BOSTES BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2014 HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
  Black pen is preferred
- 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

Total marks – 100

Section I Pages 2–26

75 marks

This section has two parts, Part A and Part B

Part A – 20 marks

- Attempt Questions 1–20
- Allow about 35 minutes for this part

Part B – 55 marks

- Attempt Questions 21–31
- Allow about 1 hour and 40 minutes for this part

Section II Pages 29–39

25 marks

- Attempt ONE question from Questions 32–36
- Allow about 45 minutes for this section

Section I
75 marks

Part A – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet for Questions 1–20.

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1 Why are spacecraft that are placed into orbit around the Earth generally launched in an easterly direction?

(A) To gain assistance from the wind

(B) To help slow down the spacecraft so it can go into orbit

(C) To reduce the interference from the Earth's magnetic field

(D) To use the Earth's rotation to increase the spacecraft's speed

2 Wire, axle, armature, commutator and brushes can be used to build a device.

Which of the following devices requires ALL of these components?

(A) Transformer

(B) DC generator

(C) Galvanometer

(D) Induction motor

3 A pendulum is used to determine the value of acceleration due to gravity. The length of the pendulum is varied, and the time taken for the same number of oscillations is recorded.

Which of the following could increase the reliability of the results?

(A) Changing the mass of the pendulum

(B) Identifying the independent and dependent variables

(C) Recording all measurements to at least four significant figures

(D) Repeating each measurement several times and recording the average

4 Why was germanium used to make the first transistors?

(A) It was an abundant semiconductor.

(B) It was cheaper than other semiconductors.

(C) Its properties allowed for simpler circuit design.

(D) It was easier to purify than other semiconductors.

5 Electricity is transported over long distances by transmission lines that are supported by pylons.

How are these transmission lines protected from lightning strikes?

(A) The pylons are insulated from the ground.

(B) There is a grounded wire on top of each pylon.

(C) The transmission lines carry voltages similar to that of lightning.

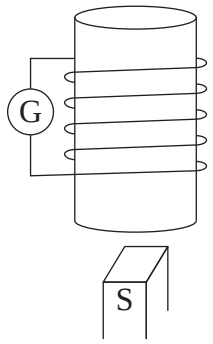
(D) Large ceramic insulators separate the transmission lines from the pylons.

6 A satellite is in a high orbit around the Earth. A particle of dust is in the same orbit.

Which row of the table correctly compares their potential energy and orbital speed?

	Potential energy	*Orbital speed*
(A)	Different	Same
(B)	Different	Different
(C)	Same	Same
(D)	Same	Different

7 The diagram shows a magnet moving upward into a coil.



Which row of the table correctly identifies the direction of the induced current as viewed from the top, and the direction of the magnetic field inside the coil?

	Current direction	*Magnetic field direction*
(A)	Anticlockwise	↓
(B)	Anticlockwise	↑
(C)	Clockwise	↑
(D)	Clockwise	↓

8 Why is an iron core used in a transformer?

(A) To limit eddy currents

(B) To reduce the heat generated

(C) To separate the magnetic fields

(D) To increase the linkage of the flux

9 The resistance of two identical-looking wires is measured. One of the wires is made of copper and the other is made of a copper alloy.

Why does the wire made of the copper alloy have a higher resistance?

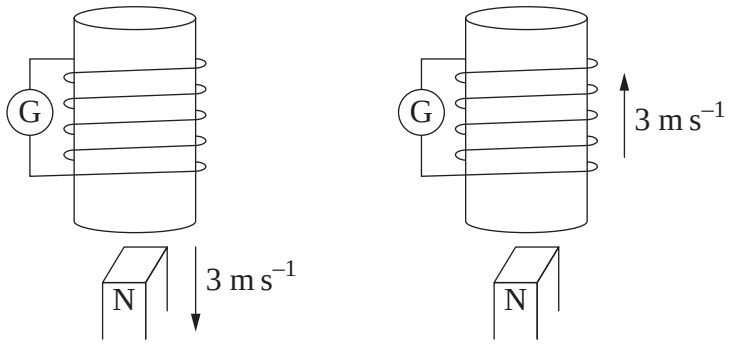
(A) The alloy has more impurities than the copper.

(B) There are more holes in the copper than the alloy.

(C) The alloy retains heat more easily than the copper.

(D) There is a greater energy gap between the conduction and valence bands for the alloy.

10 The diagram shows two experiments. In *Experiment 1*, the magnet is moved away from the coil. In *Experiment 2*, the coil is moved away from the magnet.



Experiment 1 *Experiment 2*

Why is the same electromotive force (emf) produced in both experiments?

(A) Energy is conserved.

(B) The motor effect generates the same force.

(C) The relative motion between the coil and the magnet is the same.

(D) Both the direction of the magnetic field and the direction of the motion change.

11 Why is there low intensity of black body radiation at very short wavelengths?

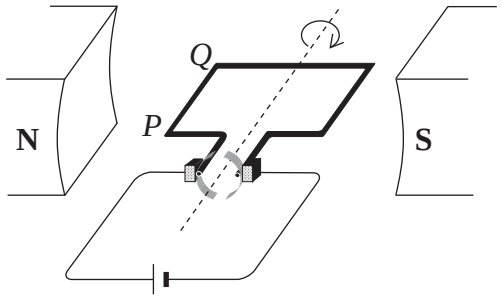
(A) The energy of each photon is reduced at very short wavelengths.

