Neap

Trial Examination 2022

**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)**

- 9 short response questions

## SECTION 1

**Instructions**

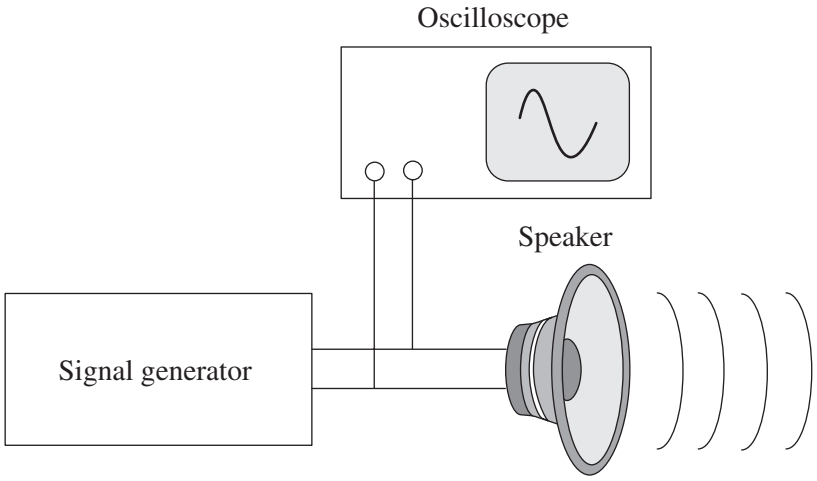
- If you need more space for a response, use the additional pages at the back of this booklet.
  - On the additional pages, write the question number you are responding to.
  - Cancel any incorrect response by ruling a single diagonal line through your work.
  - Write the page number of your alternative/additional response, i.e. See page …
  - If you do not do this, your original response will be marked.

**DO NOT WRITE ON THIS PAGE**

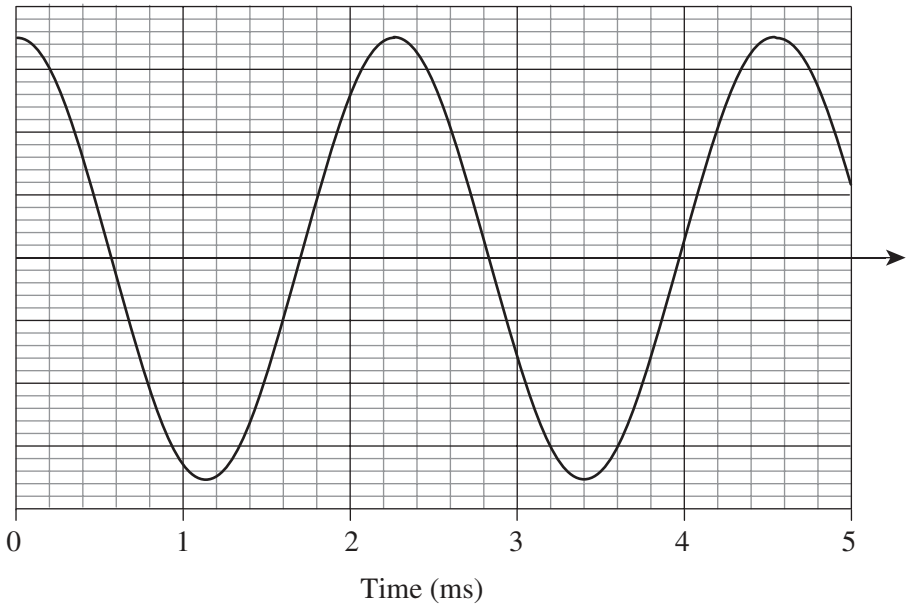
**THIS PAGE WILL NOT BE MARKED**

**QUESTION 1 (4 marks)**

A signal generator was used to create a wave signal that was sent to an audio speaker. An oscilloscope, an instrument that generates a graph of electrical wave signals, was connected to the wires going to the speaker, as shown in the diagram.




