SYDNEY GRAMMAR SCHOOL

2009
FORM VI
TRIAL HSC EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet, formulae sheets and periodic table are provided at the back of this paper
- Write your candidate number at the top of each page in Part B
- Hand in the paper in ONE bundle at the end of the exam.

Check List
Each candidate must have
- Question paper
- Multiple choice answer sheet
- Five-page booklet

Total marks (100)

Section I Pages 2 - 28

(75 marks)

This section has two parts, Part A and Part B

Part A – 15 marks

- Attempt questions 1 - 15
- Allow about 30 minutes for this part

Part B – 60 marks

- Attempt Questions 16 - 29
- Allow about 1 hour and 45 minutes for this part

Section II Pages 29 – 31

(25 marks)
- Use a separate writing booklet
- Attempt Question 33 only.
- Allow about 45 minutes for this section

Masters

AAH – Dr A. Haines
AGY – Mr A. Yabsley
MRW – Dr M. Ward
SRW – Mr S. Williams

Part A
Total marks (15 marks)
Attempt Questions 1-15
Allow about 30 minutes for this Part

Use the multiple-choice Answer Sheet.

Select the alternative A, B, C or D that best answers the question. Fill the response circle completely.

Sample 2 + 4 =

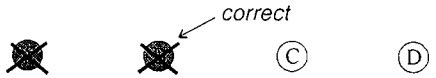
(A) 2 (B) 6 (C) 8 (D) 9

Ⓐ ● Ⓒ Ⓓ

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

● ⊗ Ⓒ Ⓓ

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.



1 The significance of the constancy of the speed of light is that:

(A) the Earth is an inertial frame of reference.
(B) measurements of time become relative to the speed of the observer.
(C) the length of an object increases as its speed increases.
(D) it makes detection of the "aether wind" possible.

2 Which of the following is a true statement?

(A) Newton's Law of Gravitation can be used to explain Kepler's Second Law.
(B) The gravitational field strength around an object is directly proportional to the distance from the object's centre of mass.
(C) The gravitational attraction between two masses is directly proportional to the separation of their centres.
(D) The acceleration of an object in a gravitational field is directly proportional to the mass of the object.

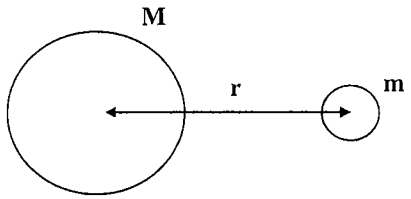
3 There is an optimum angle for a spaceship to complete a safe re-entry into the Earth's atmosphere because:

(A) if it's too steep, the spaceship will bounce off like a billiard ball.
(B) if it's too shallow, the force experienced is spread over a large area and the spaceship will burn up.
(C) if it's too shallow, the heat shield on the spaceship does not work.
(D) if it's too steep, the forces are too great on the astronauts.

4 A planet has a mass 3.6×10^{21} kg, and a radius of 2.4×10^{5} m. Calculate the escape velocity (from the surface of the planet) of a spacecraft with a mass of 5.6×10^{3} kg.

(A) 1.0×10^{3} ms^{-1}
(B) 1.4×10^{3} ms^{-1}
(C) 4.7×10^{4} ms^{-1}
(D) 1.1×10^{5} ms^{-1}

5 Object m is a satellite orbiting planet M. In the situation shown below, the gravitational potential energy of m is E.



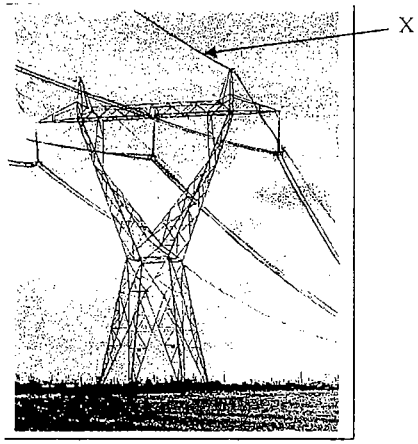
If the mass of M was doubled, and the distance between the two objects was doubled, what would be the new gravitational potential energy of m?

(A) $2E$
(B) $\sqrt{E}$
(C) E
(D) $\frac{E}{2}$

6 A voltage is induced in a long length of copper wire of very low resistance by its motion across a uniform magnetic field.
Which of the following is LEAST likely to affect the magnitude of the induced voltage?

(A) The length of the wire.
(B) The diameter of the wire.
(C) The velocity of the wire.
(D) The strength of the magnetic field.

