Neap

Trial Examination 2021

Question and response booklet

QCE Physics Units 1&2

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

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

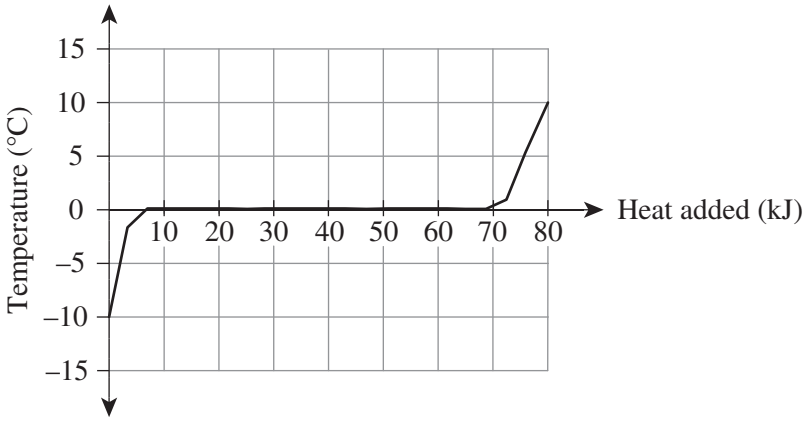
THIS PAGE WILL NOT BE MARKED

QUESTION 1 (3 marks)

The initial temperature of an insulated 150 g sample of ice is – 4.0°C. A 60 J s^{-1} immersion heater is placed in the ice and the temperature is recorded at one-minute intervals. The measurements are shown in the table below.

Time (s)	Temperature (°C)	Heat added (kJ)
0	–10.0	0.0
60	–1.7	3.6
120	0.0	7.2
180	0.0	10.8
240	0.0	14.4
300	0.0	18.0
360	0.0	21.6
420	0.0	25.2
480	0.0	28.8
540	0.0	32.4
600	0.0	36.0
660	0.0	39.6
720	0.0	43.2
780	0.0	46.8
840	0.0	50.4
900	0.0	54.0
960	0.0	57.6
1020	0.0	61.2
1080	0.0	64.8
1140	0.0	68.4
1200	1.0	72.0
1260	5.3	75.6
1320	9.6	79.2

The data is represented in the graph below.



a) Use the data to calculate the latent heat of fusion for water. Show your working. *[2 marks]*

Latent heat of fusion = _____ kJ kg^{-1}

b) Why is the value calculated in 1a) different to the accepted value? *[1 mark]*

QUESTION 2 (5 marks)

Thorium-227 (Th-227) undergoes decay to produce radium-223 (Ra-223). The table below shows the masses of different nuclei.

Nucleus	Mass (u)
Th-227	227.0278
Ra-223	223.0186
alpha particle	4.0026

a) Calculate the mass defect for the reaction. Show your working. *[4 marks]*

Mass defect = _____ u (to 2 decimal places)

b) Use the mass defect calculated in 2a) to determine the amount of energy released by the reaction. *[1 mark]*

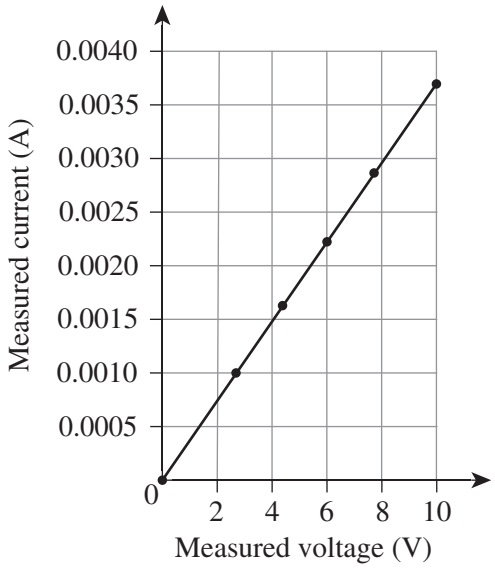
Energy released = _____ MeV (to 2 decimal places)

QUESTION 3 (5 marks)

An experiment was conducted to study the relationship between the applied potential difference across a conductor and the current produced in a resistor of known value. The data collected is shown in the table below.

