Pymble Ladies' College

Physics

2001

Trial Examination

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil

Section I Total marks **(75)**
This section has two parts. Part A and Part B

Part A Multiple choice Total marks **(15)**
- Attempt Questions 1–15
- Allow about **30 minutes** for this part

Part B Extended Answers Total marks **(60)**
- Attempt Questions 16–30
- Allow about **1 hour and 45 minutes** for this part

Section II Total marks **(25)**
- Attempt ONE question - Question 31
- Allow about **45 minutes** for this section

Physics

2001
Trial Examination

Multiple Choice Answer Sheet

Select the alternative A, B, C or D that best answers the question.

Fill in the response space completely. 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.

Question	A	B	C	D
1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D
11	A	B	C	D
12	A	B	C	D
13	A	B	C	D
14	A	B	C	D
15	A	B	C	D

Section I Total marks **(75)**
This section has two parts, Part A and Part B

Part A Multiple choice Total marks **(15)**
- Attempt **Questions 1–15**
- Allow about **30 minutes** for this part

Question 1

Jill has a weight of 550 N on the earth. What is her weight on a planet with half the mass of earth and half the radius of earth?

A 69 N

B 275 N

C 550 N

D 1100 N

Question 2

Which of the following factors does not affect the escape velocity of an object from earth?

A the mass of the object

B the mass of the earth

C the radius of the earth

D the gravitational constant G

Question 3

A satellite in orbit at a distance R from the centre of the earth has a period of 12 hours. What is the period of a satellite orbiting at a distance 3R?

A 4 hours

B 21 hours

C 36 hours

D 62 hours

Question 4

Which of the following is an inertial frame of reference?

A a rocket just after takeoff

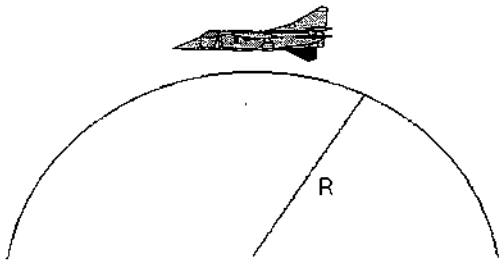
B a deep space probe without fuel

C a satellite in geostationary orbit around the earth

D a sub-orbital rocket at the point of maximum height in its trajectory

Question 5

Trainee astronauts could have the experience of 'weightlessness' by flying in a plane that is travelling in vertical, circular path, as shown in the diagram below.



What is the radius R of the vertical circle if the plane is flying at a constant speed of 20 $m.s^{-1}$ and the astronauts feel 'weightless' at the top of the circle?

A 20 m

B 40 m

C 80 m

D 160 m

Question 6

Who was the scientist who discovered that an electric current could be induced by moving a magnet near a coil of wire?

A Ampere

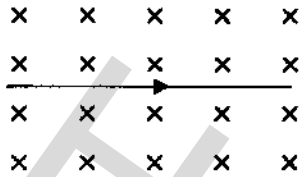
B Lenz

C Faraday

D Tesla

Question 7

The diagram below shows a current carrying wire in a magnetic field.



In which direction will the wire tend to move?

A up

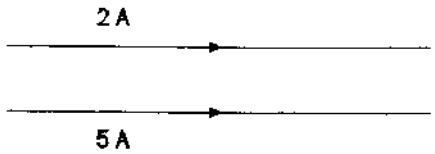
B down

C into the page

D out of the page

Question 8

Two straight current-carrying conductors are placed parallel to each other, 4 cm apart. One has a current of 2 A travelling through it and the other has a current of 5 A travelling through it. Both currents travel in the same direction.



What is the force on 1 m of the 5 A wire due to the 2 A wire?

A 5×10^{-5} N towards the 2 A wire.

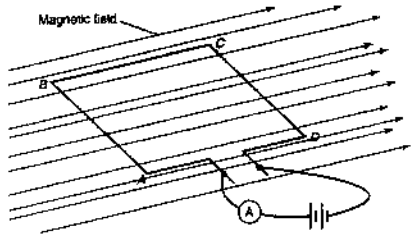
B 5×10^{-5} N away from the 2 A wire.

C 5×10^{-7} N towards the 2 A wire.