7 The following diagram shows a transmission line support tower.



What is the role of the part labelled X?

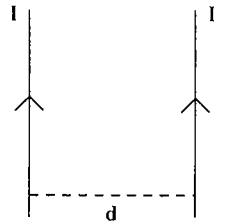
(A) Help to conduct electricity through the power lines.

(B) Protect the power lines from lightning strikes.

(C) Reduce the risk of electron flow from the power lines into the transmission tower.

(D) Attract lightning bolts so that energy of electrical storms can be added to the power grid.

8 The diagram below shows two parallel current carrying conductors separated by a distance d. The magnitude of the force per unit length when the wires carry identical currents, I is F.



If the separation between the wires is doubled, what is the new force per unit length?

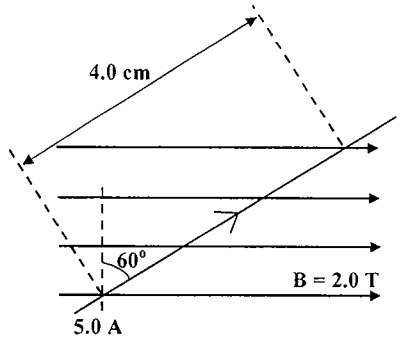
(A) F/2

(B) F/4

(C) 2F

(D) 4F

9 A wire carrying a current of 5.0 A is placed at an angle to a uniform magnetic field of strength 2.0 T as shown in the diagram below.



What is the magnitude of the magnetic force on the wire?

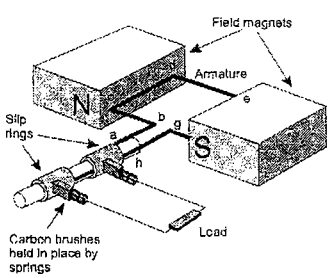
(A) 0.20 N

(B) 0.35 N

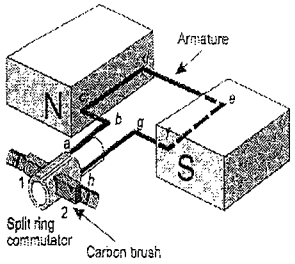
(C) 0.40 N

(D) 35 N

10 Consider the following two generators.



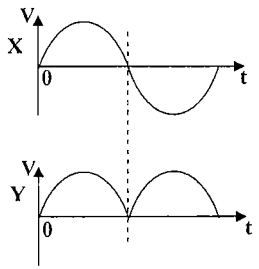
Generator X



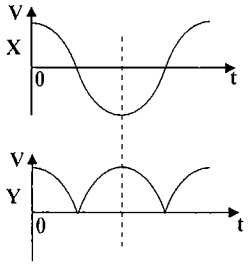
Generator Y

The loop of each generator is rotating at the same constant speed about an axis. At time t = 0 s, the plane of each loop is parallel to the magnetic field. Which of the following pair of graphs best depicts the resultant variation of voltage with time?

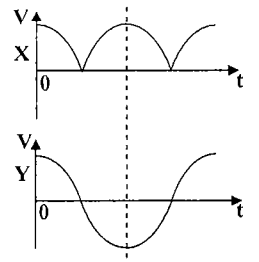
(A)



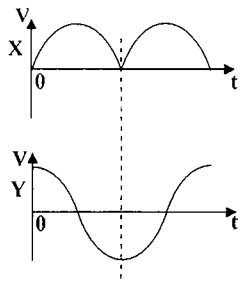
(B)



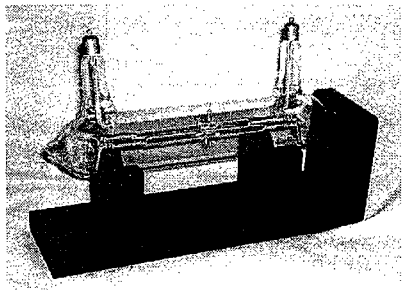
(C)



(D)



11 Consider the diagram below.



What property of cathode rays was this piece of apparatus used to demonstrate?

(A) Cathode rays travel in straight lines.

(B) Cathode rays are charged.

(C) Cathode rays possess a magnetic field.

(D) Cathode rays possess momentum.

12 A student measures the resistance of equal-sized samples of four different materials and obtains the following results.

Material	Resistance of Sample (Ω)
P	2.4×10^{-8}
Q	6.4×10^{2}
R	7.5×10^{18}
S	0

Which of the following correctly describes each material?

