Neap

Trial Examination 2022

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 (45 marks)

- 8 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 2022 QCE Physics Units 3&4 Written Examination.

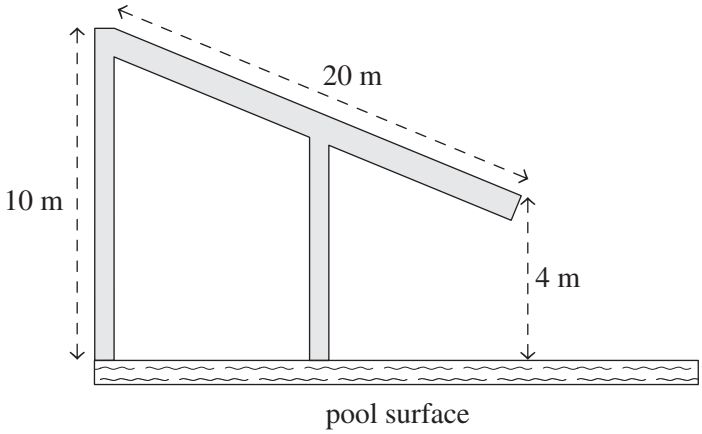
SECTION 1

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.

QUESTION 1 (8 marks)

A student of mass 60 kg slides along the straight, frictionless waterslide shown in the diagram. The waterslide is 20 m in length. The top of the waterslide is 10 m above the surface of the pool. The bottom of the waterslide is 4 m above the surface of the pool.



Not to scale

The student begins their slide from rest at the top of the waterslide. Once they leave the bottom of the waterslide, they are in free fall for 0.63 seconds before they hit the pool surface.

a) Determine the angle that the waterslide makes with the pool surface. *[1 mark]*

Angle = _____° (to 2 decimal places)

b) Calculate the magnitude of the component of the student's weight along the waterslide. *[2 marks]*

Component of weight along slide = _____ N (to 1 decimal place)

c) Calculate the magnitude of the component of the student's acceleration along the waterslide. *[1 mark]*

Component of acceleration along slide = _____ m s^{-2}
(to 2 decimal places)

d) Determine the horizontal range of the student while they are in free fall, as measured from the bottom of the waterslide. *[4 marks]*

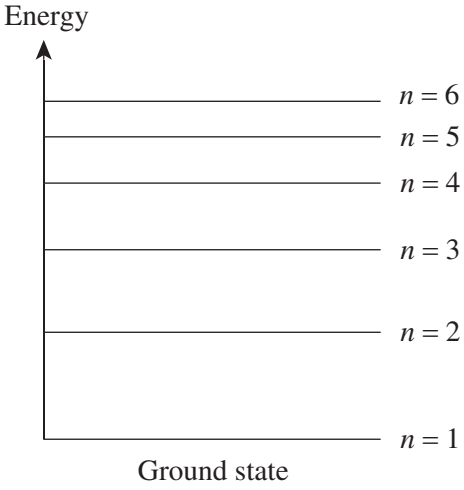
Horizontal range = _____ m (to 1 decimal place)

QUESTION 2 (5 marks)

Hydrogen gas emits light when it is ionised at room temperature and subjected to a large voltage.

The resultant visible light emission spectrum for hydrogen is shown. It is known as the Balmer series and occurs when the final energy state of any electron de-excitation is $n = 2$.

The energy level diagram for hydrogen is shown below.



a) Explain how light quanta and atomic energy states explain the specific wavelengths in the hydrogen light emission spectrum. You may refer to the diagrams above in your response. *[3 marks]*

b) The Lyman series of hydrogen emission lines is defined as any electron de-excitation whose final energy state occurs in the ground state ($n = 1$).

Explain whether the Lyman series would have longer or shorter wavelengths compared to the Balmer series. *[2 marks]*

QUESTION 3 (4 marks)

Describe four characteristics of the photoelectric effect. Refer to photons in your response.

1.

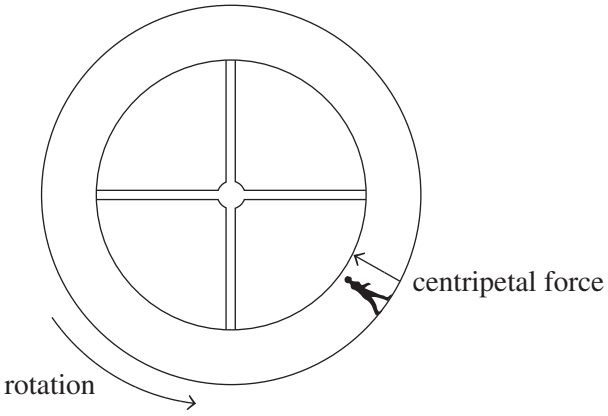
2.

3.

4.

QUESTION 4 (5 marks)

In the early twentieth century, the von Braun wheel was proposed as a means of producing artificial gravity for astronauts when aboard a space station. The proposed station was a 'wheel' design that rotated about its axis with the astronauts inside, resulting in centripetal acceleration as shown in the diagram.