D 5×10^{-7} N away from the 2 A wire.

Question 9

The square loop shown in the diagram below has sides 50 mm x 50 mm and is supported on a central axle, parallel to the sides AB and CD. It carries a current of 5 A and is in a uniform magnetic field of 2.0×10^{-2} T.



What is the torque experienced by the loop when the plane of the loop is lying parallel to the magnetic field as shown?

A 0 Nm

B 2.5×10^{-4} Nm

C 5.0×10^{-3} Nm

D 2.5 Nm

Question 10

Which of the following methods is used to reduce energy losses in electrical transmission wires?

A using good insulation

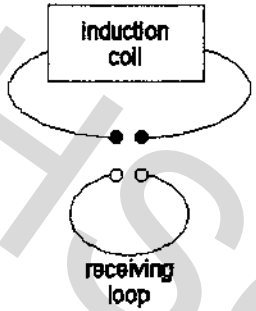
B keeping voltage as low as possible

C keeping current as low as possible

D keeping resistance as high as possible

Question 11

What was the equipment below used for?



A To demonstrate the photoelectric effect

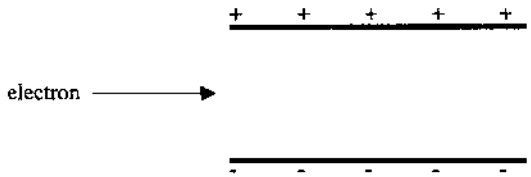
B Hertz' experiment with electromagnetic waves

C The first radio

D To demonstrate thermionic conduction

Question 12

The diagram below shows two charged, parallel plates.



An electron is fired into the space between the two plates in the direction shown. The electron will travel through without being deflected if a magnetic field is also present between the plates. What would the direction of the magnetic field have to be?

A into the page

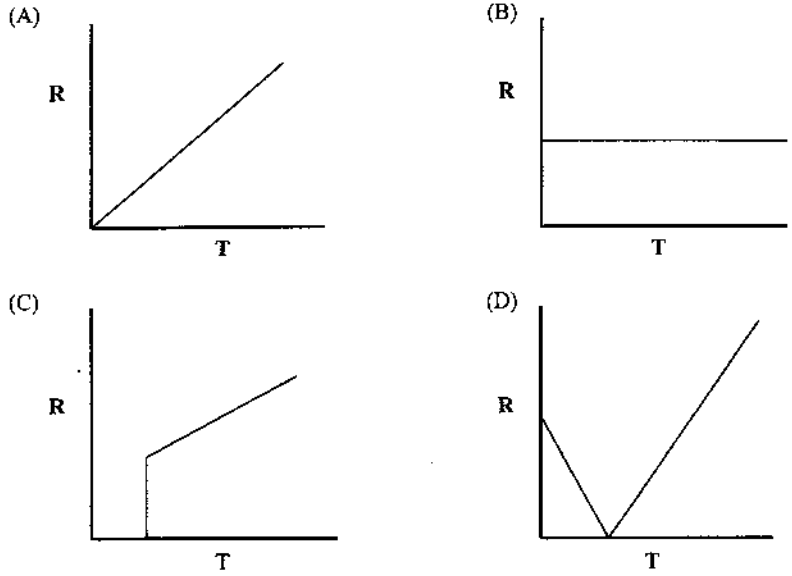
B out of the page

C towards the positive plate

D towards the negative plate

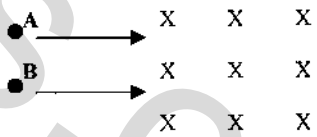
Question 13

The resistance (R) of a superconductor is plotted as a function of temperature (T).
Which graph would most closely represent the results obtained?



Question 14

Two charged particles, **A** and **B**, are fired into a uniform magnetic field as shown below.



The initial velocity of particle **A** is twice that of particle **B**.
Particle **A** has a charge of -0.5Q coulombs.
Particle **B** has a charge of +Q coulombs.
F_A is the force acting on particle **A** due to the magnetic field.
F_B is the force acting on particle **B** due to the magnetic field.

Which of the following statements is true?

A F_A is the same size as F_B.