	P	Q	R	S
(A)	Conductor	Semiconductor	Insulator	Superconductor
(B)	Semiconductor	Conductor	Insulator	Superconductor
(C)	Semiconductor	Conductor	Superconductor	Insulator
(D)	Conductor	Semiconductor	Superconductor	Insulator

13 Which of the following observations made by Heinrich Hertz in his investigation into radio waves is due to the photoelectric effect?

(A) The radio waves were able to form standing waves when reflected from a metal surface.

(B) The spark size increased in the dark.

(C) The spark size decreased when UV light was not present.

(D) The radio waves could be detected at large distances.

14 In terms of band theory, the major difference between an insulator and a semiconductor is:

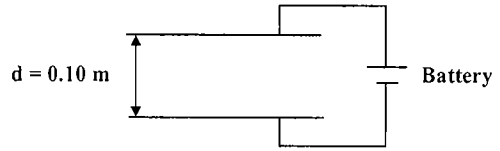
(A) an insulator has free electrons in the conduction band, while a semiconductor does not.

(B) an insulator has free holes in the valence band, while a semiconductor does not.

(C) the band gap of a semiconductor is larger than that of an insulator.

(D) the band gap of a semiconductor is smaller than that of an insulator.

15 Consider the diagram below, in which two parallel metal plates are connected to a battery.



Determine the voltage across the battery if an electron placed between the plates experiences a force of 3.2×10^{-16} N.

(A) 50 V

(B) 100 V

(C) 200 V

(D) 400 V

Class

Candidate Number

Part B

Total marks - 60
Attempt Questions 16 - 29
Allow about 1 hour and 45 minutes for this Part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 16 (4 marks) **Marks**

Describe the Michelson – Morley attempt to measure the relative velocity of the Earth through the aether. Include a diagram in your answer.

4

Class

Candidate Number

Question 17 (4 marks) **Marks**

The following data relates to a planet in a circular orbit around a star.

Mass of Star (kg)	**3.75×10^{30}**
Mass of Planet (kg)	**2.62×10^{25}**
Radius of Orbit (m)	**1.98×10^{16}**

Use this information to answer the following questions.

a) Calculate the gravitational force acting on the planet.

2

b) Calculate the orbital speed of the planet.

2

Class

Candidate Number

Question 18 (6 marks) **Marks**

"The exploration of space has led to the development of technologies that have had a significant impact on society."

Assess this statement, and support your answer by giving specific examples.

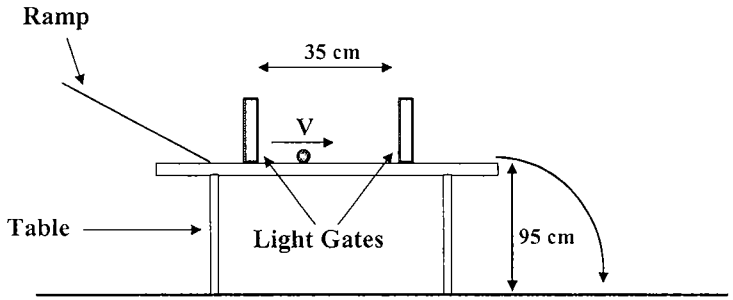
6

Class

Candidate Number

Question 19 (6 marks) **Marks**

A student performed an experiment investigating projectile motion in the laboratory. He rolled a ball down a ramp and onto a table, as shown in the diagram below.



The ball passed through two light gates on its way to the edge of the table, and took 0.78 s to travel the 35 cm distance between the light gates.

a) Stating any assumptions you make, estimate the speed with which the ball left the edge of the table.

2

Question 19 continued on next page.

Class

Candidate Number

Question 19 continued. **Marks**

b) Calculate the time it takes the ball to hit the floor, from the moment it leaves the edge of the table.

1

c) Calculate the velocity with which the ball hits the floor.

3

Class

Candidate Number

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Class

Candidate Number

Question 20 (5 marks) **Marks**

A DC electric motor has a coil with a resistance of 2.0 Ω. When the motor is connected to a 240 V power supply and operating at its maximum speed it draws a current of 4.00 A.

a) Calculate the back emf of the motor at its maximum speed.

2

b) If the machine the motor is driving jams and the coil of the motor suddenly stops turning, the current in the motor at the moment the coil jams increases significantly. Explain this observation.

3

Class

Candidate Number

Question 21 (4 marks) **Marks**

With the aid of a labelled diagram, describe how the motor effect is used in the operation of a galvanometer.

4

Class

Candidate Number

Question 22 (3 marks) **Marks**

Explain why transformers are used in the transfer of electrical energy from a power station to its point of use (e.g. a house).

