2019

Higher School Certificate

Trial Examination

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided
- For questions in Section II, show all relevant working in questions involving calculations
- Write your student number and/or name at the top of every page

Total marks – 100

Section I (Pages 2–13)
20 marks
- Attempt Questions 1–20
- Allow about 35 minutes for this part

Section II (Pages 14–34)
80 marks
- Attempt Questions 21–37
- Allow about 2 hours and 25 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME:...................................

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Section I
20 marks

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

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
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	A	B	C	D
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20				

STUDENT NUMBER/NAME..............................

1 Which identifies the characteristics of the motion of projectiles?

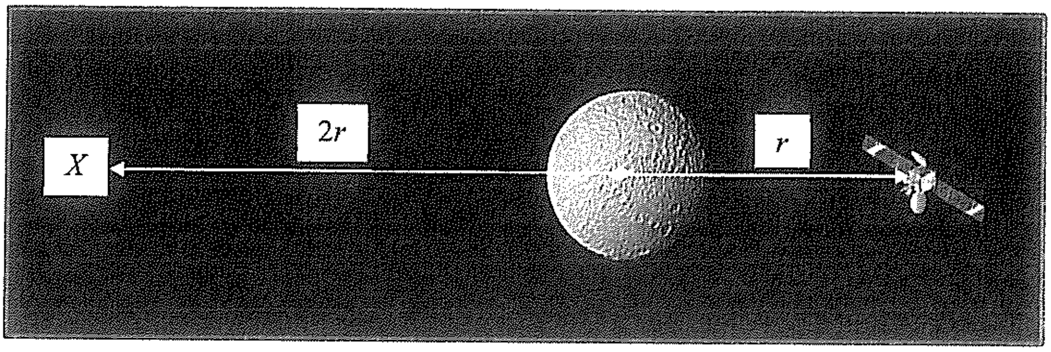
(A) Their vertical velocity is greater than their horizontal velocity.

(B) Both their net velocity and acceleration are constant.

(C) They have constant horizontal motion and uniformly accelerated vertical motion.

(D) They have constant vertical motion and uniformly accelerated horizontal motion.

2 The diagram (not to scale) shows a satellite orbiting a planet. The orbital radius of the satellite is r. Another orbital position, X, is shown on the diagam a distance of $2r$ from the planet's cente.



How would the gravitational potential energy of the satellite change if the satellite was moved into the orbit indicated by X?

(A) It would increase by a factor of 3.

(B) It would increase by a factor of 2.

(C) It would decrease by a factor of 3.

(D) It would decrease by a factor of 2.

3 A 250 g mass is rotating at 100 revolutions per minute on a 2.0 m long string.

How would the angular velocity of this mass change if it continued to rotate with the same frequency, but the string was let out until it was 3.0 m long?

(A) The angular velocity would be 1.5 times greater.

(B) The angular velocity would decrease by one third.

(C) The angular velocity would decrease by two thirds.

(D) The angular velocity would not change.

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4 Consider the information about three planets shown in the table.

Planet	*Mass (kg)*	*Diameter (km)*	*Distance from Sun ($\times 10^6$ km)*
X	3.3×10^{23}	4879	57.9
Y	4.87×10^{24}	12 104	108.2
Z	6.42×10^{23}	6792	227.9

Based on this information, which choice best predicts the relative size of the escape velocity for each planet?

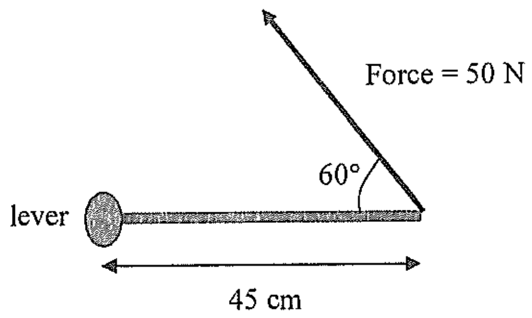
(A) $X > Y > Z$

(B) $Y > Z > X$

(C) $Y > X > Z$

(D) $Z > Y > X$

5 What is the magnitude of the net torque on the lever?



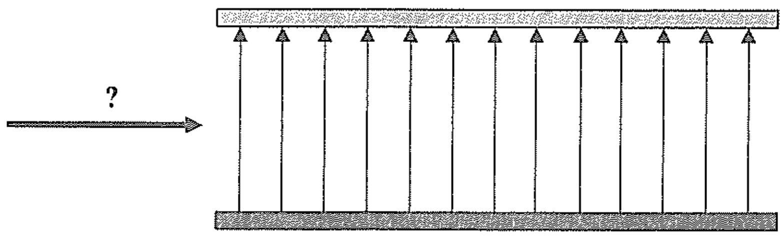
(A) 11.25 Nm

(B) 19.5 Nm

(C) 1125 Nm

(D) 1948.5 Nm

6 Consider the electric field between two parallel plates.



Which particle, fired horizontally from the left and moving into the field, would experience the greatest electric force downwards?

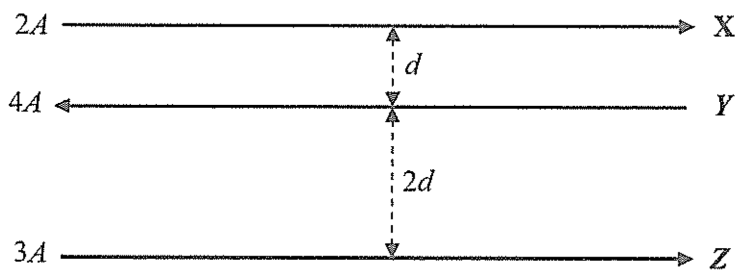
(A) An electron

(B) A proton

(C) An alpha particle

(D) A magnesium ion, Mg^{2+}

7 Three current-carrying wires are set up as shown. The force on wire Y due to the other two wires in this situation is F.



What will happen to the force on Y if the currents in X and Z are each doubled but the distances stay the same?

(A) It will halve to $F/2$.

(B) It will be the same value but in the opposite direction.

(C) It will double to $2F$.

(D) It will quadruple to $4F$.

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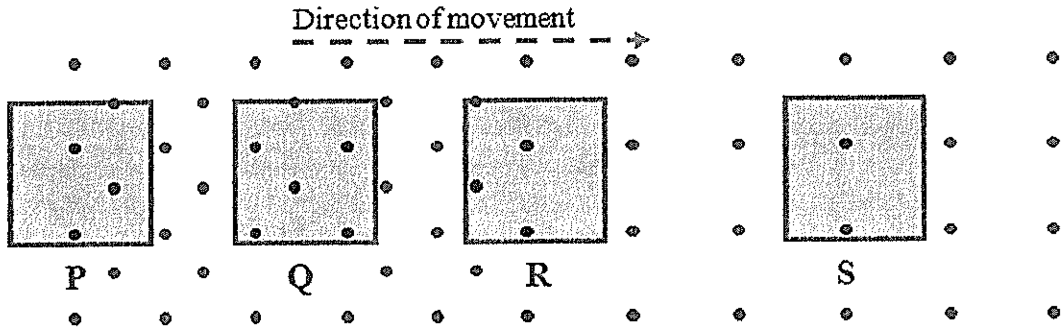
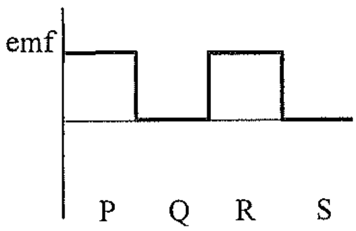
8 Consider the square copper plate moving at constant speed through the magnetic field.

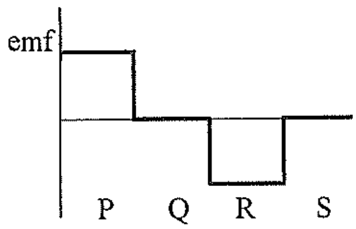


Which graph best shows the emf induced in the plate due to its movement through the field?