(B) There are fewer photons with high energy at very short wavelengths.

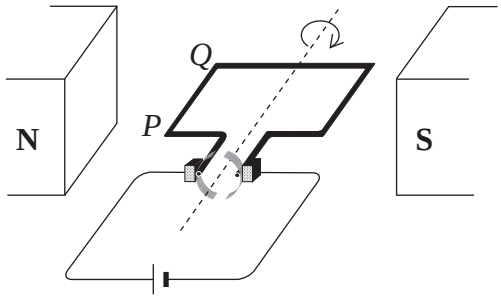
(C) Only photons of very short wavelengths are reabsorbed by the black body.

(D) Photons of very short wavelengths interact with each other causing destructive interference.

12 The diagrams show a wire loop rotating clockwise in a radial magnetic field and in a parallel magnetic field. There is a constant current in the wire loop.

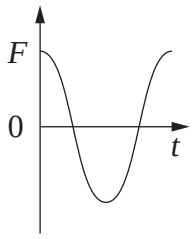
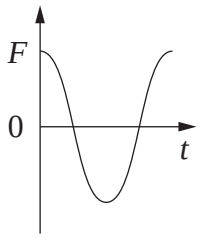
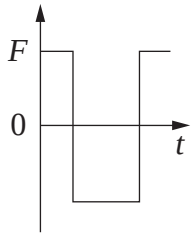
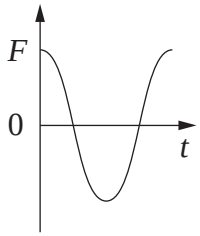
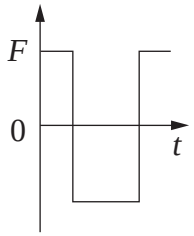
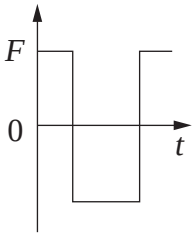
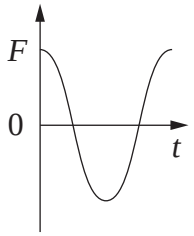
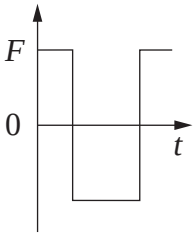


Radial magnetic field



Parallel magnetic field

Which pair of graphs best describes the behaviour of the force (F) on the length of wire PQ as a function of time (t) for one revolution of the wire loop?

	Radial field	Parallel field
(A)		
(B)		
(C)		
(D)		

13 Which of the following is a consequence of the motor effect?

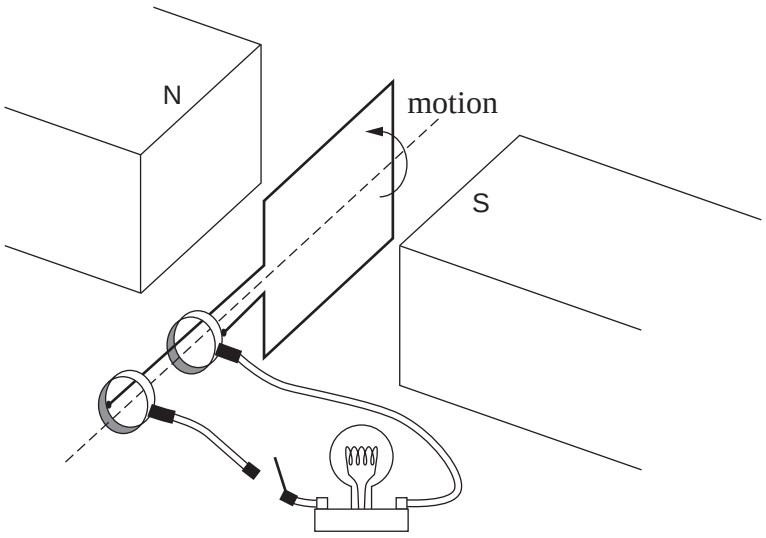
(A) Rapid heating in an induction cooktop

(B) Minimising energy loss in transmission lines

(C) The wire loops of an operating transformer pulling its coils together

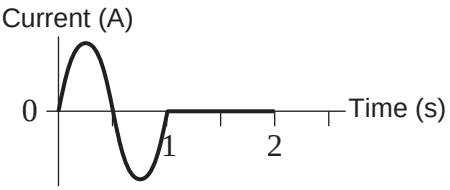
(D) A superconductor repelling small magnetic dust particles vertically above it

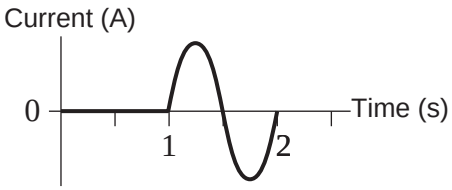
14 The diagram shows a generator circuit connected with a switch.

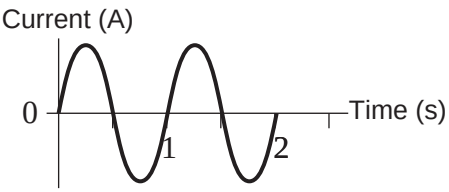


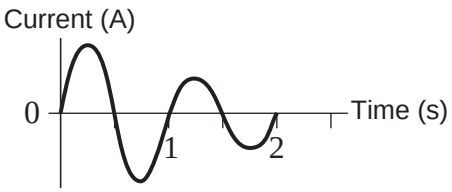
The generator is rotated by one revolution in the first second with the switch open. It is then rotated by one revolution in the next second with the switch closed.