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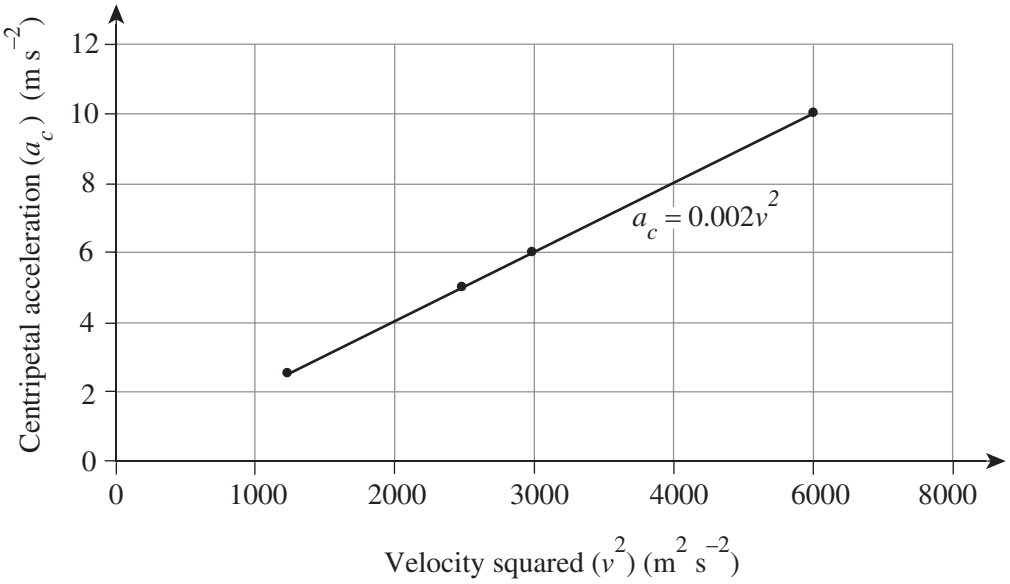
An astronaut aboard a von Braun wheel space station conducted an experiment by changing the station's rotational velocity and measuring the resultant centripetal acceleration. The results are shown in the graph.



a) Determine the radius of the space station using the equation of the trendline. *[2 marks]*

Radius = _____ m (to the nearest whole number)

b) Use the equation of the trendline to calculate the period of rotation when the centripetal acceleration is 7.2 m s^{-2}. *[3 marks]*

Period of rotation = _____ s (to the nearest whole number)

QUESTION 5 (8 marks)

A set of twins aged 30 years old decided to embark on a science experiment. Twin A remained on Earth, while twin B travelled to a star and back with an average speed of 0.866*c*. Twin B had aged 20 years upon their return to Earth.

a) Determine the time elapsed on Earth from twin A's perspective during twin B's journey. *[2 marks]*

Time elapsed from twin A's perspective = _____ years
(to the nearest whole number)

b) Determine the time elapsed on Earth from twin B's perspective during their journey. *[2 marks]*

Time elapsed from twin B's perspective = _____ years
(to the nearest whole number)

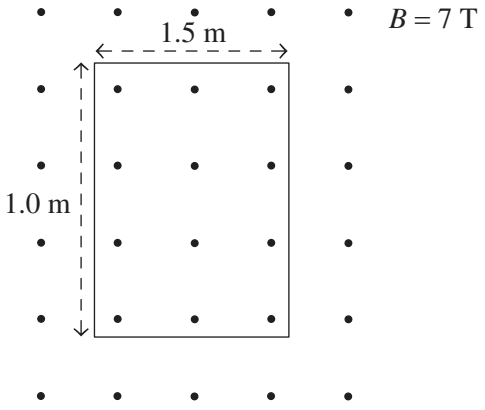
c) Describe the paradoxical situation. *[1 mark]*

d) Suggest a resolution to the paradox. *[1 mark]*

e) As both twins agree on their relative velocity to each other, what other realtivistic effect occurs in this situation to ensure their relative velocities agree? Explain which twin experiences this effect. *[2 marks]*

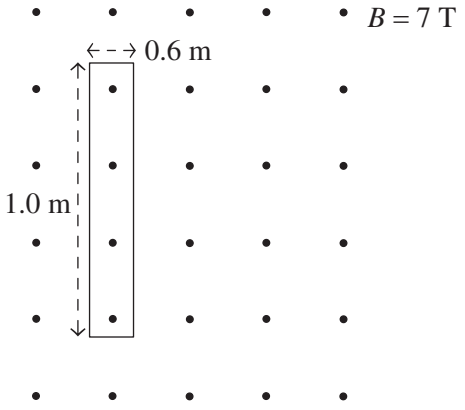
QUESTION 6 (5 marks)

A single loop of wire is perpendicular to a uniform magnetic field of 7 T, as shown in Figure 1. The loop has its dimensions altered in 0.05 seconds to the position shown in Figure 2.



Not to scale

Figure 1



Not to scale

Figure 2

a) Calculate the magnitude of the induced emf in the loop. *[3 marks]*

emf = _____ V (to the nearest whole number)

b) Explain the direction of the **induced** magnetic field inside the loop of wire. *[2 marks]*

QUESTION 7 (5 marks)

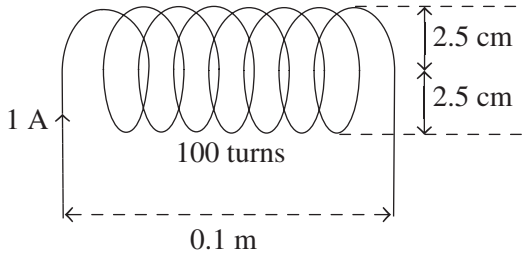
Laser light is shone onto a surface of sodium metal. The wavelength of the laser light is 4.5×10^{-7} m, and the work function of sodium is 2.36 eV.

Calculate the magnitude of the maximum velocity of the resultant photoelectrons. Express your answer in scientific notation.

Maximum velocity = _____ m s^{-1} (to 2 significant figures)

QUESTION 8 (5 marks)

A 0.1 m long solenoid with 100 turns of wire and a cross-sectional radius of 2.5 cm carries a current of 1 A.



Not to scale

Calculate the magnitude of the magnetic flux inside the solenoid. Express your answer in microwebers.

Magnetic flux = _____ μWb (to 1 decimal place)

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 2022

Formula and Data Booklet

QCE Physics Units 3&4

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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 the 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.