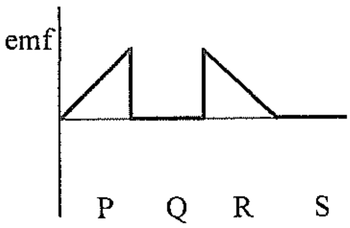
(A)



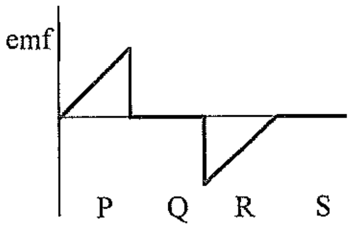
(B)



(C)



(D)



9 Which of the following is NOT an application of the motor effect?

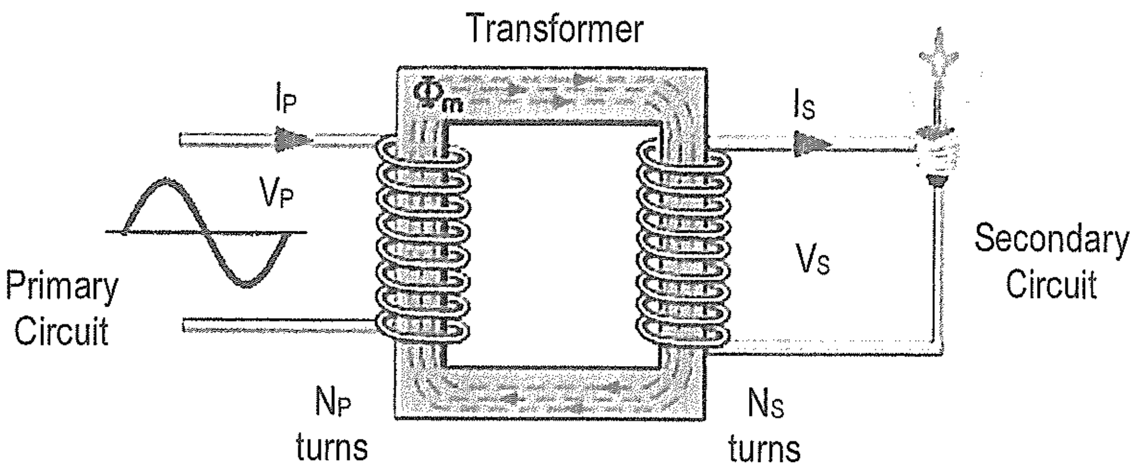
(A) Back emf in motors

(B) Magnetic braking systems

(C) Torque on a coil in a motor

(D) Transformers

10 Consider the following ideal transformer with 1000 turns in the primary and 1125 turns in the secondary.



If the input voltage is 240 V and current 5 A, what is the voltage across the globe and the current through it?

(A) 213.3 V, 5.6 A

(B) 213.3 V, 4.4 A

(C) 270 V, 5.6 A

(D) 270 V, 4.4 A

11 What essential feature of the structure of matter allows us to use the atomic spectra of elements to identify them?

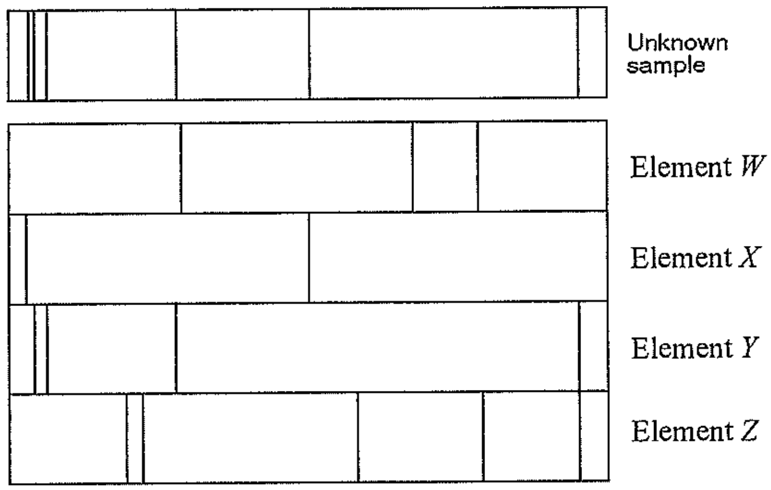
(A) Electron orbits have quantised energy values.

(B) The number of electrons is different for each element.

(C) The number of electrons that can fit into any obit is given by $2n^2$.

(D) Electrons can absorb or release energy when they change levels.

12 Consider the simple line spectra.



Which of the elements *W*, *X*, *Y* and *Z* are contained in the unknown sample?

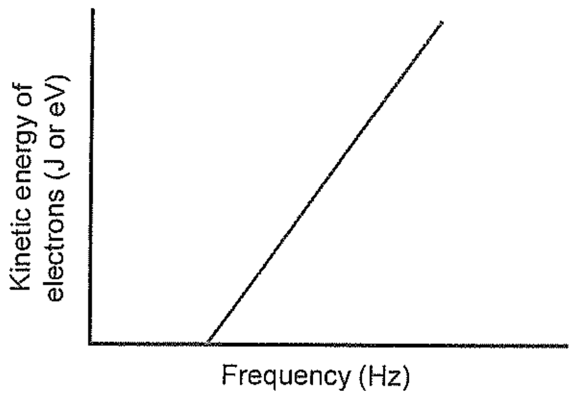
(A) Only element *X*

(B) Only elements *X* and *Y*

(C) Only elements *W* and *Z*

(D) Only elements *X*, *Y* and *Z*

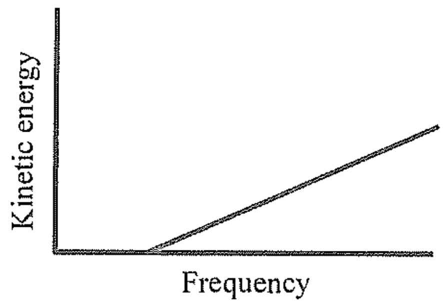
13 The graph shows the relationship between the kinetic energy of photoelectrons emitted from a surface and the frequency of the incident light.



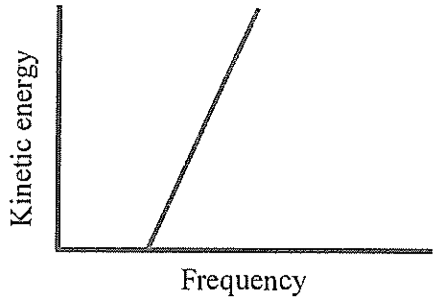
Which of the following graphs correctly shows the same relationship for a different photo-emitter that has a threshold frequency less than the graph above?

(The graphs below have identical scales)

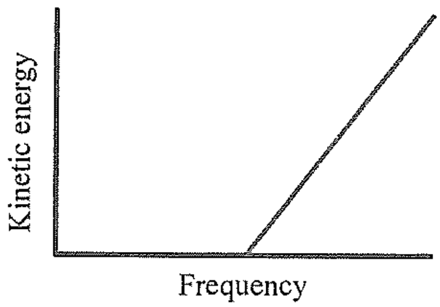
(A)



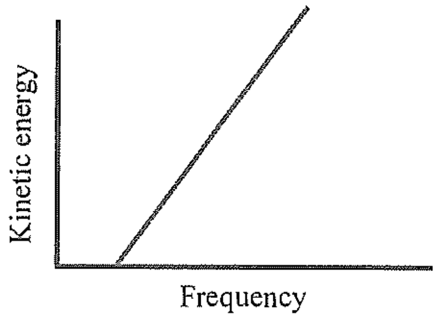
(B)



(C)



(D)



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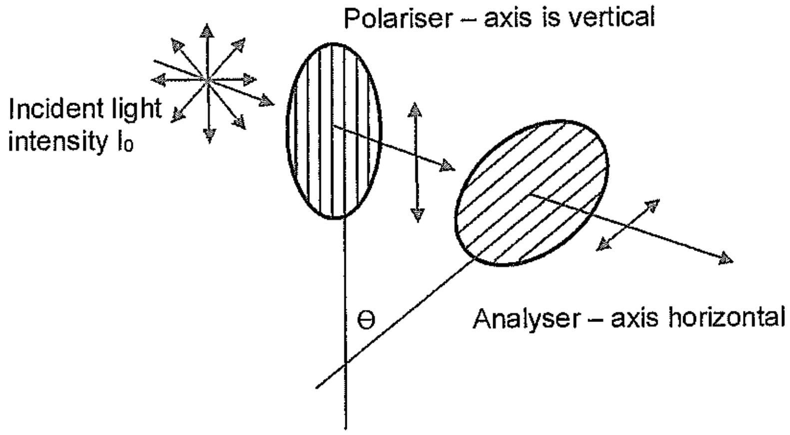
14 The diagram shows a polarising filter which has its polarising axis vertical and an analyser which has its polarising axis at an angle (Θ) to the first.



What value for angle Θ will allow only 40% of the incident light intensity to pass though the analyser?

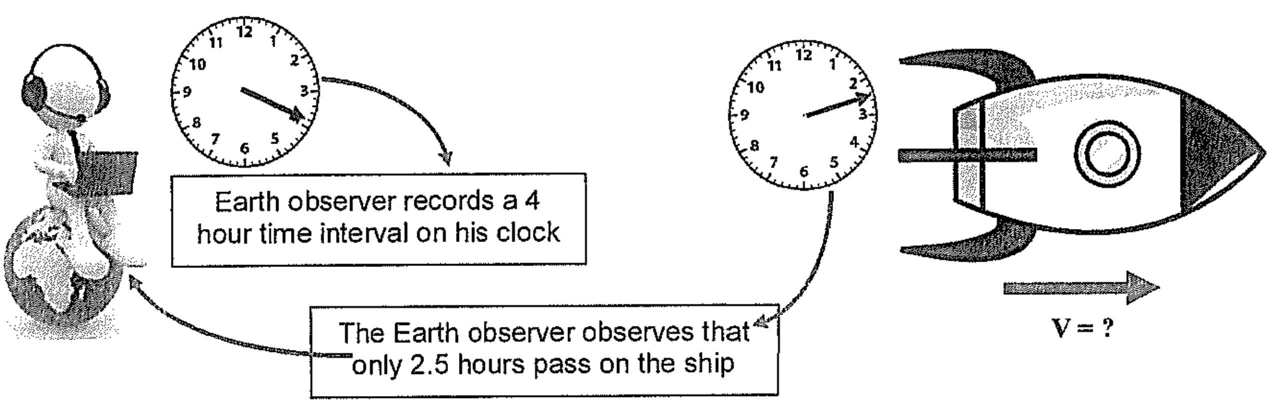
(A) 20°

(B) 26.5°

(C) 31.9°

(D) 50.7°

15 The diagram shows an observer on Earth watching a space ship travel away from him.



According to this information, how fast is the ship travelling?