Which graph shows the current produced by this generator for these two seconds?

(A)


(B)


(C)


(D)


15 Two masses have a gravitational force of 12 N between them.

If the distance between the masses is doubled, what would be the new gravitational force between them?

(A) 3 N

(B) 6 N

(C) 12 N

(D) 24 N

16 How did Hertz determine the speed of radio waves?

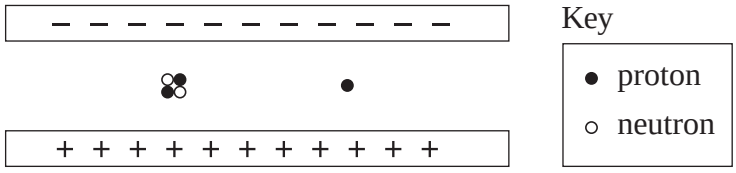
(A) By measuring the interference pattern of radio waves

(B) By sending radio waves through a block of pitchblende

(C) By balancing the effect of a magnetic field in a cathode ray tube

(D) By comparing the intensity of two perpendicular beams of radio waves

17 The diagram shows an alpha particle (⁂) and a proton (•), placed at equal distances from two large charged metal plates.



Which of the following best describes the motion of the particles?

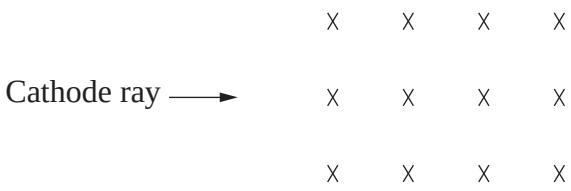
(A) Both particles move with the same acceleration.

(B) The alpha particle moves with half the acceleration of the proton.

(C) The alpha particle moves with twice the acceleration of the proton.

(D) The alpha particle moves with a quarter of the acceleration of the proton.

18 The diagram shows a cathode ray entering a magnetic field.



An electric field is applied to cancel the effect of the magnetic field on the cathode ray.

Which row of the table correctly describes the direction of the applied electric field, and the direction of the force acting on the cathode ray as a result of the magnetic field?

	Direction of the electric field applied	*Direction of force as result of the magnetic field*
(A)	↑	↑
(B)	↓	↑
(C)	↑	↓
(D)	↓	↓

19 The rest length of a train is 200 m and the rest length of a railway platform is 160 m. The train rushes past the platform so fast that, when observed in the platform's frame of reference, the train and the platform are the same length.

How fast is the train moving?

(A) $0.60\,c$

(B) $0.75\,c$

(C) $0.80\,c$

(D) $1.25\,c$

20 A ball is launched horizontally from a cliff with an initial velocity of $u\ \mathrm{m\,s^{-1}}$. After two seconds, the ball's velocity is in the direction 45° from the horizontal.

What is the magnitude of the velocity in $\mathrm{m\,s^{-1}}$ at two seconds?

(A) u

(B) $1.5\,u$

(C) 19.6

(D) 27.7

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Physics

Centre Number

Student Number

Section I (continued)

Part B – 55 marks
Attempt Questions 21–31
Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Extra writing space is provided on pages 27–28. If you use this space, clearly indicate which question you are answering.

Write your Centre Number and Student Number at the top of this page.

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Question 21 (3 marks)

Identify THREE limitations of the use of superconductors. **3**

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Question 22 (3 marks)

How does the re-entry angle affect the safety of astronauts returning to Earth in a spacecraft? **3**

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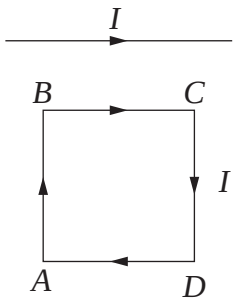
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Question 23 (3 marks)

A square current-carrying wire loop is placed near a straight current-carrying conductor, as shown in the diagram. **3**



Explain how the current in the wire loop affects the straight conductor.

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Question 24 (5 marks)

The primary winding of a transformer contains 2000 turns. The primary AC voltage is 23 000 volts and the output voltage is 660 000 volts.

(a) Calculate the number of turns on the secondary winding. **2**

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(b) If the current in the primary winding of the transformer is 100 A, and the secondary winding has a resistance of 2000 Ω, what is the power loss in the secondary winding, assuming there is no power loss in the primary winding? (Show calculations.) **3**

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Question 25 (5 marks)

(a) Outline an investigation that can be used to demonstrate the principle of an AC induction motor. **2**

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(b) Explain how the motor effect is used in an AC motor. **3**

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Question 26 (5 marks)

(a) Calculate the energy of a photon of wavelength 415 nm. **2**

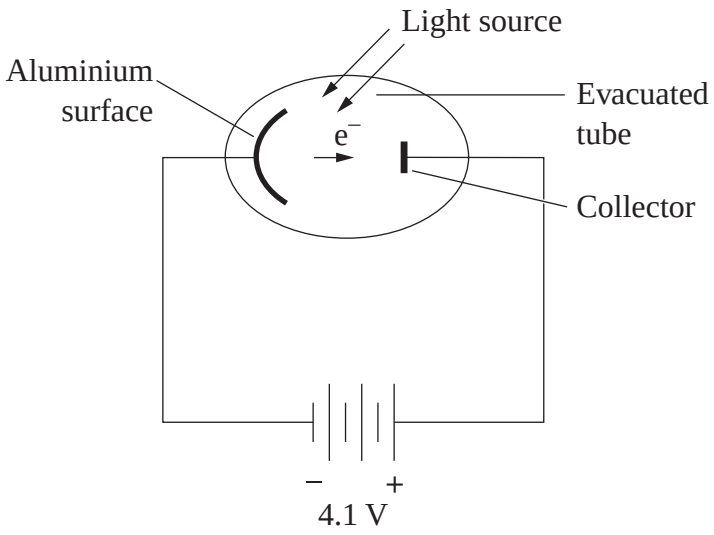
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(b) An experiment was conducted using a photoelectric cell as shown in the diagram. **3**