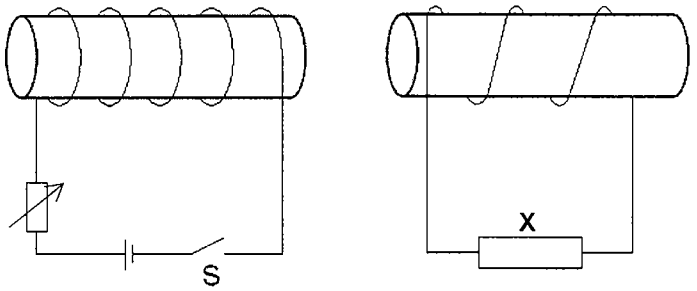
3

Class

Candidate Number

Question 23 (4 marks) **Marks**

Consider the following arrangement of solenoids.



In an experiment, a student closes switch S, keeps it closed for a few seconds, and then opens it again.

a) On the diagram above, show the direction of the current that flows through resistor X when switch S is opened again.

1

b) Justify your answer to part a).

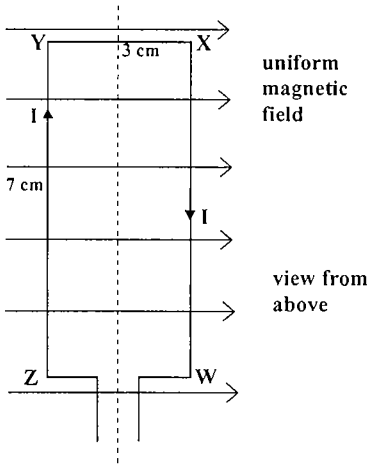
3

Class

Candidate Number

Question 24 (4 marks) **Marks**

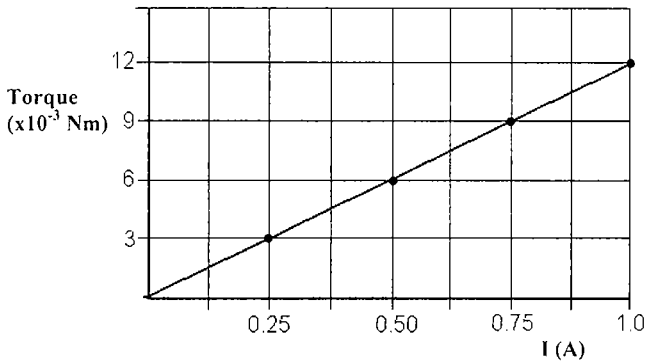
A coil of wire consists of 100 turns and has sides of length 3 cm and 7 cm. The coil is placed parallel to a uniform magnetic field of unknown strength as shown in the following diagram.



uniform magnetic field

view from above

The current in the coil is steadily increased and the maximum torque acting on the coil is measured. The following graph is a plot of the torque acting on the coil for the measured current.



Question 24 continued on next page.

Class

Candidate Number

Question 24 continued. **Marks**

a) Use the graph to determine the magnitude of the magnetic field strength. **2**

b) Calculate the force acting on side ZY of the coil when a current of 1.0 A flows through the coil, in the direction shown in the diagram. **2**

Class

Candidate Number

Question 25 (4 marks) **Marks**

Outline how a cathode ray tube is utilised in the operation of conventional TV.

4

Class

Candidate Number

Question 26 (6 marks) **Marks**

With the aid of suitable diagrams, compare the conduction of electricity through pure silicon, n-doped silicon and p-doped silicon.

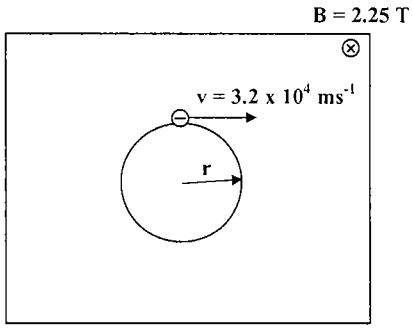
6

Class

Candidate Number

Question 27 (3 marks) **Marks**

An electron is travelling at a velocity of 3.2×10^4 ms^{-1} perpendicular to a magnetic field of 2.25 T, as shown below.



Determine the radius of the electron in its motion.

3

Class

Candidate Number

Question 28 (3 marks) **Marks**

A blue LED has a power output of 340 mW (i.e. 3.40×10^{-1} Js^{-1}). Determine the number of photons emitted per second if the wavelength of the light emitted is 410 nm.