The graph shown was displayed on the oscilloscope screen.




a) Determine the period of the wave signal. *[1 mark]*

Period = _____ m $s^{-1}$ (to 1 decimal place)

b) Determine the frequency of the wave signal. *[1 mark]*

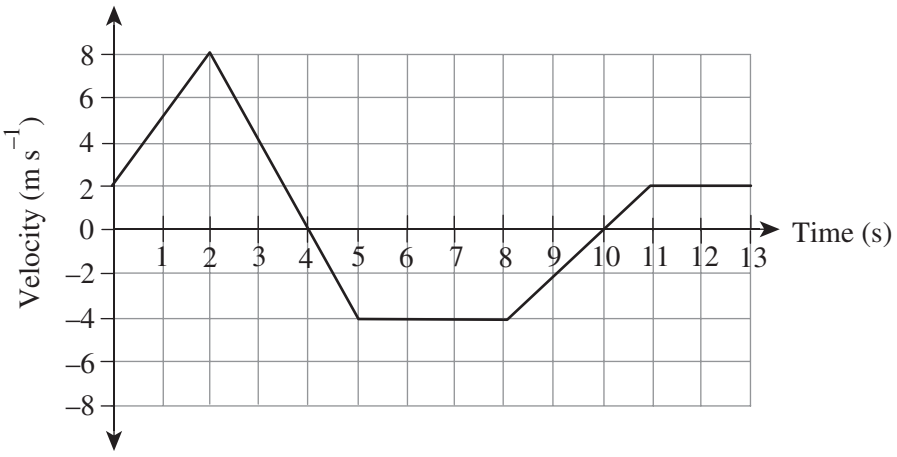
Frequency = _____ Hz (to the nearest whole number)

c) Given that the speed of sound in air is 346 m $s^{-1}$, calculate the wavelength of the soundwave emitted by the speaker. *[2 marks]*

Wavelength = _____ cm (to the nearest whole number)

**QUESTION 2 (6 marks)**

The graph shown represents the motion of a car over 13 seconds.




a) What was the velocity of the car when it had been travelling for 3 seconds? *[1 mark]*

Velocity = _____ m s$^{-1}$ (to th nearest whole number)

b) At which time(s) did the car change direction? *[1 mark]*

c) Determine the displacement of the car between 2 and 5 seconds. Show your working. *[2 marks]*

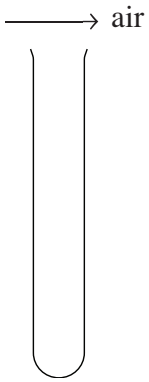
Displacement = _____ m (to the nearest whole number)

d) Calculate the maximum positive acceleration of the car. Show your working. *[2 marks]*

Acceleration = _____ m s$^{-2}$ (to the nearest whole number)

**QUESTION 3 (4 marks)**

A physics student finds that she can create a 481 Hz sound by blowing air across the top of a test tube, as shown in the diagram.

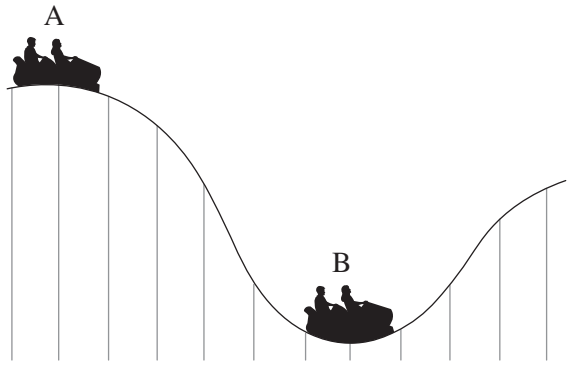



Assuming the sound the student is making is the first mode of vibration, calculate the length of the test tube that the student is using.