Question 26 continues on page 19

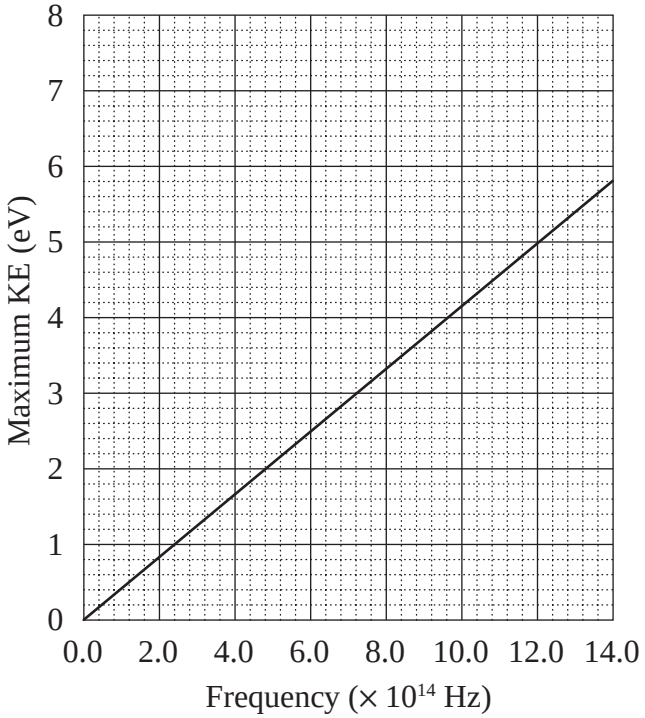
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Question 26 (continued)

The graph plots the maximum kinetic energy of the emitted photoelectrons against radiation frequency for the aluminium surface.



The experiment is planned to be repeated using a voltage of 0.0 V.

Draw a line on the graph to show the predicted results of the planned experiment, and determine the radiation frequency which would produce photoelectrons with a maximum kinetic energy of 1.2 eV using a voltage of 0.0 V.

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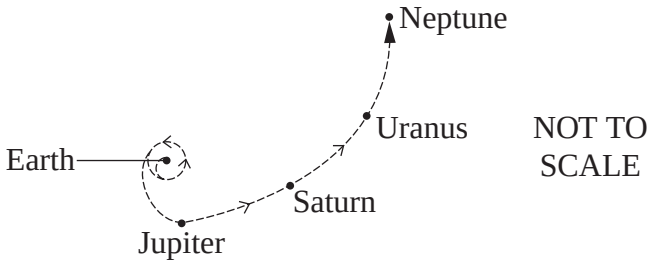
End of Question 26

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Question 27 (7 marks)

The diagram illustrates the path of a space probe launched from Earth and sent to Neptune.



(a) Explain, using physics principles, why the space probe takes this path instead of travelling directly to Neptune. **3**

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Question 27 continues on page 21

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Question 27 (continued)

(b) The space probe is placed in an orbit at an altitude of 188 km above Earth. **2**

Given Earth has a radius of 6380 km, calculate the period of this orbit.

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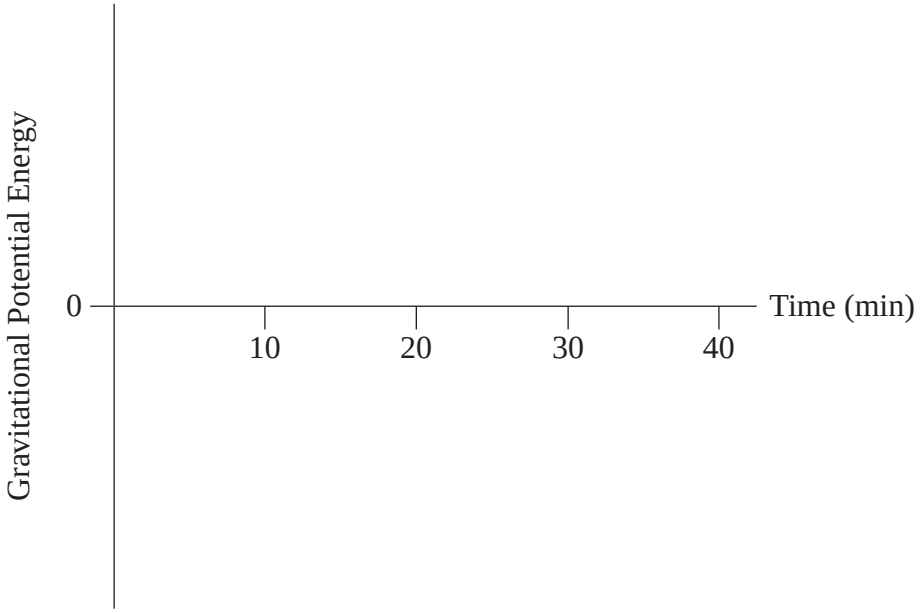
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(c) It takes 10 minutes for the space probe to reach its orbit around Earth and it remains in orbit for several hours. **2**

Sketch a graph on the axes showing the changes in gravitational potential energy for the first 40 minutes.