Measured voltage (V)	Measured current (A)	Current (mA)	Resistance (Ω)
0.0	0.0000	0.0	0.00
2.7	0.0010	1.0	2700.00
4.3	0.0016	16.0	
6.0	0.0022	22.0	
7.8	0.0029	29.0	
10.0	0.0037	37.0	

The graph below shows the collected data of measured current against measured voltage.



a) Complete the resistance values column in the table above. *[2 marks]*

b) Determine the average resistance. *[1 mark]*

Average resistance = _____ Ω (to 2 decimal places)

c) With reference to the magnitude of the gradient of the graph, explain whether the resistor is ohmic or non-ohmic. Include a calculation to support your answer. *[2 marks]*

QUESTION 4 (8 marks)

An object of mass 80 g is initially at rest. A 0.16 N net force to the north then acts on the object for 5.0 seconds.

a) Calculate the magnitude and indicate the direction of the acceleration produced by the force. *[1 mark]*

Acceleration = _____ m s^{-2}

Direction = _____

b) Calculate the magnitude and indicate the direction of the final velocity of the object. Show your working. *[2 marks]*

Velocity = _____ m s^{-1}

Direction = _____

c) Calculate the object's displacement after 5.0 seconds. Show your working. *[2 marks]*

Displacement = _____ m

d) Calculate the magnitude and indicate the direction of the acceleration required to stop the object in 3.0 seconds. Show your working. *[2 marks]*

Acceleration = _____ m s^{-2} (to 2 decimal places)

Direction = _____

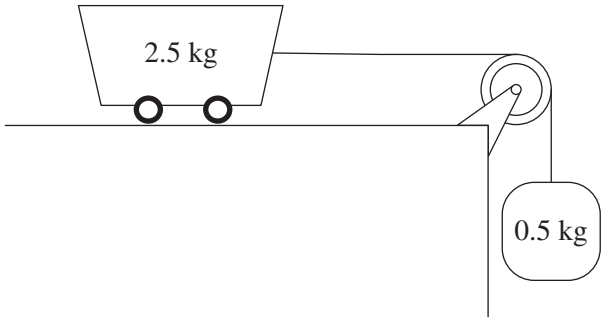
e) Calculate the magnitude and indicate the direction of the force required to stop the object in 3.0 seconds. *[1 mark]*

Force = _____ N (to 2 decimal places)

Direction = _____

QUESTION 5 (6 marks)

A small cart on a table is attached to a metal block by a string and pulley system. The cart is initially stationary as the metal block is held in position. When the block is released, the cart begins to move forward.



a) Ignoring friction, calculate the acceleration of the block as it falls. Show your working. *[2 marks]*

Acceleration = _____ m s^{-2} (to 2 decimal places)

b) Determine the speed of the block after 0.5 seconds. Show your working. *[2 marks]*