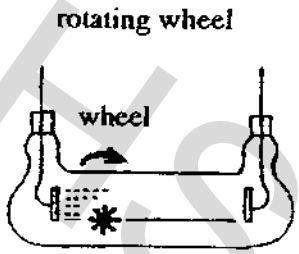
B F_A is twice the size of F_B.

C F_A is half the size of F_B.

D F_A is a quarter the size of F_B.

Question 15

The diagram below shows one of the cathode ray tubes that can be used to demonstrate the properties of cathode rays. Which of the following can be deduced from the effect observed from this particular cathode ray tube?



A Cathode rays are negatively charged.

B Cathode rays are fast moving electrons.

C Cathode rays have energy and momentum.

D Cathode rays are electromagnetic.

Part B Extended Answers Total marks **(60)**

- Attempt **Questions 16–30**
- Allow about **1 hour and 45 minutes** for this part

Question 16: (3 marks) **Marks**

Describe difficulties associated with effective and reliable communications between satellites and earth. **3**

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Question 17: (4 marks) **Marks**

A rocket is fired from its launch pad with an initial speed of 80 $m.s^{-1}$ at an angle of 35° to the horizontal.

Calculate:

(a) its total time of flight. **3**

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(b) its range. 1

Question 18: (4 marks) **Marks**

A rocket is travelling to the star closest to earth, Proxima Centauri, which is a distance of 4.3 light years away. The rocket travels at a speed of 0.7c and the time taken to accelerate and decelerate is negligible.

(a) Calculate the number of years that will pass, as measured by the crew of the rocket, as they travel to Proxima Centauri. 2

(b) Calculate the distance to Proxima Centauri, as measured by the crew, in light years. 2

Question 19: (5 marks) **Marks**

Describe a first-hand investigation to determine a value for the acceleration due to gravity using pendulum motion. 5

The relevant equation is $g = 4\pi^2 \ell / T^2$

where g is the acceleration due to gravity

ℓ is the length of the pendulum

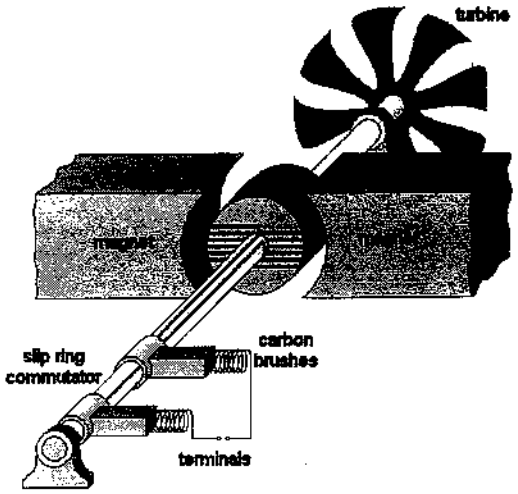
T is the period of oscillation of the pendulum

Question 20: (4 marks) **Marks**

Explain how space probes may use planets to provide a slingshot effect. 4

Question 21: (5 marks) **Marks**

The diagram below shows a generator.

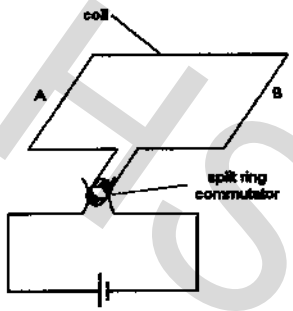


(a) Explain how the generator works. 4

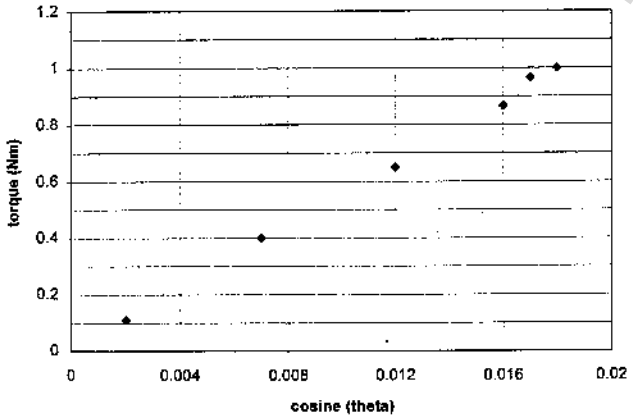
(b) Describe how this generator could be transformed into a DC generator. 1

Question 22: (3 marks) **Marks**

Below is a diagram of a square coil of wire attached to a split-ring commutator and a power source that provided a current of 2 A. The coil had 250 turn and sides of 4 cm x 4 cm.