End of Question 27

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Question 28 (6 marks)

(a) Thomson's experiment measures the charge/mass ratio of an electron. **3**

Use an annotated diagram to show how Thomson's experiment can be performed.

(b) An electron is projected at 90° into a magnetic field of 9×10^{-4} T, at a speed of 1×10^{7} m s^{-1}. This causes the electron to undergo uniform circular motion. **3**

Calculate the radius of the electron's path.

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Question 29 (5 marks)

How does doping affect the way a current is carried in a semiconductor? **5**

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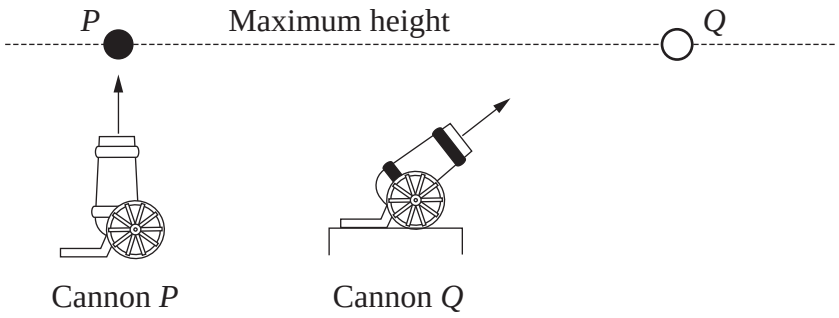
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Question 30 (7 marks)

Cannonballs *P* and *Q* are fired so that they leave their barrels from the same height. Cannonball *P* is fired vertically upwards while cannonball *Q* is fired at an angle as shown.

Both cannonballs take 3 seconds to reach the same maximum height.



(a) Explain how the resulting motion of the cannonballs supports Galileo's analysis of projectile motion. **3**

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Question 30 continues on page 25

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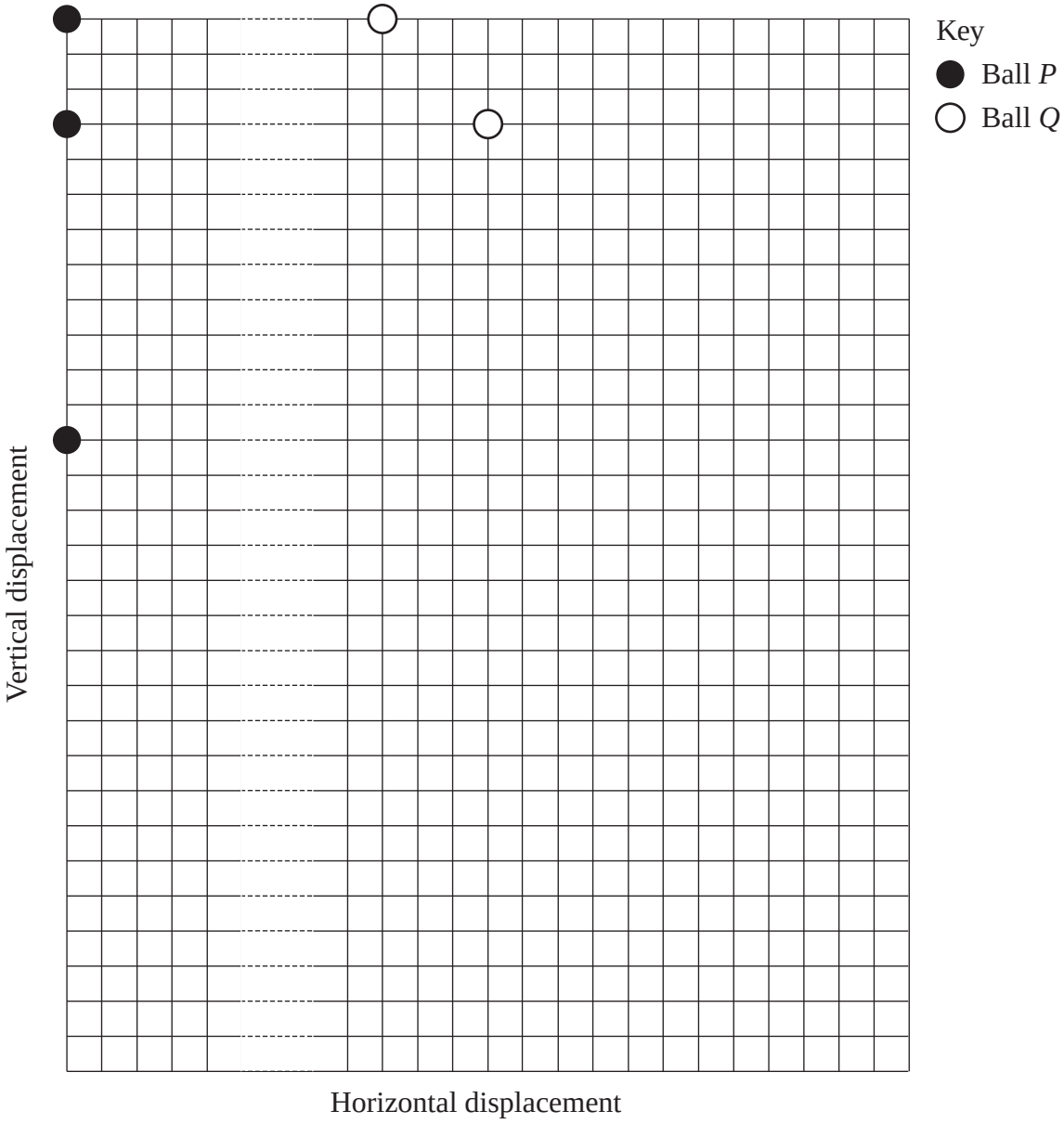
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Question 30 (continued)