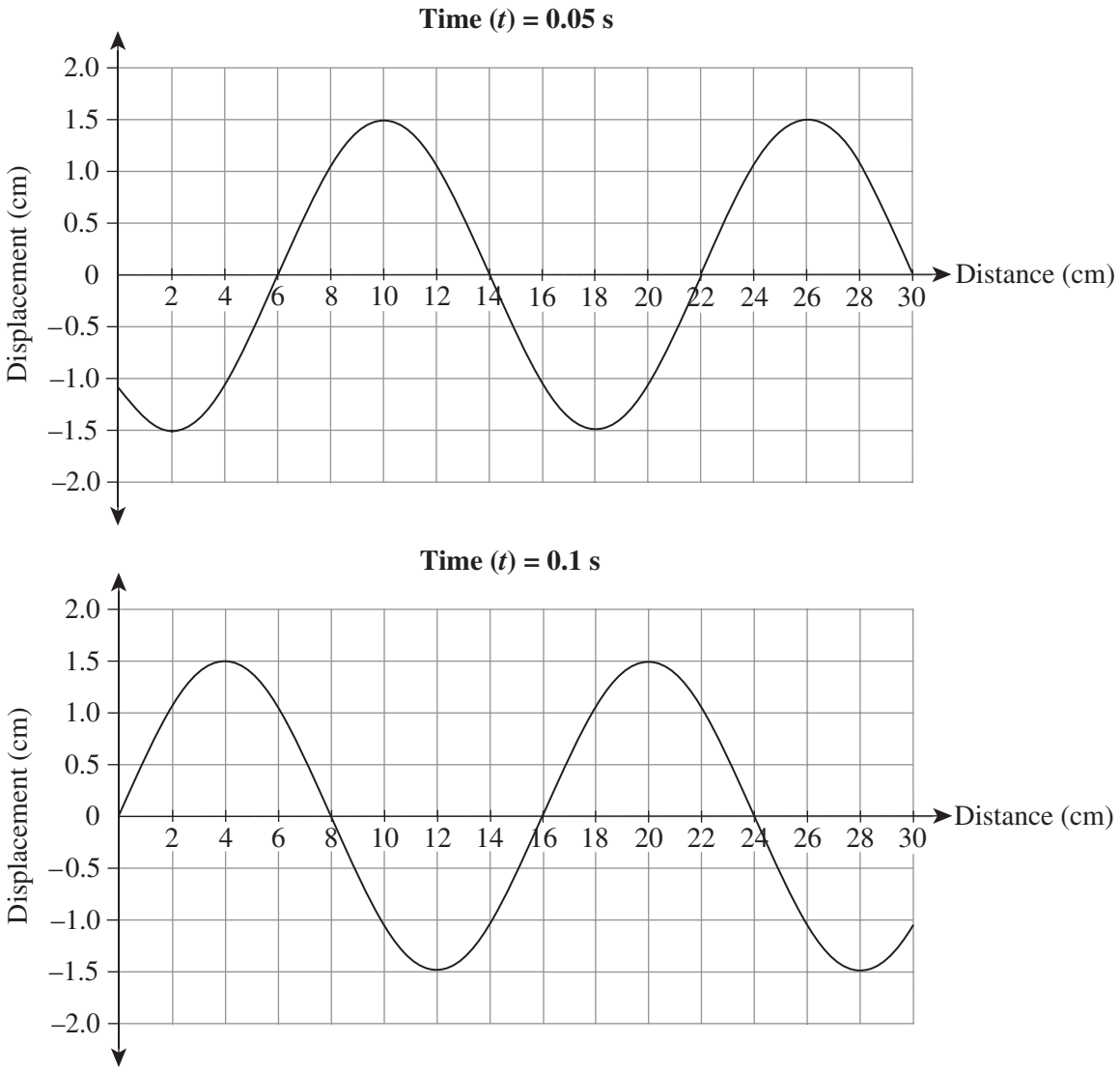
Speed = _____ m s^{-1} (to 2 decimal places)

c) If there were a frictional force of 4.3 N acting on the cart, calculate the acceleration of the cart. Show your working. *[2 marks]*

Acceleration = _____ m s^{-2}

QUESTION 6 (6 marks)

The graphs below show two positions of the same wave 0.05 seconds apart. The wave is moving to the right.