(A) 0.61 c

(B) 0.625 c

(C) 0.78 c

(D) 1.2 c

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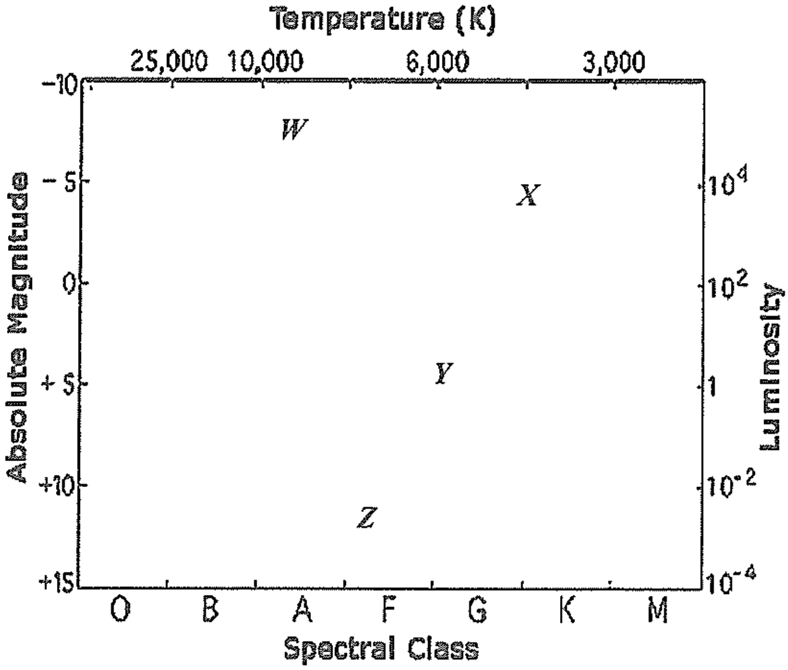
16 Consider the Hertzsprung-Russell diagram of Four stars, *W*, *X*, *Y* and *Z*.



Which statement about these stars is correct?

(A) *W* is the most massive star.

(B) *X* is a main sequence star.

(C) *Y* will be bluish-yellow in colour.

(D) *Z* is a red dwarf.

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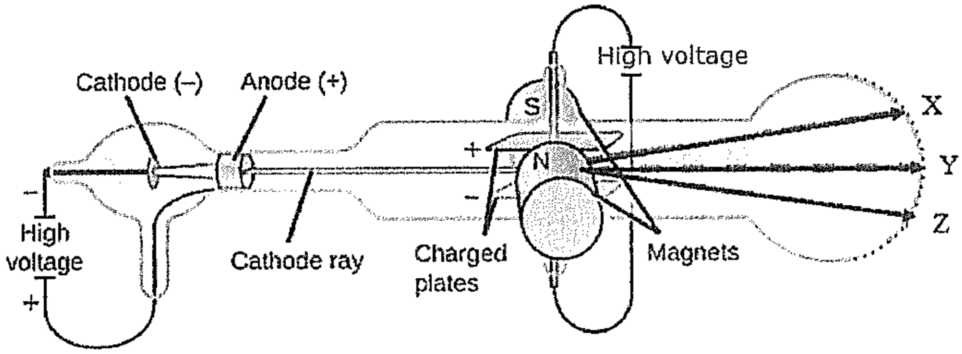
17 The diagram shows a discharge tube similar to those used by Thomson in his experiments with cathode rays. Three impact positions of the cathode rays, X, Y and Z are labelled on the screen.



Which choice correctly identifies these impact points?

	Point X	*Point Y*	*Point Z*
(A)	Deflection by electric field only	No net deflection	Deflection by magnetic field only
(B)	Deflection by magnetic field only	Deflection by electric field only	No net deflection
(C)	Deflection by electric field only	Deflection by magnetic field only	No net deflection
(D)	Deflection by magnetic field only	No net deflection	Deflection by electric field only

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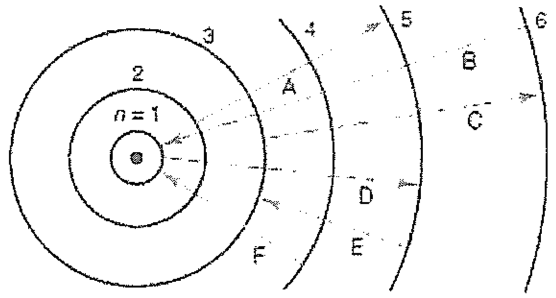
18 The diagram shows a representation of an atom.



What is this diagram showing?

(A) Energy being released as electrons fall to lower levels on the Balmer model

(B) The particle nature of electrons according to De Broglie

(C) Quantised energy level transitions within the Bohr model of the atom

(D) Schrödinger's contribution to the model of the atom

19 Atom X undergoes alpha decay to form atom Y.

How will the nucleus of Y be different from that of X?

(A) The nucleus of Y will have 2 protons more than the nucleus of X.

(B) The nucleus of Y will have 2 protons less but the same number of neutrons as the nucleus of X.

(C) The nucleus of Y will have 2 protons and 2 neutrons more as the nucleus of X.

(D) The nucleus of Y will have 2 protons and 2 neutrons less as the nucleus of X.

20 In the Standard Model of matter, which particles are the fundamental particles?

(A) Quarks and fermions

(B) Quarks, electrons and neutrinos

(C) Quarks, electrons and hadrons

(D) Fermions, baryons and hadrons

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Section II

80 marks
Attempt Questions 21–37
Allow about 2 hours and 25 minutes for this part

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

Show all relevant working in questions involving calculations.

Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Marks

Question 21 (3 marks)

On planet *X*, much smaller than Earth, a projectile is fired at 40 m s^{-1} at an angle of 60° to the horizontal and lands 17.67 s later at the same level from which it was launched. **3**

Calculate the maximum height reached by the projectile above the launch point.

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Question 22 (4 marks) **Marks**

Students carried out an experiment measuring the velocity of a 100 g object in uniform circular motion for six different radius magnitudes, keeping the centripetal force constant. Their results are shown in the table below. 4

Radius of turn (cm)	*Velocity (m s^{-1})*
10	1.48
20	2.10
30	2.60
40	2.97
50	3.32
60	3.63

Their challenge was to use all the results to determine the constant centripetal force.

List and explain the steps of the analysis required to calculate the centripetal force. (You are not required to calculate the force.)

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Question 23 (7 marks) **Marks**

(a) Derive an equation for the orbital velocity v of a satellite orbiting a planet of mass M at a radius r. **2**

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(b) Show that the total energy of an orbiting satellite is half its gravitational potential energy. **2**

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(c) Explain why the gravitational potential energy of an orbiting satellite is negative. **3**

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Question 24 (3 marks) **Marks**

The table shows information about Earth and Jupiter. **3**

	Earth	*Jupiter*
Mass (kg)	6×10^{24}	1.9×10^{27}
Orbital radius (km)	150 000 000	778 000 000
Orbital radius (AU)	1.0	X
Orbital period	365 days	Y

Using the values above, calculate the quantities X and Y in the table.

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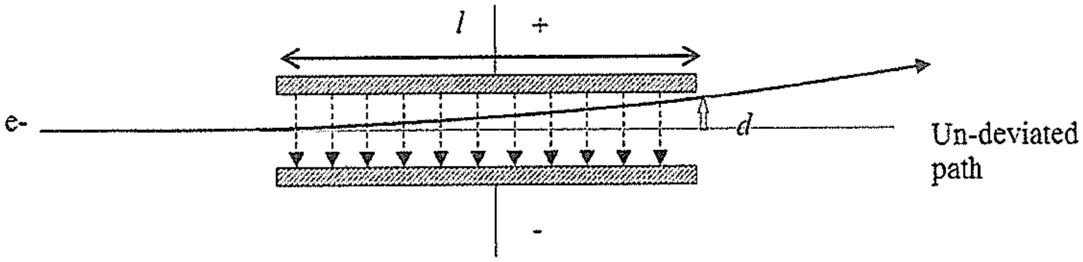
Question 25 (4 marks) **Marks**

(a) The diagram below shows the path of an electron, charge *e*, in the electric field *E* between parallel charged plates length *l*. The electron, mass *m*, is deviated from its path by a distance *d*. **1**



Derive an expression for the vertical component of the electron's velocity as it leaves the electric field.