(b) The position of cannonball *P* is plotted at the 3rd, 4th and 5th seconds of its flight. The position of cannonball *Q* is plotted at the 3rd and 4th seconds of its flight. **4**

Plot the positions of the balls at each second for the remainder of their flight. Show calculations.



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End of Question 30

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Question 31 (6 marks)

Explain how the adoption of AC as the dominant electricity supply benefits society in terms of the advantages of AC over DC. **6**

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Physics

Section II

25 marks
Attempt ONE question from Questions 32–36
Allow about 45 minutes for this section

Answer parts (a)–(e) of ONE question in the Section II Writing Booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

		Pages
Question 32	Geophysics	30–31
Question 33	Medical Physics	32–33
Question 34	Astrophysics	34–35
Question 35	From Quanta to Quarks	36–37
Question 36	The Age of Silicon	38–39

Question 32 — Geophysics (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Draw a labelled diagram to describe Earth's present magnetic field. **2**

(ii) Outline how magnetic anomalies near a diverging plate boundary provide evidence for sea floor spreading. **3**

(b) (i) What happens to white light when it hits a red surface? **2**

(ii) Describe how remote sensing can be used to monitor changes in vegetation. **3**

(c) Compare the use of seismic refraction and seismic reflection techniques in oil and gas exploration. **4**

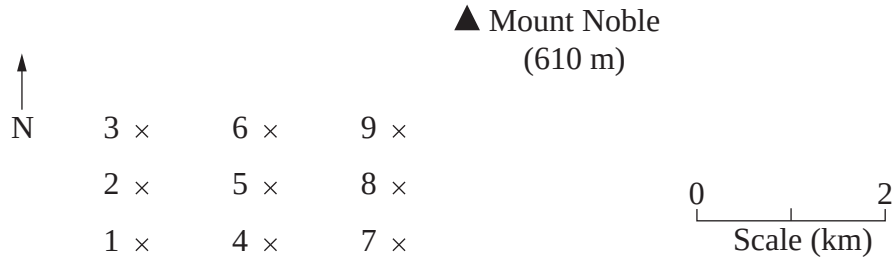
Question 32 continues on page 31

Question 32 (continued)

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) A potential resource was identified near Mount Noble. The diagram shows the plan of a gravitational survey that was carried out, and the table summarises information gained from the survey. **5**

Plan of gravitational survey



Survey data

Locality	*Gravimeter reading* (milligals)	*Altitude* (m)	*Substrate*
1	1067	410	sandstone
2	1067	412	granite
3	1070	414	granite
4	1086	410	sandstone
5	1261	414	sandstone
6	1257	415	granite
7	1083	411	sandstone
8	1269	411	sandstone
9	1280	425	granite

With reference to the diagram and the table, explain why data reduction has to be carried out on the raw data from this survey before geologists can assess the potential resource.

(e) Explain how geophysical methods have benefited mineral exploration programs. **6**

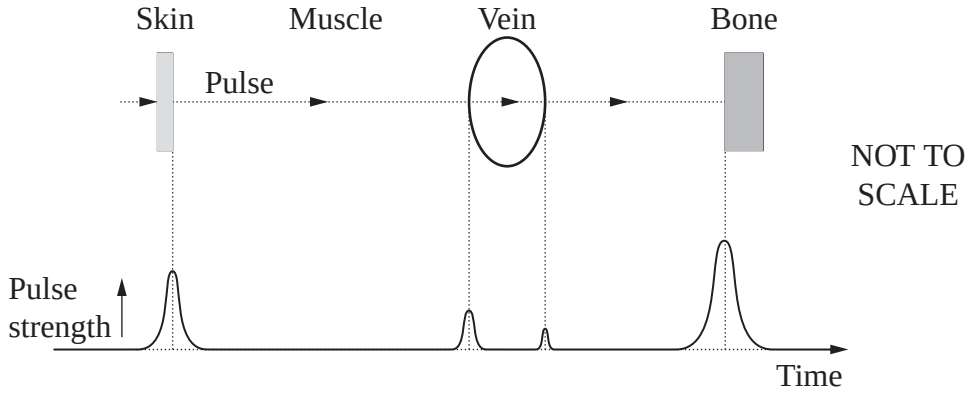
End of Question 32

Question 33 — Medical Physics (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Outline how ultrasound can be used to determine the flow of blood in the human heart. **2**

(ii) The diagram shows part of a lower leg cross-section and its corresponding ultrasound scan image from a single transducer. **3**



Explain how this type of scan can be used to construct a two-dimensional image of internal body structures.