Length = _____ cm (to the nearest whole number)

**QUESTION 4 (7 marks)**

A 250 kg rollercoaster car is at point A on a track, as shown in the diagram, and is moving at a velocity of 1.20 m $s^{-1}$ to the right. Point A is 12.5 m above the ground. The rollercoaster rolls down the slope of the track, propelled only by gravity, to point B. Point B is 1.0 m above the ground.




a) Explain how the law of conservation of energy applies to this scenario. *[2 marks]*

b) Calculate the total mechanical energy of the rollercoaster at point A. Use the ground as your reference for potential energy. Show your working. *[2 marks]*

Energy = _____ kJ (to 1 decimal place)

c) Calculate the velocity of the rollercoaster at point B. Assume that any energy losses due to friction and air resistance are negligible. *[3 marks]*

Velocity = _____ m $s^{-1}$ (to 1 decimal place)

**QUESTION 5 (7 marks)**

The transmutation equation shown represents the nuclear fission of uranium-233.

$$^{233}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{137}_{54}\mathrm{Xe} + {}^{94}_{38}\mathrm{Sr} + 3\,{}^{1}_{0}\mathrm{n} + \text{energy}$$

a) Define *nuclear fission*. *[1 mark]*

b) Explain why the three neutrons produced in this reaction are significant to the usefulness of uranium-233 as a fuel for nuclear reactors. *[2 marks]*

c) Consider the data shown in the table.

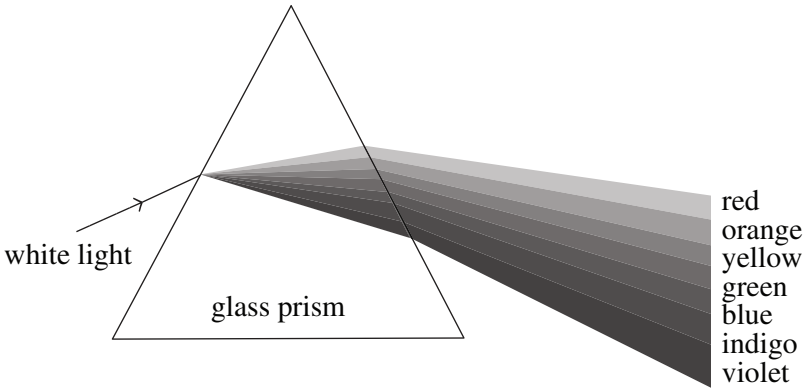
| Particle | Mass (AMU) |
|---|---|
| neutron | 1.008664 |
| uranium-233 | 233.039634 |
| xenon-137 | 136.911557 |
| strontium-94 | 93.915355 |

Use the data in the table to calculate the amount of energy released from the fission of a single uranium-233 atom. Give your answer in scientific notation. *[4 marks]*

Energy = _____ J (to 3 significant figures)

**QUESTION 6 (3 marks)**

A glass prism is shown in the diagram.



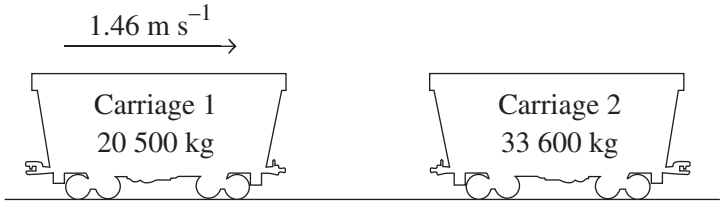

Use the wave model of light to explain how a glass prism disperses a ray of white light into its constituent colours.

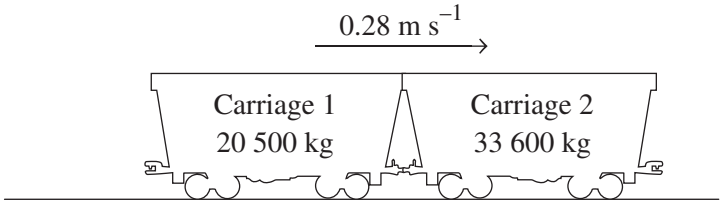
**QUESTION 7 (5 marks)**

The following diagram shows the position of two railway carriages before and after a collision. Before the collision, carriage 1 is moving to the right at a velocity of 1.46 m $s^{-1}$ and carriage 2 is moving at an unknown velocity.