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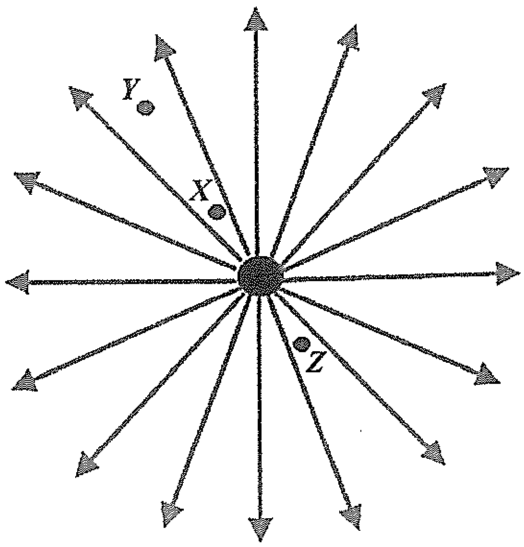
Question 25 continues on the next page

Question 25 (continued) **Marks**

(b) Consider the following diagram which shows three points (*X*, *Y* and *Z*) in the electric field around a point charge.



(i) What is the sign of the charge in the diagram? Justify your answer. **1**

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(ii) Compare the work needed to move identical negative charges from *X* to *Y* and from *X* to *Z*. Justify your answer. **2**

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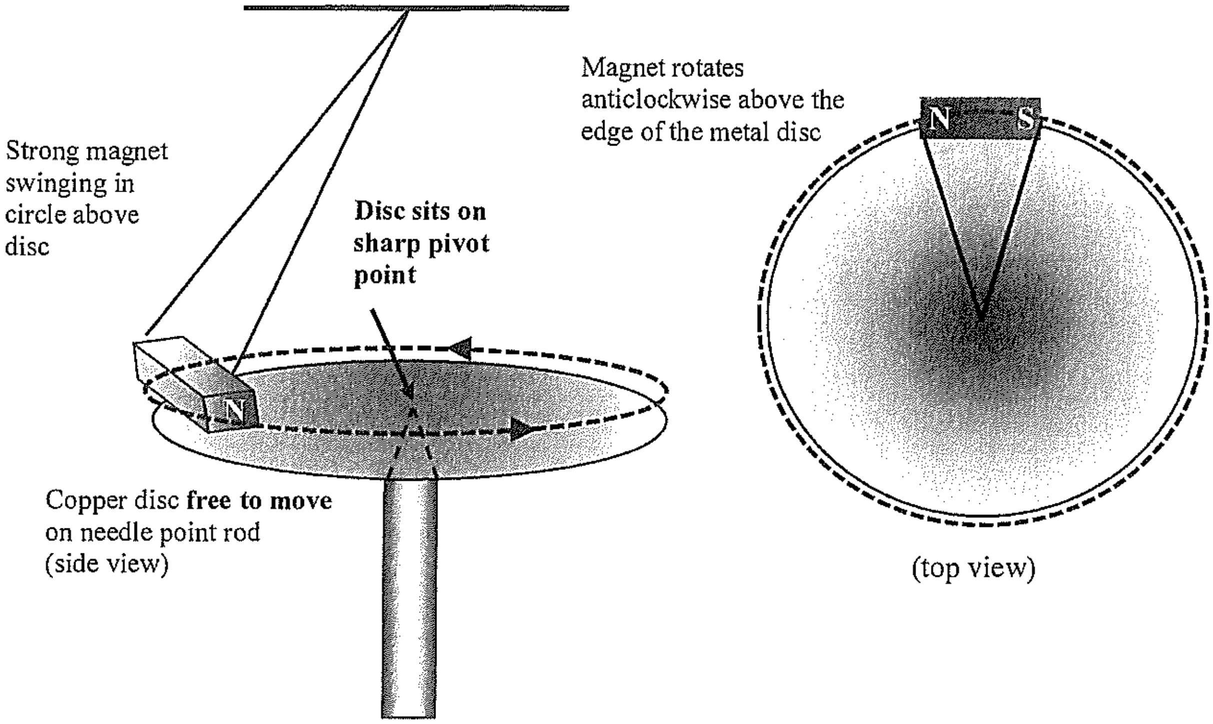
End of Question 25

STUDENT NUMBER/NAME.............................

Question 26 (4 marks) **Marks**

Consider a strong magnet suspended from the ceiling and moving in a circle just slightly above a thin copper disc which is resting on a sharp pivot point, as shown in the diagram. **4**



In terms of the principles of physics involved, describe and explain what happens as the magnet rotates around above the disc.

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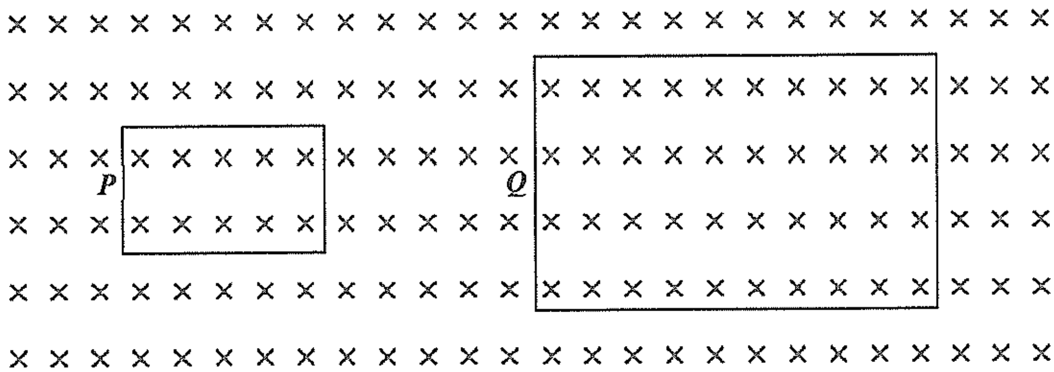
Question 27 (3 marks) **Marks**

Two rectangular, single turn coils of wire, *P* and *Q* are inside a magnetic field as shown in the diagram. **3**



Compare the magnetic flux and flux density through each coil. Justify your answer.

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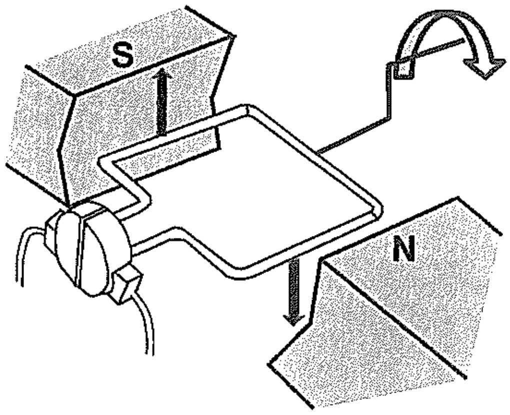
Question 28 (4 marks) **Marks**

The diagram shows an electrical device where the coil is being rotated by an external force in the direction shown by the arrows (clockwise).



(a) What is this device? Justify your answer. 1

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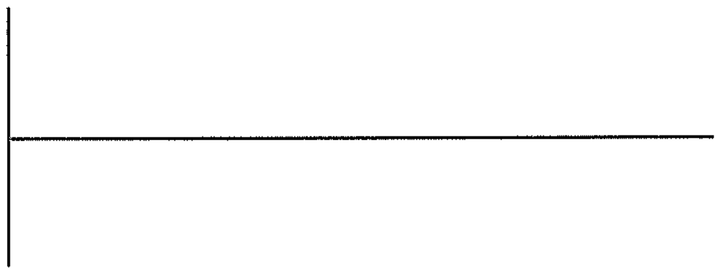
(b) On the diagram, draw arrows to show the direction of current induced in the coil at the instant shown. 1

Question 28 continues on the next page

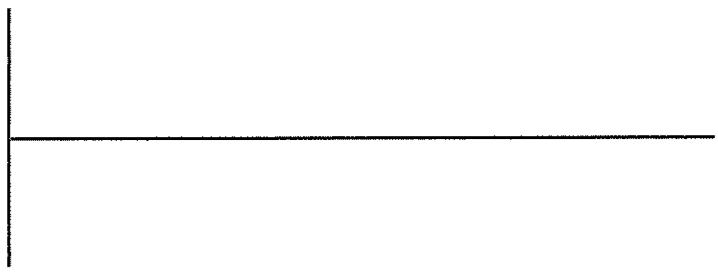
Question 28 (continued) **Marks**

(c) On the axes, sketch separate graphs to show the emf produced in the device AND the emf delivered to the external circuit for TWO complete rotations of the coil. **2**

Emf produced in the device



Emf delivered to external circuit

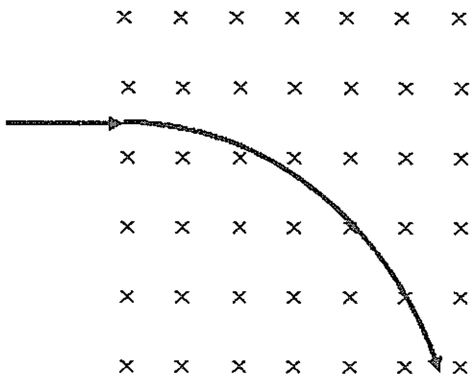


End of Question 28

STUDENT NUMBER/NAME.............................