(b) (i) Outline a method of generating X-ray radiation. **2**

(ii) Compare the use of a conventional X-ray image to a CT scan in an investigation of the lungs. **3**

(c) Describe how this transmutation is used to produce a diagnostic image. **4**

$$^{11}_{6}\mathrm{C} \rightarrow {}^{11}_{5}\mathrm{B} + {}^{0}_{+1}\mathrm{e}$$

Question 33 continues on page 33

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) Describe how properties of protons in nuclei are used in the production of magnetic resonance imaging (MRI). **5**

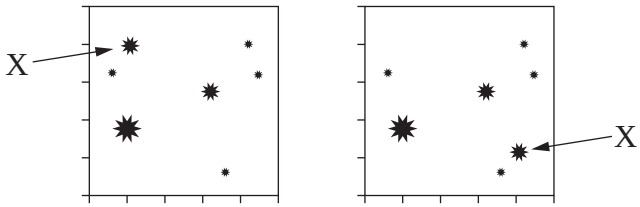
(e) Assess the impact of medical applications of physics on society. **6**

End of Question 33

Question 34 — Astrophysics (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) The diagram shows stars in the same section of sky viewed six months apart. **2**



Explain why star X appears in different positions.

(ii) Star X is 2.5 pc from Earth. **3**

Calculate how much brighter star X would appear from Earth than if it were viewed from a distance of 10 pc.

(b) (i) Why would a spectral class A star be brighter when viewed through a blue filter than through a red filter? **2**

(ii) Why is it useful to view stars through different coloured filters? **3**

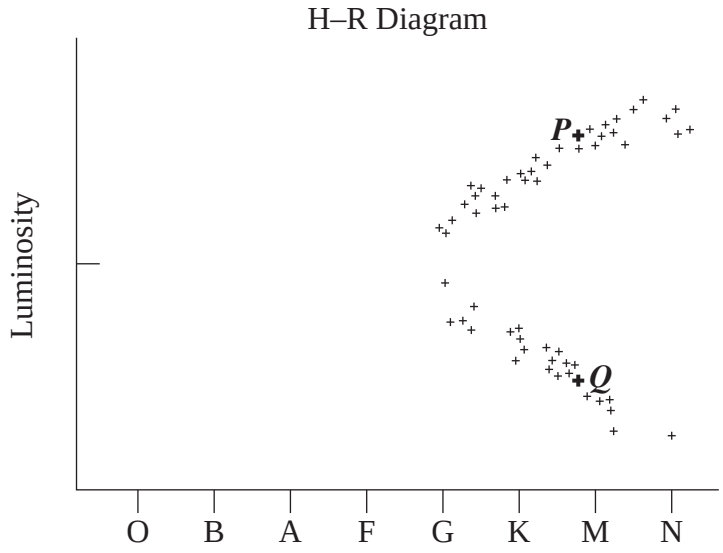
(c) An astronomer has noticed that a star has become brighter. **4**

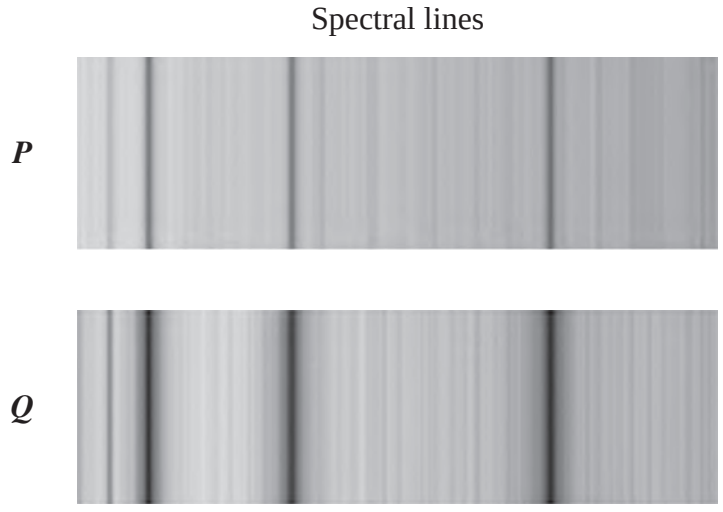
Explain TWO possible reasons for the change in brightness.

Question 34 continues on page 35

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) A Hertzsprung–Russell (H–R) diagram of a cluster of stars and the spectral lines for stars ***P*** and ***Q*** are shown. **5**





Explain how this data provides evidence for the evolutionary age of the stars in this cluster.

(e) Evaluate methods of obtaining good quality images of celestial objects using ground-based telescopes. **6**

End of Question 34

Question 35 — From Quanta to Quarks (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) A photon is emitted when an electron in a hydrogen atom transitions from the $n = 3$ excited state to the ground state. **2**

Calculate the wavelength of the photon.