After the collision, the carriages join together and move with a velocity of 0.28 m $s^{-1}$ to the right.




Before collision




After collision

a) State the condition that must be true for momentum to be conserved during a collision. *[1 mark]*

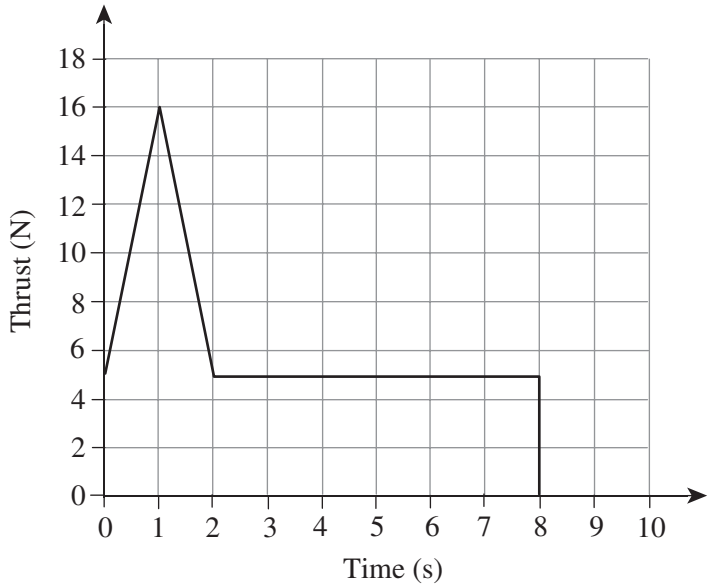
b) Determine the direction and velocity of carriage 2 before the collision. *[4 marks]*

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

Direction = _____

**QUESTION 8 (4 marks)**

The graph shows the thrust curve for the engine of a model rocket car.




a) Determine the total impulse provided by the engine. *[2 marks]*

Impulse = _____ N s (to the nearest whole number)

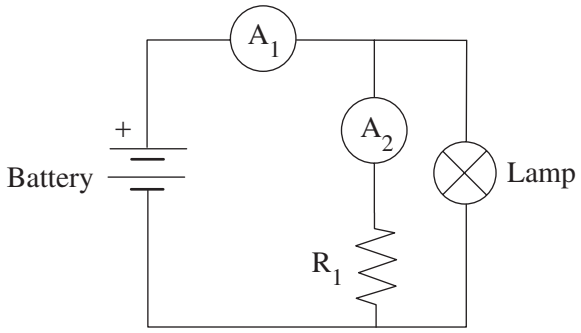
b) The engine was used to horizontally accelerate the rocket car, which has a mass of 1.23 kg and was initially at rest.

Calculate the maximum velocity that the car could reach under the engine's impulse. *[2 marks]*

Velocity = _____ m $s^{-1}$ (to the nearest whole number)

**QUESTION 9 (5 marks)**

The circuit shown in the diagram contains two ammeters, $A_1$ and $A_2$. $A_1$ displays a current of 2.2 A and $A_2$ displays a current of 1.0 A.




a) State Kirchhoff's current law. *[1 mark]*

b) Determine the current flowing through the lamp. Show your working. *[2 marks]*

Current = _____ A (to 1 decimal place)

c) If the battery has a potential difference of 3 V, calculate the resistance of the lamp. Show your working. *[2 marks]*

Resistance = _____ Ω (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.

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Write the question number you are responding to.

 

Neap

Trial Examination 2022

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

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

| **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 = $1.66 \times 10^{-27}$ 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 | $\frac{1}{4\pi\varepsilon_0} = 9\times10^{9}\ \text{N m}^2\ \text{C}^{-2}$ |
| 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 | $\mu$ |
| $10^{-3}$ | 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

| | |
|---|---|
| 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.