Question 29 (4 marks) **Marks**

Scientists fired a beam of charged particles into a magnetic field of strength 0.8 T at 3×10^5 m s^{-1}. They measured the radius of curvature of the beam as 0.15 m.



(a) The scientists concluded that the beam was composed of electrons. **3**

Using the data given, evaluate their conclusion.

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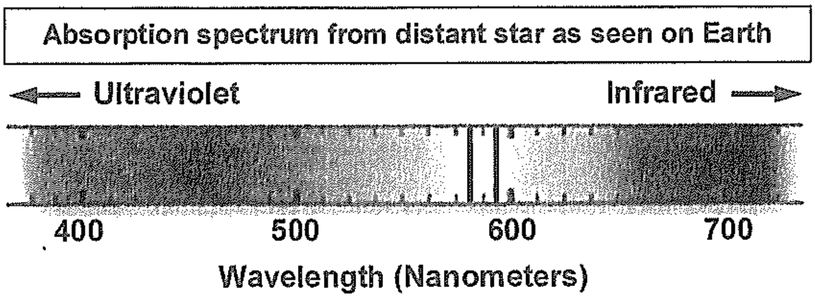
(b) On the diagram above, show the path the beam of charged particles would take as it left the magnetic field. **1**

Question 30 (5 marks) **Marks**

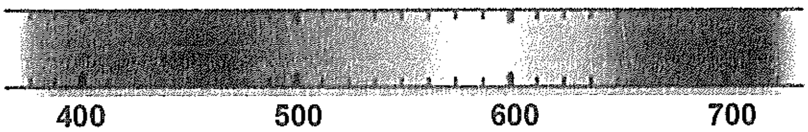
The diagram shows the absorption spectrum of light received from a distant star. There are only two lines in this spectrum.



(a) Scientists on Earth deduced that the star is moving away from Earth. 4

Explain how an absorption spectrum is formed and how scientists are able to determine the direction of movement of the star.

(b) On the diagram below, draw the two spectral lines in a position they could be observed by scientists if they were on a planet orbiting this star. 1



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Question 31 (7 marks) **Marks**

Compare the models of light that were proposed by Newton and Huygens and analyse the experimental evidence that supported the models at the time. 7

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Question 32 (3 marks) **Marks**

Muons travel through the atmosphere at a speed of 0.998c. The mean lifetime of a stationary muon is 2.2 μs. **3**

Show that muons formed at an altitude of 9 km can, despite their life of 2.2 μs, reach the surface of the Earth.

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Question 33 (8 marks) **Marks**

Evaluate Einstein's contribution to the development of special relativity and the evidence confirming or denying the postulate that the speed of light in a vacuum is an absolute constant. **8**

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Question 34 (5 marks) **Marks**

The diagram below shows one of the reaction sequences in the CNO cycle, which is the main energy producing sequences in stars at least 1.3 times larger than our Sun. Note that one product of the second reaction in the cycle is missing, (X).

$^{12}_{6}C + ^{1}_{1}H \longrightarrow ^{13}_{7}N + \gamma$	1.95 MeV
$^{13}_{7}N \longrightarrow ^{13}_{6}C + (X) + \nu_e$	1.20 MeV
$^{13}_{6}C + ^{1}_{1}H \longrightarrow ^{14}_{7}N + \gamma$	7.54 MeV
$^{14}_{7}N + ^{1}_{1}H \longrightarrow ^{15}_{8}O + \gamma$	7.35 MeV
$^{15}_{8}O \longrightarrow ^{15}_{7}N + ^{0}_{1}\bar{e} + \nu_e$	1.73 MeV
$^{15}_{7}N + ^{1}_{1}H \longrightarrow ^{12}_{6}C + ^{4}_{2}He$	4.96 MeV

(a) What are the reactants and products of the CNO cycle? Justify your answer. **2**

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(b) Identify the missing particle, (X). **1**

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(c) Why is only 2% of the helium fused in the Sun using the CNO cycle? **2**

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Question 35 (7 marks) **Marks**

(a) Rutherford's model of the atom was based on results of experiments carried out by Geiger and Marsden.

Justify Rutherford's conclusions that were the basis of his model **3**

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(b) Draw a labelled diagram of the model of the atom proposed by Rutherford following these experiments and a labelled diagram of the model it replaced. **2**

<u>Rutherford model</u> <u>Previous model</u>

(c) Outline the main problem with the Rutherford model. **2**

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End of Question 35

Question 36 (3 marks) **Marks**

Outline Schödinger's model of the atom. **3**

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Question 37 (6 marks)

Before an experiment to find the half-life of a radioactive isotope, a nuclear scientist switched on her radiation counter in the lab for five 60 second intervals and recorded the following results:

Radiation recorded (counts/min^{-1})
1123
1126
1128
1127
1121

The scientist then placed a sample of radioactive isotope *X* near the counter and measured the counts per minute each second Monday for 14 weeks. Counting the first week as week 0, (the starting week), her results are shown in the table below.

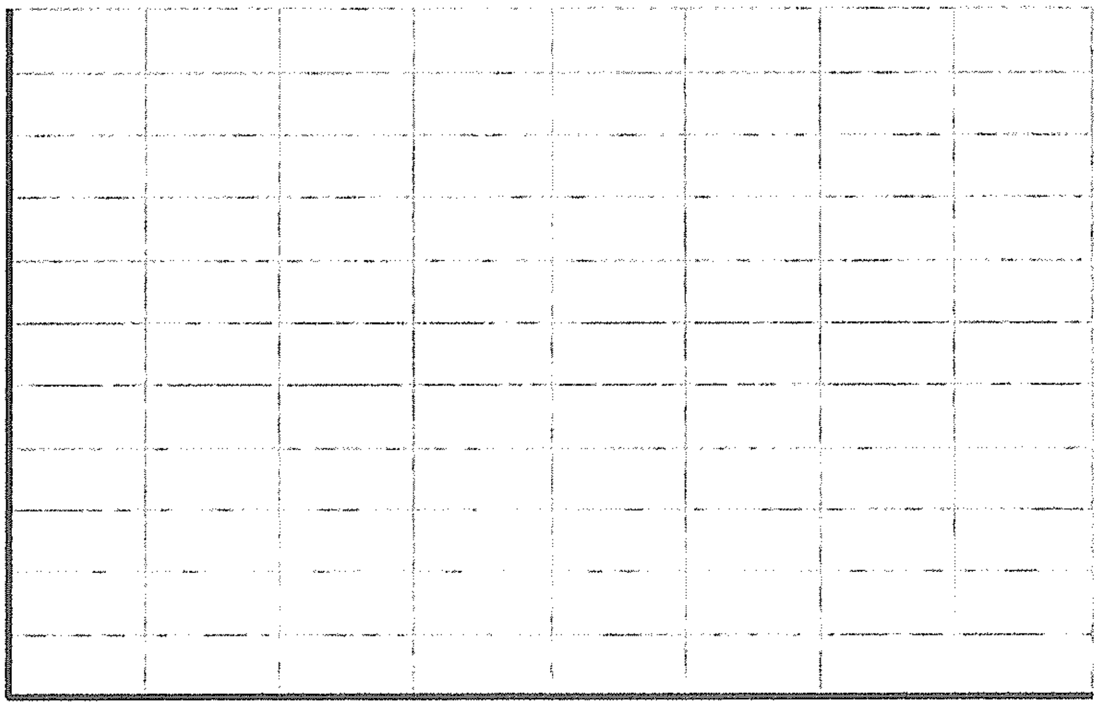
Time (weeks)	*Total radiation counts recorded (counts min^{-1})*
0	11 125
2	7725
4	5525
6	4125
8	3125
10	2425
12	2075
14	1625

Question 37 continues on the next page

STUDENT NUMBER/NAME..............................

Question 37 (continued) **Marks**

(a) Plot results to show the relationship between time and the radiation of X. **4**



(b) Use your graph to determine the half-life of *X*. **1**

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(c) Identify an assumption made by the scientist. **1**

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End of paper

STUDENT NUMBER/NAME..............................