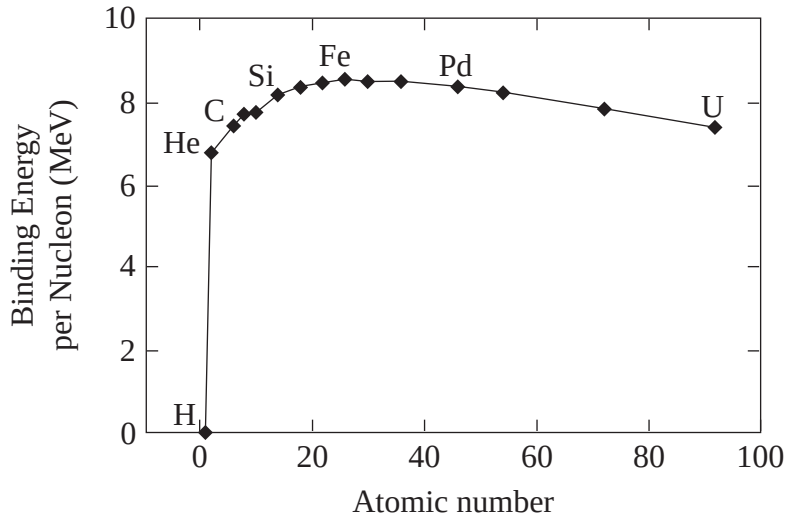
(ii) A photon is incident on a hydrogen atom in the ground state. **3**

Explain, using de Broglie's hypothesis, why the photon is not absorbed by the hydrogen atom.

(b) (i) Outline why gravitational forces are irrelevant in the nucleus of an atom. **2**

(ii) The graph shows the binding energy per nucleon. **3**

Using this diagram, explain how energy may be released in a nuclear reaction.



(c) With reference to the properties of neutrons, describe the use of the neutron as a probe. **4**

Question 35 continues on page 37

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) Describe the significance of the Manhattan Project to society. **5**

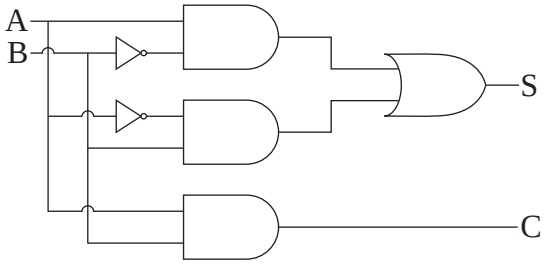
(e) Assess the effectiveness of the Bohr–Rutherford model of the atom in accounting for experimental observations. **6**

End of Question 35

Question 36 — The Age of Silicon (25 marks)

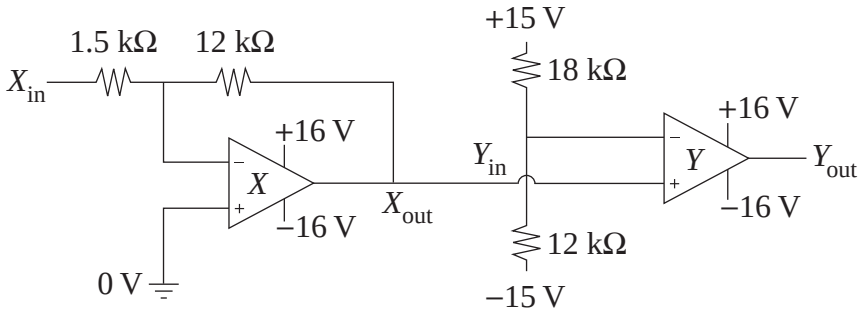
Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) For the logic circuit shown, construct a truth table. **2**



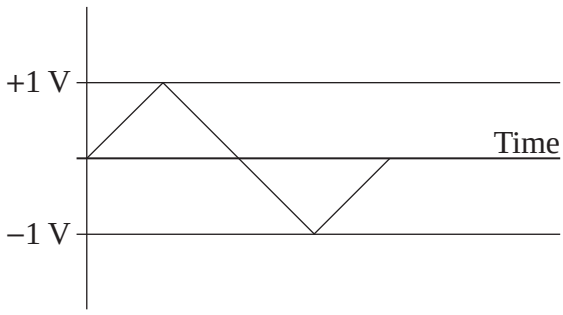
(ii) Explain why a thermistor can be considered an input or an output transducer. **3**

(b) The diagram shows two operational amplifiers, *X* and *Y*, connected in a circuit.



(i) Outline the purpose of each of the four resistors in the circuit. **2**

(ii) The graph shows the input X_{in}. Copy this graph in your Writing Booklet and draw the outputs X_{out} and Y_{out}. **3**



Question 36 continues on page 39

Question 36 (continued)

(c) Outline similarities and differences between transistors and integrated circuits. **4**

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) Justify the use of LEDs over traditional forms of illumination in everyday situations. **5**

(e) Explain how the development of the silicon chip has influenced the development of electronics. **6**

End of paper

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DATA SHEET

Charge on 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, 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 constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	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}

FORMULAE SHEET

$$v = f\lambda$$

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

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

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

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

$$P = VI$$

$$\text{Energy} = VIt$$

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

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

$$\Sigma F = ma$$

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

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

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

$$E_p = -G\frac{m_1 m_2}{r}$$

$$F = mg$$

$$v_x^{\,2} = u_x^{\,2}$$

$$v = u + at$$

$$v_y^{\,2} = u_y^{\,2} + 2a_y\Delta y$$

$$\Delta x = u_x t$$

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

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

$$F = \frac{Gm_1 m_2}{d^2}$$

$$E = mc^2$$

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

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

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

FORMULAE SHEET

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

$$F = BIl\sin\theta$$

$$\tau = Fd$$

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

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

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

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

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

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

$$F = qvB\sin\theta$$

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

$$E = hf$$

$$c = f\lambda$$

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

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

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$Z = \rho v$$

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

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{i}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number
Symbol
Standard Atomic Weight
Name

79 Au 197.0 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 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 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 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc 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 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 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 Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium						

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm 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 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Elements with atomic numbers 113 and above have been reported but not fully authenticated.

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of data. Some data may have been modified.