A student placed some permanent magnets at A and B and the motor started spinning. Attaching a torque meter to the axle, the student was able to determine the torque at various angles θ (theta). The student then plotted a graph of torque (Nm) against cosine θ, as shown below.



Use the graph and the information given to calculate the strength of the magnetic field provided by the magnets. Show all working. 3

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Question 23: (3 marks) **Marks**

Explain the advantages of induction motors compared with conventional A.C. motors. 3

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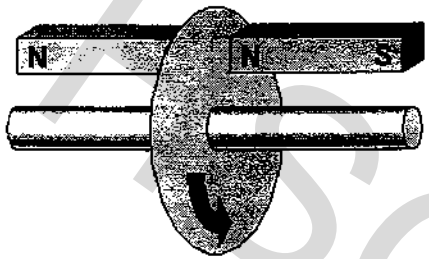
Question 24: (4 marks) **Marks**

Two magnets are brought near to a spinning aluminium disc, as shown in the diagram below.



(a) Explain what happens when the magnets are brought near. **2**

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(b) Explain how this effect could be reduced. **2**

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Question 25: (5 marks) **Marks**

A transformer has 300 turns in the primary coil and 10 turns in the secondary coil. The primary voltage is 240 V AC and the primary current is 2 A.

(a) Calculate the secondary voltage in the transformer. **1**

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(b) Explain why an experimentally observed value might be different to your answer to part (a)? **1**

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(c) Explain why some electrical appliances in the home that are connected to the mains domestic power supply use a transformer. **3**

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Question 26: (4 marks)

Outline Thomson's experiment to measure the charge/mass ratio of the electron. **4**

Question 27: (7 marks)

a) Discuss the ability of the wave model of light to explain the photoelectric effect. **4**

b) Explain the photoelectric effect using Einstein's model for light. **3**

Question 28: (3 marks)

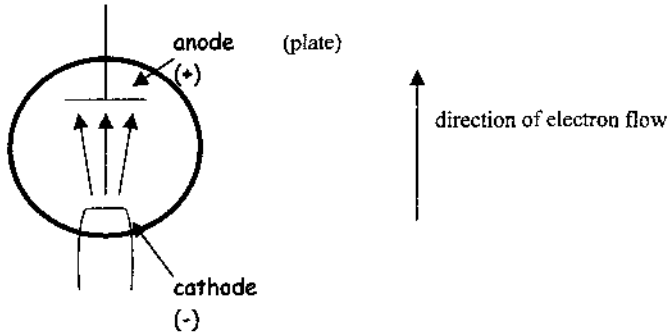
With reference to the two types of doped semiconductors, explain what the term doping means. **3**

Question 29: (2 marks)

Evaluate one current or possible future application of superconductors. **2**

Question 30: (4 marks)

The diagram below shows a thermionic device called a diode valve.



a) State what the term "thermionic" means when used for this type of diode. **1**

b) Compare and contrast the equivalent semiconductor device to the thermionic diode. **3**

Section II Total marks **(25)**
Allow about **45 minutes** for this section.
Answer **Question 31** on the writing paper provided.
Extra writing paper is available.

Question 31 – From Quanta to Quarks (25 marks) **Marks**

a) Carbon-13 is one isotope of the element carbon. With reference to Carbon explain the term "isotope". **1**

b) i) By considering the various forces within the nucleus explain why there must be a strong nuclear force. **2**

ii) State one property of the strong nuclear force. **1**

c) i) Compare and contrast a controlled and uncontrolled nuclear chain reaction **3**

ii) Explain how a controlled nuclear chain reaction is maintained in a nuclear reactor. **3**

d) Write an equation for the nuclear reaction that occurs when Plutonium-241 undergoes α decay. **2**

e) A typical fission reaction is **3**

$$ {}^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n $$

Calculate the amount of energy released in this reaction.

