____ N (to three significant figures)

c) Calculate the strength of the magnetic field. *[3 marks]*

Strength = _____ T (to three significant figures)

QUESTION 9 (4 marks)

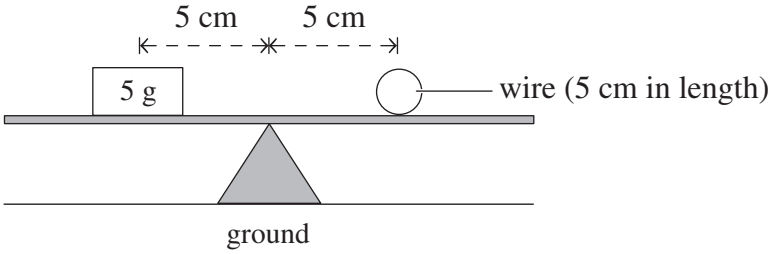
The Sun has a mass of 2.0×10^{30} kg.

Calculate the average distance between the Sun and Earth.

Distance = _____ m (to two significant figures)

QUESTION 10 (5 marks)

A platform is balanced on a pivot point with a small mass placed on one side and a current-carrying wire placed equidistant from the pivot point on the other side, as shown in the diagram.



The small mass is 5 g, and the length of the current-carrying wire is 5 cm. The whole system exists in an external magnetic field of 0.7T to the right.

Determine the magnitude and direction of the current in the current-carrying wire.

Magnitude of the current = _____ A (to one decimal place)

Direction of the current = _____

QUESTION 11 (7 marks)

A photon with a frequency of 6.60×10^{14} Hz is incident upon a metal with a threshold frequency of 2.50×10^{14} Hz.

a) Determine the energy of the photon. *[2 marks]*

Energy = _____ J (to three significant figures)

b) Determine the work function of the metal. *[2 marks]*

Work function = _____ J (to three significant figures)

c) Determine the maximum velocity of the associated photoelectron. *[3 marks]*

Maximum velocity = _____ m s^{-1} (to three significant figures)

END OF PAPER

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

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Write the question number you are responding to.

Neap

Trial Examination 2023

Formula and Data Booklet

QCE Physics Units 3&4

FORMULAS

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

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	
$N = N_0\left(\dfrac{1}{2}\right)^n$	$\Delta E = \Delta m c^2$

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

Linear motion and force	
$v = u + at$	$W = \Delta E$
$s = ut + \frac{1}{2}at^2$	$W = Fs$
$v^2 = u^2 + 2as$	$E_k = \frac{1}{2}mv^2$
$a = \frac{F_{\text{net}}}{m}$	$\Delta E_{\text{p}} = mg\Delta h$
$p = mv$	$\sum \frac{1}{2}mv^2_{\text{before}} = \sum \frac{1}{2}mv^2_{\text{after}}$
$\sum mv_{\text{before}} = \sum mv_{\text{after}}$	

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

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

Electromagnetism	
$F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$	$F = qvB\sin\theta$
$E = \frac{F}{q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$	$\phi = BA\cos\theta$
$V = \frac{\Delta U}{q}$	$\text{emf} = -\frac{n\Delta\left(BA_{\perp}\right)}{\Delta t}$
$B = \frac{\mu_0 I}{2\pi r}$	$\text{emf} = -n\frac{\Delta\phi}{\Delta t}$
$B = \mu_0 nI$	$I_{\text{p}}V_{\text{p}} = I_{\text{s}}V_{\text{s}}$
$F = BIL\sin\theta$	$\frac{V_{\text{p}}}{V_{\text{s}}} = \frac{n_{\text{p}}}{n_{\text{s}}}$

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

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

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 = 1.66×10^{-27} kg
Electron volt	1 eV = 1.60×10^{-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 Earth	$m_E = 5.97 \times 10^{24}$ kg

Electromagnetism	
Coulomb's constant	$\frac{1}{4\pi\varepsilon_0} = 9\times10^{9}\ \text{N m}^2\ \text{C}^{-2}$
Magnetic constant	$\mu_0 = 4\pi \times 10^{-7}\ T\,A^{-1}\ \text{m}$

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

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
Hydrogen	1	H
Helium	2	He
Lithium	3	Li
Beryllium	4	Be
Boron	5	B
Carbon	6	C
Nitrogen	7	N
Oxygen	8	O
Fluorine	9	F
Neon	10	Ne
Sodium	11	Na
Magnesium	12	Mg
Aluminium	13	Al
Silicon	14	Si
Phosphorus	15	P
Sulfur	16	S
Chlorine	17	Cl
Argon	18	Ar
Potassium	19	K
Calcium	20	Ca
Scandium	21	Sc
Titanium	22	Ti
Vanadium	23	V
Chromium	24	Cr
Manganese	25	Mn
Iron	26	Fe
Cobalt	27	Co
Nickel	28	Ni
Copper	29	Cu
Zinc	30	Zn
Gallium	31	Ga
Germanium	32	Ge
Arsenic	33	As
Selenium	34	Se
Bromine	35	Br

Name	Atomic no.	Symbol
Krypton	36	Kr
Rubidium	37	Rb
Strontium	38	Sr
Yttrium	39	Y
Zirconium	40	Zr
Niobium	41	Nb
Molybdenum	42	Mo
Technetium	43	Tc
Ruthenium	44	Ru
Rhodium	45	Rh
Palladium	46	Pd
Silver	47	Ag
Cadmium	48	Cd
Indium	49	In
Tin	50	Sn
Antimony	51	Sb
Tellurium	52	Te
Iodine	53	I
Xenon	54	Xe
Cesium	55	Cs
Barium	56	Ba
Lanthanum	57	La
Cerium	58	Ce
Praseodymium	59	Pr
Neodymium	60	Nd
Promethium	61	Pm
Samarium	62	Sm
Europium	63	Eu
Gadolinium	64	Gd
Terbium	65	Tb
Dysprosium	66	Dy
Holmium	67	Ho
Erbium	68	Er
Thulium	69	Tm
Ytterbium	70	Yb

LIST OF ELEMENTS (CONTINUED)

Name	Atomic no.	Symbol
Lutetium	71	Lu
Hafnium	72	Hf
Tantalum	73	Ta
Tungsten	74	W
Rhenium	75	Re
Osmium	76	Os
Iridium	77	Ir
Platinum	78	Pt
Gold	79	Au
Mercury	80	Hg
Thallium	81	Tl
Lead	82	Pb
Bismuth	83	Bi
Polonium	84	Po
Astatine	85	At
Radon	86	Rn
Francium	87	Fr
Radium	88	Ra
Actinium	89	Ac
Thorium	90	Th
Protactinium	91	Pa
Uranium	92	U
Neptunium	93	Np
Plutonium	94	Pu

Name	Atomic no.	Symbol
Americium	95	Am
Curium	96	Cm
Berkelium	97	Bk
Californium	98	Cf
Einsteinium	99	Es
Fermium	100	Fm
Mendelevium	101	Md
Nobelium	102	No
Lawrencium	103	Lr
Rutherfordium	104	Rf
Dubnium	105	Db
Seaborgium	106	Sg
Bohrium	107	Bh
Hassium	108	Hs
Meitnerium	109	Mt
Darmstadtium	110	Ds
Roentgenium	111	Rg
Copernicium	112	Cn
Nihonium	113	Nh
Flerovium	114	Fl
Moscovium	115	Mc
Livermorium	116	Lv
Tennessine	117	Ts
Oganesson	118	Og

PERIODIC TABLE OF THE ELEMENTS

KEY

																	2 He 4.00
												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.