Extra writing space

NSW INDEPENDENT TRIAL EXAMS – 2019
PHYSICS – TRIAL HSC EXAMINATION
MARKING GUIDELINES

Section I

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C	B	D	B	B	A	C	B	D	D	A	B	D	B	C	A	A	C	D	B

Section II

Q21

Criteria	Marks
• Provides correct answer for maximum height	3
• Provides correct substitution into TWO appropriate formulae with ONE calculation error	2
• Provides using Earth's acceleration due to gravity	1

Sample answer:

From $v_{top} = u + at$

$0 = 40\sin 60° + a(17.67/2)$

$a = -3.92 \text{ m s}^{-2}$

From $v^2 = u^2 + 2a\,\Delta y$

$0 = (40\sin 60°)^2 - 2 \times 3.92 \times \Delta y$

$\Delta y = (40\sin 60°)^2 / 2 \times 3.92$

$\Delta y = 153 \text{ m}$

Q22

Criteria	Marks
• Provides clear instructions for drawing suitable graph and for use of gradient	4
• Provides instructions for drawing suitable graph and measuring gradient	3
• Provides instructions for unsuitable graph and to use gradient	2
• Provides instructions for unsuitable graph	1

Sample answer:

1. Since $F = m\,v^2/r$, $F / m = v^2 / r$ Since F / m is constant, v^2 / r is constant and v^2 is proportional to r.
2. Plot the velocity squared (on *y* axis) against the radius (on *x* axis).
3. The graph should be a straight line. Draw a line of best fit and calculate the gradient.
4. From the above, the gradient is equal to F / m. Mass is 0.1 kg, therefore centripetal force is equal to gradient × 0.1.

Q23(a)

Criteria	Marks
• Equates the gravitational force and the centripetal force and provides velocity equation	2
• Equates the gravitational force and the centripetal force and provides incorrect velocity equation	1

Sample answer:

$F_{centripetal} = \frac{mv^2}{r}$ $\quad F_{gravity} = \frac{GMm}{r^2}$ $\quad$ Therefore $\frac{GMm}{r^2} = \frac{mv^2}{r}$

Rearranging, $v = \sqrt{\frac{GM}{r}}$

Q23(b)

Criteria	Marks
• Provides the kinetic energy, potential energy and total energy formulae using their velocity from part (a) correctly	2
• Provides a formula for the total energy using kinetic and potential energy	1

Sample answer: Kinetic energy of an orbiting satellite = KE = $\frac{1}{2}mv^2$

Using v from above, KE = $\frac{1}{2}m(\sqrt{\frac{GM}{r}})^2 = \frac{1}{2}m\frac{GM}{r} = \frac{GMm}{2r_{orbit}}$

Total energy = kinetic energy + potential energy = KE + U

$= \frac{GMm}{2r_{orbit}} + (-\frac{GMm}{r_{orbit}}) = -\frac{GMm}{2r_{orbit}}$ = half gravitational potential energy

Q23(c)

Criteria	Marks
• Identifies zero gravitational energy position and relates the negative value to the changes in potential and kinetic energy of a satellite in moving to or away from Earth	3
• Identifies zero gravitational energy position and the negative value to the change in potential of a satellite in moving to or away from Earth	2
• Identifies zero gravitational energy position	1

Sample answer: The reference position in space for zero gravitational potential energy is infinity because it is only at an infinite distance from Earth (or any heavenly object) that the value of U will be zero.

In moving closer to Earth from infinity, a satellite will lose gravitational potential energy and gain kinetic energy – it "falls" and increases its velocity.

In losing potential energy from a value of zero, the gravitational potential energy must become a negative quantity.

Q24

Criteria	Marks
• Calculates orbital radius and period correctly	3
• Calculates orbital radius and period with ONE error	2
• Calculates orbital radius	1

Sample answer:

X, orbital radius = 778 000 000 / 150 000 000 = 5.2 AU

Using Kepler's law of periods, R^3 / T^2 is constant.

$778\,000\,000^3 / T^2 = 150\,000\,000^3 / 1^2$

Period for Jupiter, Y = 11.8 years

Q25(a)

Criteria	Marks
• Provides expression for vertical velocity component	1

Sample answer:
Work done on electron = q Ed = e E d

Since work done increases the vertical velocity component, e E d = ½ m v^2

Vertical velocity component = $\sqrt{\dfrac{2e\,E\,d}{m}}$

Q25(b)(i)

Criteria	Marks
• Provides charge using electric field definition	1

Sample answer: The direction of an electric field is the force on a unit positive charge. As the field lines show repulsion from the point charge, it must be positive.

Q25(b)(ii)

Criteria	Marks
• Provides correct comparisons with reason	2
• Provides ONE correct comparison with reason	1

Sample answer: The electric field has equal strength at X and at Z, as at same distance from point charge and the field is weaker at Y, further away from centre charge and shown by the greater spacing of the field lines. No work is done in moving a charge from X to Z because no force is required to move a charge perpendicular to the field lines – there is no potential difference. Work is required to move a negative charge to Y which is further from the positive point charge because opposite charges attract.

Q26

Criteria	Marks
• Explains clearly the formation of eddy currents, their direction using Lenz Law and the motion of the disc by the interaction of magnetic poles	3–4
• Identifies the formation and direction of the eddy currents	2
• Identifies the formation of eddy currents	1

Sample answer: The motion of the magnetic field relative to the metal disc induces eddy currents in the disc in front of and behind the magnet (Faraday's Law of Electromagnetic Induction). These eddy currents induce a second magnetic field around them which, by Lenz Law, opposes the magnetic field of the moving magnet.

The magnet is presenting a north pole at the front as it moves across the surface of the disc, so the eddy current will induce a north pole to try to stop the magnet moving. At the back of the moving magnet is a south pole, to the eddy current will induce a north pole to attract the magnet backwards and slow it down. Because the disc is free to move and on a fine pivot point, and because the magnet will require a significant force to stop it, the repulsive force between the north poles at the front of the magnet and the attractive north pole at the rear will actually push and pull the disc (respectively) causing it to rotate in the same direction as the rotating magnet.

Q27

Criteria	Marks
• Provides numerical comparison of magnetic flux and identifies equal flux due to same field	3
• Provides comparison of magnetic flux and identifies equal flux due to same field	2
• Provides comparison of magnetic flux or identifies equal flux due to same field	1

Sample answer: Flux through Q is four times the flux though P as it has four times the area. Flux density through each is the same as they are inside the same strength magnetic field into the page shown by regular spacing of crosses.

Q28(a)

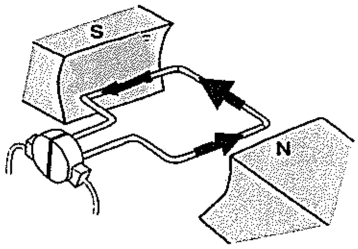
Criteria	Marks
• Identifies device and energy transformation	1

Sample answer: DC generator – it has a split ring commutator and is using a mechanical input of energy to produce electrical energy.

Q28(b)

Criteria	Marks
• Draws anticlockwise current	1

Sample answer:

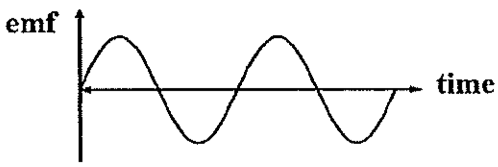


Q28(c)

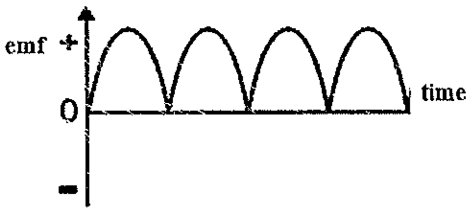
Criteria	Marks
• Provides TWO correct graphs	2
• Provides ONE correct graph	1

Sample answer:

Emf produced in the device



Emf delivered to external circuit



Q29(a)

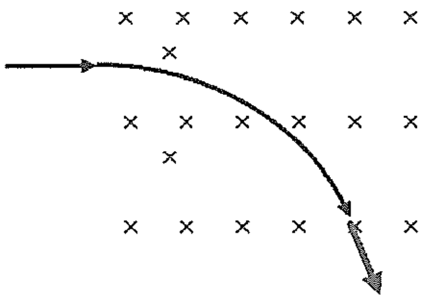
Criteria	Marks
• Calculates mass of particles in beam and states conclusion based on electron mass or q/m ratio	3
• Calculates mass of particles incorrectly with ONE error and states conclusion based on electron mass or q/m ratio	2
• Equates centripetal force and force due to magnetic field	1

Sample answer:
Assuming the beam is made up of electrons, then $q = 1.6 \times 10^{-19}$ Coulomb
From $F = Bqv = mv^2/r$, $m = Bqr/v$
Substituting values into the equation, $m = (0.8 \times 1.6 \times 10^{-19} \times 0.15) / (3 \times 10^5)$
M, mass of the particles in the beam $= 6.4 \times 10^{-26}$ kg
Mass of the electron $= 9.1 \times 10^{-31}$ kg
Therefore, although the particles in the beam are negatively charged, they cannot be electrons as their mass is too large to have q/m ratio of electrons.