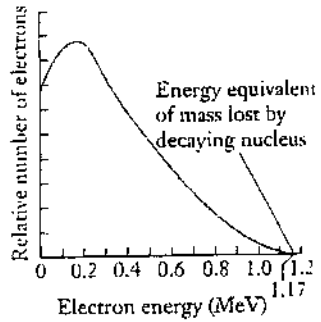
Data: $^{1}_{0}n$ 1.008665 u $^{141}_{56}Ba$ 140.9141 u

$^{235}_{92}U$ 235.043925 u $^{92}_{36}Kr$ 91.9250 u

Question 31 continued on next page

Question 31 continued.

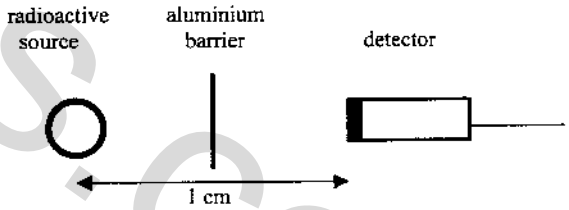
f) The graph below shows the relative number of beta particles emitted by a radioactive source as a function of the beta particle's kinetic energy.



i)Explain the difficulty in understanding this pattern of energy distribution when it was first observed. **3**

ii) Describe how this difficulty was overcome. **1**

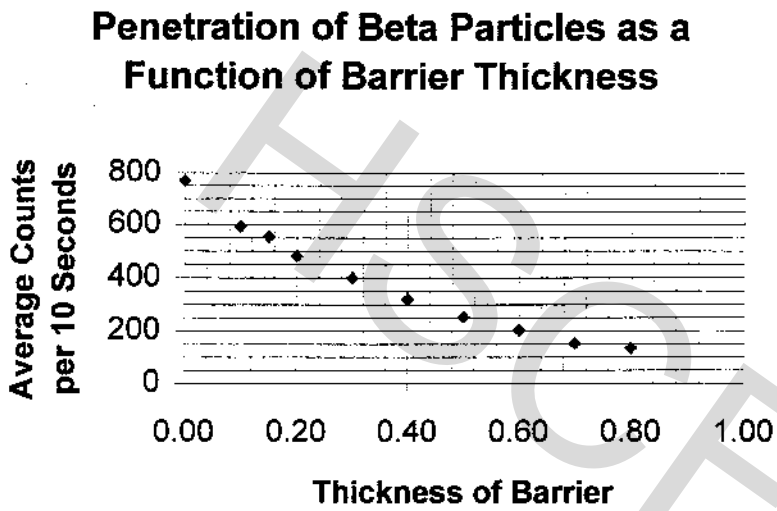
g) An experiment was done in which an aluminium barrier was placed between a radioactive source and a detector. The radioactive source emitted α particles and the number of counts during a 10 second time interval was recorded. The diagram below shows the experimental arrangement. When the radioactive source was removed, the detector registered 4 counts in the 10 second interval.



In the experiment a number of different thicknesses of aluminium were used.

The graph of the experimental results is shown below.

Question 31 continued on next page.



Analyse the experimental results.

6

Numerical values of several constants

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}
Speed of light (in vacuo), 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}
Mass of Earth	6.0×10^{24} kg
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, r	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

$$c = f\lambda$$

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

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

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

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

$$P = VI$$

Energy = VIt

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

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

$$\sum F = ma$$

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

$$p = mv$$

$$\Delta p = Ft$$

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

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

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

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

$$d = \frac{1}{p}$$

$$F = BIl\sin\theta$$

$$\frac{F}{l} = k\frac{I_1I_2}{d}$$

$$\tau = Fd$$

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

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

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

$$v = u + at$$

$$v_x^2 = u_x^2$$

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

$$\Delta x = u_x t$$

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

$$\frac{s}{t} = \frac{u+v}{2}$$

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

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

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$Z = \rho v$$

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

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

Amplifier gain = $\frac{V_{out}}{V_{in}}$

$$A_o = \frac{V_o}{V_+ - V_-}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — 79 — Symbol of element
Atomic Weight — 197.0 — Name of element
Au — Gold

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 [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Ununnilium	112 Uub — Ununbium	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.

This sheet should be REMOVED for your convenience.