a) Deduce the wavelength of the wave. *[1 mark]*

Wavelength = _____ cm (to the nearest whole number)

b) Deduce the period of the wave. Show your working. *[2 marks]*

Period = _____ s (to 2 decimal places)

c) Deduce the frequency of the wave. *[1 mark]*

Frequency = _____ Hz (to 1 decimal place)

d) Deduce the amplitude of the wave. *[1 mark]*

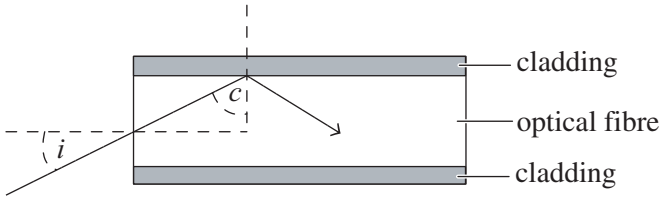
Amplitude = _____ cm (to 1 decimal place)

e) Deduce the speed of the wave. *[1 mark]*

Speed = _____ cm s^{-1} (to the nearest whole number)

QUESTION 7 (8 marks)

The diagram below shows a ray of light entering an optical fibre from air. The optical fibre is made of glass that has a refractive index of 1.50. The optical fibre is covered by opaque plastic cladding that has a refractive index of 1.40. Light is not absorbed by the plastic.



a) Calculate the critical angle, *c,* for the optical fibre. Show your working. *[3 marks]*

c = _____ ° (to 2 decimal places)

b) Determine the minimum value of the external angle of incidence, i, that allows the light to reflect inside the optical fibre when $n_{air} = 1.00$. Show your working. *[5 marks]*

i = _____° (to 1 decimal place)

QUESTION 8 (4 marks)

A student was investigating Newton's second law. The student used a cart and pulley system to find the acceleration of the cart. In each trial, the cart had a mass of 361.79 g and travelled a distance (d) of 98 cm. The acceleration was calculated using the following formula.

$$a = \frac{2d}{t^2}$$

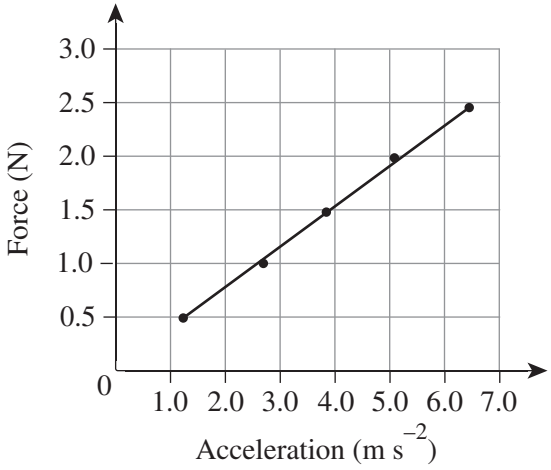
The results are shown in the table below.

Hanging mass (kg)	Force applied (N) (hanging mass × gravity)	Time for the cart to reach the pulley (s)			Average time (s)	Acceleration (m s^{-2})
		Trial 1	Trial 2	Trial 3		
0.049	0.49	1.26	1.22	1.26	1.25	1.25
0.099	0.98	0.85	0.86	0.84	0.86	?
0.149	1.47	0.69	0.73	0.72	0.71	3.88
0.202	1.96	0.62	0.62	0.63	0.62	5.10
0.251	2.45	0.54	0.54	0.57	0.55	6.48

a) Calculate the acceleration for the hanging mass of 0.099 kg. Show your working. *[2 marks]*

Acceleration = _____ m s^{-2} (to 2 decimal places)

b) The results were recorded in the force–acceleration graph below, giving the line $y = 0.3796x + 0.0004$ and $R^2 = 0.9993$.



For the trials to be accurate, the mass of the cart used in the trials should be equal to the gradient of the graph.

Calculate the percentage error in the student's investigation. Show your working. *[2 marks]*

Percentage error = _____% (to 2 decimal places)

END OF PAPER

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

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Neap

Trial Examination 2021

Formula and data booklet

QCE Physics Units 1&2

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

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

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

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
Tellerium	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

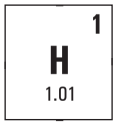
LIST OF ELEMENTS (CONTINUED)

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



atomic number
symbol
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.