Q29(b)

Criteria	Marks
• Draws straight line in appropriate direction	1

Sample answer:



Q30(a)

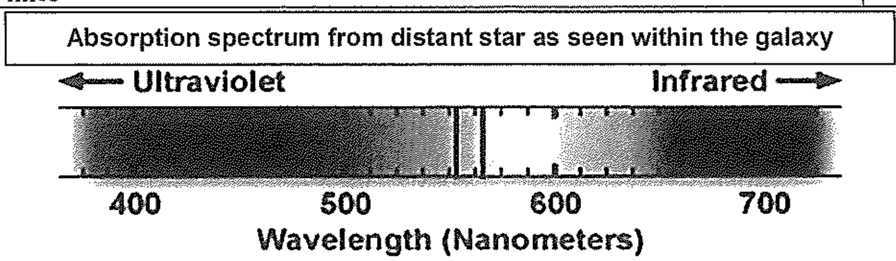
Criteria	Marks
• Provides a clear explanation of black line formation and applies the Doppler effect	4
• Shows a basic understanding of black line formation and applies the Doppler effect	3
• Provides ONE detail about black line formation OR applies the Doppler effect	2
• Names the Doppler effect	1

Sample answer: An absorption spectrum is produced by a cooler gas in front of a source of continuous spectrum. Radiation with the right wavelength to excite electrons in the cooler gas atoms will be absorbed resulting in the black lines. The wavelengths and hence the line spacing are unique to each element and the spacing is maintained when the source of the absorption spectrum moves relative to the observer, allowing the element to be identified. The scientists must have observed that the 2 black lines shown have longer wavelengths, that is, are shifted to the red end of the spectrum as predicted by the Doppler effect.

Q30(b)

Criteria	Marks
• Draws correct lines	1

Sample answer:



(Note that the position of the two lines can be anywhere so long as they are displaced towards the blue end of the spectrum.)

Q31

Criteria	Marks
• Provides comprehensive descriptions of both models and compares how well each model could explain the known properties of light	7
• Provides basic descriptions of both models and compares how well each model could explain the known properties of light	5–6
• Provides basic descriptions of both models OR compares how well each model could explain the known properties of light	3–4
• Provides some relevant information	1–2

Sample answer: Newton's corpuscular theory of light proposed that light consisted of very tiny particles known as "corpuscles" which travel out from any source at very high speeds. Huygen's wave theory proposed that light was a form of energy which travelled in the form of waves which vibrate up and down perpendicular to the direction of travel.

Newton proposed that the corpuscles could travel though a vacuum. Huygen stated that a medium was necessary for the propagation of his waves and that space is filled with an imaginary medium called aether and that each point in a source of light sends out waves in all directions though this hypothetical medium.

There was no direct evidence for either model, except the fact that they could explain properties of light. Both models could explain light travelling in straight lines as well as the reflection and refraction of light, but only Newton's model allowed light to travel though a vacuum. Only Huygen's model could explain interference and diffraction, including the blurred edges of shadows and Poisson's spot. Newton had a weak explanation for diffraction, but it really did not fit his model.

When the models were proposed, there was no conclusive evidence to rule out either model but based on his reputation, Newton's model was preferred until further experimental evidence was found.

Q32

Criteria	Marks
• Applies time dilation correctly to show dilated time less than muon life	3
• Substitutes correctly in time dilation formula and calculates travel time	2
• Attempts to apply time dilation formula and calculates travel time	1

Sample answer:

At 0.998c, the time to travel 9 km = 9000 / (0.998 × 3 × 10^8) s = 30 μs

The average dilated lifetime of a muon travelling at 0.998c, t is given by:

$t = t_0/\sqrt{(1 - v^2/c^2)}$

$= 2.2/\sqrt{(1 - 0.998^2)}$

$= 34.8$ μs which is more than 30 μs, therefore the muons reach the surface.

Q33

Criteria	Marks
• Provides a clear and ordered discussion including the following points: the earlier time dilation and length contraction work, Maxwell's equations, Michelson-Morley experiment, the non-existence of the aether, the validity of the principle of relativity, the use a thought experiment, an assessment of the importance of Einstein's contribution	7–8
• Provides a discussion including FIVE of the following points: the earlier time dilation and length contraction work, Maxwell's equations, Michelson-Morley experiment, the non-existence of the aether, the validity of the principle of relativity, the use a thought experiment, an assessment of the importance of Einstein's contribution	5–6
• Provides THREE of the following points: the earlier time dilation and length contraction work, Maxwell's equations, Michelson-Morley experiment, the non-existence of the aether, the validity of the principle of relativity, the use a thought experiment, an assessment of the importance of Einstein's contribution	3–4
• Provides some relevant information	1–2

Sample answer: While it is thought that Einstein was the creator of special relativity, he was not the first to develop the equations we use for time dilation and length contraction – these were developed by Lorentz and Poincare. Einstein was not even the first to suggest that time dilation and length contraction occurred. In fact, Einstein was not even the first to propose that the speed of light was constant – Maxwell's mathematics predicted this in 1873.

During the 1800's it was thought that light was carried by an invisible, undetectable medium called the aether, and all the mathematics developed by the scientists before Einstein tried to incorporate the aether into their work. What Einstein did that was different was that instead of trying to incorporate the aether into the mathematical model, he stated that it did not exist. The Michelson-Morley experiments had failed to provide evidence for the existence of the aether despite using a valid method and very precise measurements. The results made sense if there was no aether and are therefore evidence for Einstein's ideas. The mathematics which had been unable to explain developing ideas when the aether was included, suddenly made much more sense and held together more coherently.

While there was no direct experimental evidence for the constancy of the speed of light, Einstein's postulate was the result of a thought experiment and his belief that the principle of relativity cannot be violated. If the principle is violated, the laws of physics would not be the same in all frames of reference. His thought experiment discussed what would happen to the reflection in a mirror of a person in a train travelling at the speed of light.

His work was crucial in that it set the platform for the continued development of special relativity and quantum mathematics by showing that the aether was not necessary for the propagation of light and showing that the developing mathematics of the time was correct.

Q34(a)

Criteria	Marks
• Identifies reactant and product and provides the reason	2
• Identifies reactant and product	1

Sample answer: The reactant is hydrogen and the product is helium. The other elements are catalysts for various reactions in the sequence, but they are reformed and remain unchanged, at the end of the sequence.

Q34(b)

Criteria	Marks
• Identifies X	1

Sample answer: X = $^{0}_{1}\bar{e}$ = positron

Q34(c)

Criteria	Marks
• Explains need of higher temperature to fuse larger atoms	2
• Identifies need for higher temperature	1

Sample answer: Because the CNO cycle involves fusion of some larger atoms (carbon, nitrogen, oxygen), it needs higher temperatures to initiate the reactions. These high temperatures are common in very hot stars which are more massive than the Sun but not common in the Sun.

Q35(a)

Criteria	Marks
• Provides outline of experiment and Rutherford's interpretation of two results	3
• Provides outline of experiment and Rutherford's interpretation of one result	2
• Provides Rutherford's interpretation of one result	1

Sample answer:

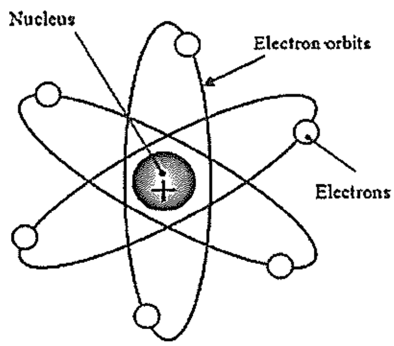
Geiger and Marsden bombarded thin layers of gold foil with alpha particles and determined the scattering pattern of the particles by counting and measuring the scintillations on a fluorescent screen through a microscope. The results did not agree with the predictions based on the Thomson model. Rutherford proposed a model with most of the atom being empty space, based on the large number of alpha particles that passed straight through with no deflection. Some of the α-particles were deflected by very small angles and a very small number were deflected by 180°. Rutherford stated that the positive charge in an atom could not be uniformly distributed but had to be concentrated in a very small volume in the centre of the atom to produce the deflection pattern obtained by Geiger and Marsden. Only a concentration of both positive charge and mass could have resulted in any alpha particles being reflected back to the source.

Q35(b)

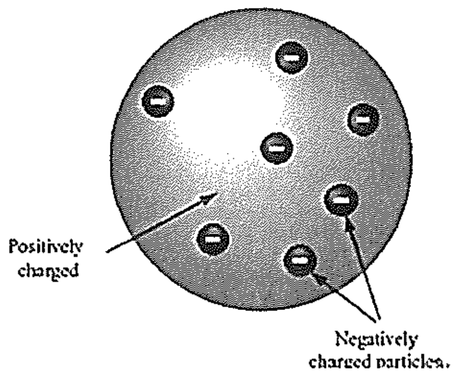
Criteria	Marks
• Draws TWO correct, labelled diagrams	2
• Draws ONE correct, labelled diagram	1

Sample answer:

Rutherford model



Previous model, by Thomson



Q35(c)

Criteria	Marks
• Stated motion of negative particle is accelerated circular motion and involved energy emission with consequent collapse of atom	2
• Stated motion of negative particle is accelerated circular motion OR involved energy emission with consequent collapse of atom	1

Sample answer: The Rutherford model had negative charges moving around the positive nucleus. This type of motion involves acceleration and accelerated charges emit electromagnetic energy. As the negative charges lost energy, they should spiral into the nucleus. The atom should collapse.