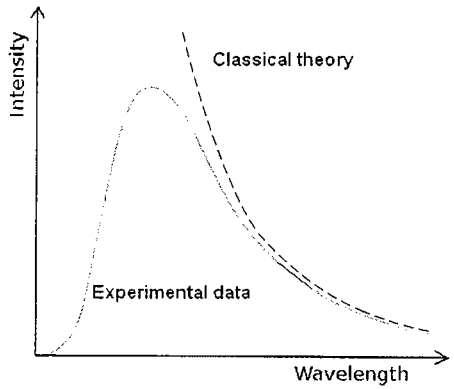
3

Class

Candidate Number

Question 29 (4 marks) **Marks**

In the history of blackbody radiation it was curves like the following which inspired Planck and others to realise that a modification of classical physics was required.



Describe the role played by the concept of blackbody radiation in the development of quantum theory from classical physics.

4

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Section II

25 marks

Attempt Question 33 only from Questions 30 - 34
Allow about 45 minutes for this section.

Answer the question in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

Pages

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Question 33 - From Quanta to Quarks (25 marks) **Marks**

(a) (i) Describe an experiment you have performed to observe the Balmer Series. **3**

(ii) Explain how Bohr's model of the hydrogen atom accounts for the Balmer Series. **2**

(iii) Calculate the wavelength of the photon produced when an electron makes a transition from the n=4 electron energy level to the n=1 electron energy level in a hydrogen atom. **2**

(b) (i) State de Broglie's proposal concerning the nature of matter. **1**

(ii) Calculate the de Broglie wavelength of a proton travelling at a velocity of 3.4×10^5 ms^{-1}. **2**

(c) The radio-isotope Radium-223 is an alpha emitter, decaying to Radon-219 in the following reaction:

$$^{223}_{88}Ra \rightarrow ^{219}_{86}Rn + ^{4}_{2}He$$

(i) Identify the number of nucleons in this isotope of Radium. **1**

(ii) Calculate the mass defect of this reaction, using the data below. **2**

Nucleus	Mass of Nucleus
$^{223}_{88}Ra$	222.97010 u
$^{219}_{86}Rn$	218.96278 u
$^{4}_{2}He$	4.00150 u

(iii) Calculate the amount of energy released in this reaction. **1**

(d) Explain how particle accelerators have enabled Physicists to better understand the Standard Model of Matter. **5**

(e) Describe how the process of nuclear fission can be controlled in nuclear reactors to produce electricity. **6**

End of Question 33

END OF PAPER

Physics

Data Sheet

Charge on the electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Radius of Earth, R_E	6.4×10^6 m
Mass of Earth	6.0×10^{24} kg
Speed of light, c	3.00×10^8 m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Planck's constant, h	6.626×10^{-34} J s
Rydberg's constant, R_H	1.097×10^7 m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

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FORMULAE SHEET

$$v = f\lambda$$

$$I \propto \frac{1}{d^2}$$

$$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

$$E = \frac{F}{q}$$

$$R = \frac{V}{I}$$

$$P = VI$$

$$Energy = VIt$$

$$v_{av} = \frac{\Delta r}{\Delta t}$$

$$a_{av} = \frac{\Delta v}{\Delta t} = \frac{v-u}{t}$$

$$\sum F = ma$$

$$F = \frac{mv^2}{r}$$

$$E_k = \frac{1}{2}mv^2$$

$$W = Fs$$

$$p = mv$$

$$Impulse = Ft$$

$$E_p = -\frac{Gm_1m_2}{r}$$

$$F = mg$$

$$v_x^2 = u_x^2$$

$$v = u + at$$

$$v_y^2 = u_y^2 + 2a_y\Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$F = \frac{Gm_1m_2}{d^2}$$

$$E = mc^2$$

$$l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$$

$$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$m_v = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

FORMULAE SHEET

$$\frac{F}{l} = k\frac{I_1 I_2}{d} \qquad d = \frac{1}{P}$$

$$F = BIl\sin\theta \qquad M = m - 5\log\left(\frac{d}{10}\right)$$

$$\tau = Fd \qquad \frac{I_A}{I_B} = 100^{\frac{(m_B - m_A)}{5}}$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s} \qquad m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$F = qvB\sin\theta \qquad \frac{1}{\lambda} = R_H\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$E = \frac{V}{d} \qquad \lambda = \frac{h}{mv}$$

$$E = hf \qquad A_0 = \frac{V_{out}}{V_{in}}$$

$$c = f\lambda \qquad \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_i}$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

79 Au 197.0 Gold

Atomic Number
Symbol of element
Atomic Weight
Name of element

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.11] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.11] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ubnilium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.