Q36

Criteria	Marks
• Describes the electron cloud model, the use of probability and de Broglie's matter/wave concept and existence of subshells	3
• Describes TWO of the following: the electron cloud model with its use of probability, de Broglie's matter/wave concept, existence of subshells	2
• Describes ONE of the following: the electron cloud model with its use of probability, de Broglie's matter/wave concept, existence of subshells	1

Sample answer: In 1926 Schrödinger's proposed a wave mechanics model, often called the "electron cloud" model because it described the electronic structure of an atom in terms of the mathematical probability of finding the electrons in certain regions of the space around the nucleus.

Schrödinger's view of the atom, based on de Broglie's wave-particle duality, was that it had "layers within layers". In other words, the electron shells were not discrete but had varying mathematical probability of being in various distances from the nucleus.

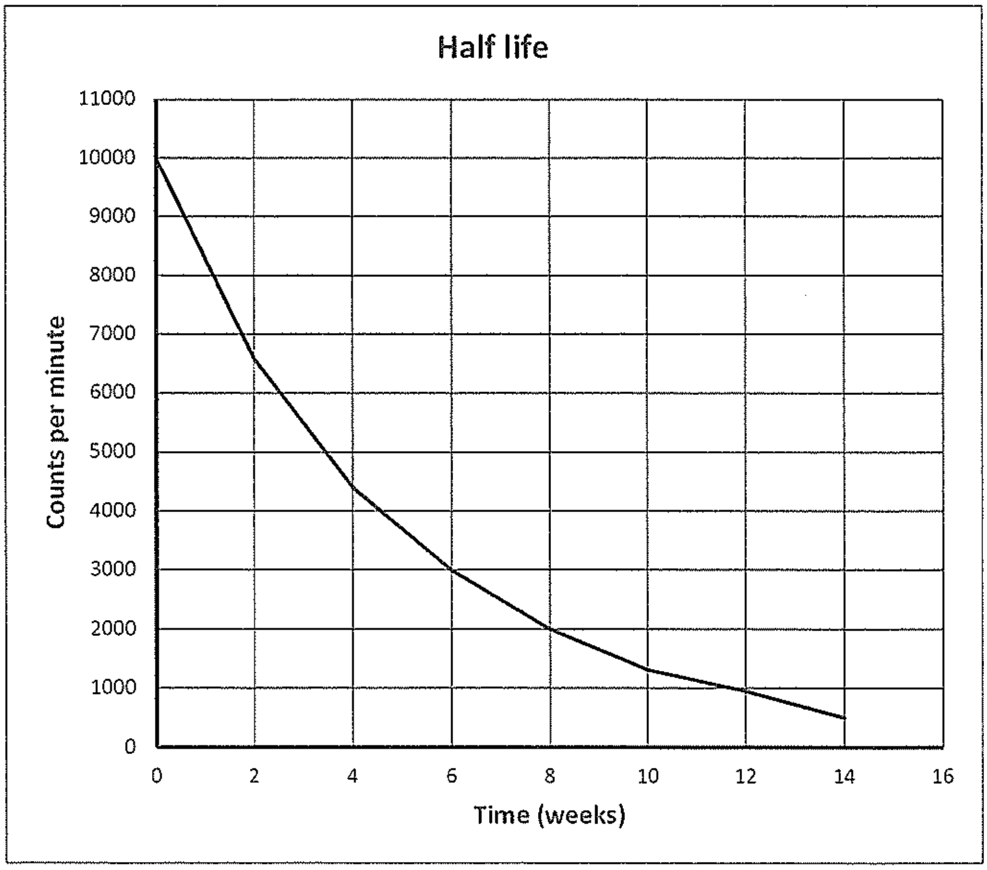
Schrödinger's model indicated that electron shells (or orbits) would not be simple, but would have shells within shells – sub shells – called the s, p, d, f and g sub shells.

Q37(a)

Criteria	Marks
• Provides a graph with axes suitably labelled, independent variable on x-axis, evidence of subtracting average background radiation, correctly plotted radiation values, a smooth curve through values plotted	4
• Provides FOUR of the following: suitably labelled axes, independent variable on x-axis, evidence of subtracting average background radiation, correctly plotted radiation values, a smooth curve through values plotted	3
• Provides THREE of the following: suitably labelled axes, independent variable on x-axis, evidence of subtracting average background radiation, correctly plotted radiation values, a smooth curve through values plotted	2
• Provides TWO of the following: suitably labelled axes, independent variable on x-axis, evidence of subtracting average background radiation, correctly plotted radiation values, a smooth curve through values plotted	1

Sample answer: Average background radiation = 1125 counts/min

Total radiation counts recorded (counts min^{-1})	*Radiation due to X (counts min^{-1})*
11125	10000
7725	6600
5525	4400
4125	3000
3125	2000
2425	1300
2075	950
1625	500



Q37(b)

Criteria	Marks
• Provides answer based on graph drawn	1

Sample answer: Approximately 3.4 weeks

Q37(c)

Criteria	Marks
• Identifies a valid assumption	1

Sample answer: The scientist has assumed that the initial radiation counts do not need to be repeated each time radiation from sample X is counted ie background radiation constant.

NSW INDEPENDENT TRIAL EXAMS – 2019
PHYSICS – TRIAL HSC EXAMINATION
MAPPING GRID

Question	Marks	Content module		Syllabus Outcomes (PH)	Targeted performance bands
Section I					
1	1	5	Projectile Motion	12-12	2-3
2	1	5	Motion in a Gravitational Field	11/12-6, 12-12	4-5
3	1	5	Motion in a Gravitational Field	11/12-6, 12-12	3-4
4	1	5	Motion in a Gravitational Field	11/12-6, 12-12	4-5
5	1	6	The Motor Effect	11/12-6	3-4
6	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-13	2-3
7	1	6	The Motor Effect	11/12-6, 12-13	3-4
8	1	6	Electromagnetic Induction	11/12-5, 12-13	4-5
9	1	6	Applications of the Motor Effect	12-13	2-3
10	1	6	Electromagnetic Induction	11/12-6, 12-13	3-4
11	1	7	Electromagnetic Spectrum	12-14	3-4
12	1	7	Electromagnetic Spectrum	12-14	2-3
13	1	7	Light: the Quantum Model	12-14	5-6
14	1	7	Light: the Wave model	12-14	3-4
15	1	7	Light and Special Relativity	11/12-6, 12-14	5-6
16	1	8	Origin of the Elements	12-15	2-3
17	1	8	Structure of the Atom	12-15	2-3
18	1	8	Quantum Mechanical Nature of the Atom	12-15	2-3
19	1	8	Properties of the Nucleus	12-15	2-3
20	1	8	Deep Inside the Atom	12-15	3-4
Section II					
21	3	5	Projectile Motion	11/12-6, 12-12	3-4
22	4	5	Circular Motion	11/12-4, 11/12-5 12-12	3-5
23(a)	2	5	Motion in a Gravitational Field	11/12-6, 12-12	4-5
23(b)	2	5	Motion in a Gravitational Field	11/12-6, 12-12	5-6
23(c)	3	5	Motion in a Gravitational Field	11/12-6, 12-12	4-5
24	3	5	Motion in a Gravitational Field	11/12-6, 12-12	3-4
25(a)	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	11/12-6, 12-13	4-5
25(b)(i)	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-13	2-3
25(b)(ii)	2	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-13	3-4
26	4	6	Electromagnetic Induction	11/12-6, 12-13	4-6
27	3	6	Electromagnetic Induction	12-13	2-3
28(a)	1	6	Applications of the Motor Effect	12-13	2-3
28(b)	1	6	Applications of the Motor Effect	12-13	2-3
28(c)	2	6	Applications of the Motor Effect	12-13	3-4
29(a)	3	6	Charged Particles, Conductors and Electric and Magnetic Fields	11/12-6, 12-13	4-5
29(b)	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-13	2-3
30(a)	4	6	Electromagnetic Spectrum	11/12-7, 12-14	3-5
30(b)	1	6	Electromagnetic Spectrum	11/12-7, 12-14	3-4

NSW INDEPENDENT TRIAL EXAMS – 2019
PHYSICS – TRIAL HSC EXAMINATION
MAPPING GRID - cont'd

Question	Marks	Content module		Syllabus Outcomes (PH)	Targeted performance bands
Section I					
31	7	7	Light: Wave Model	11/12-7	3-6
32	3	7	Light and Special Relativity	11/12-6, 12-14	5-6
33	8	7	Light and Special Relativity	11/12-7, 12-14	3-5
34(a)	2	8	Origin of the Elements	12-15	3-4
34(b)	1	8	Origin of the Elements	12-15	3-4
34(c)	2	8	Origin of the Elements	12-15	3-4
35(a)	3	8	Structure of the Atom	12-15	3-4
35(b)	2	8	Structure of the Atom	12-15	2-3
35(c)	2	8	Structure of the Atom	12-15	3-4
36	3	8	Quantum Mechanical Nature of the Atom	12-15	4-6
37(a)	4	8	Properties of the Nucleus	11/12-4, 12-15	2-5
37(b)	1	8	Properties of the Nucleus	11/12/5, 12-15	4-5
37(c)	1	8	Properties of the Nucleus	12-2, 12-15	3-4