

Please write clearly in block capitals.

Centre number

--	--	--	--	--

Candidate number

--	--	--	--

Surname

StemUp Model Solution

Forename(s)

Candidate signature

A-level PHYSICS

Paper 2

Wednesday 21 June 2017

Morning

Time allowed: 2 hours

Materials

For this paper you must have:

- a pencil and a ruler
- a scientific calculator
- a Data and Formulae booklet.

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill** in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do **all** rough work in this book. Cross through any work you do not want to be marked.
- Show **all** your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 85.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8–32	
TOTAL	



J U N 1 7 7 4 0 8 2 0 1

Section A

Answer **all** questions in this section.

0 1 . 1

A number of assumptions are made when explaining the behaviour of a gas using the molecular kinetic theory model.

State **one** assumption about the size of molecules.

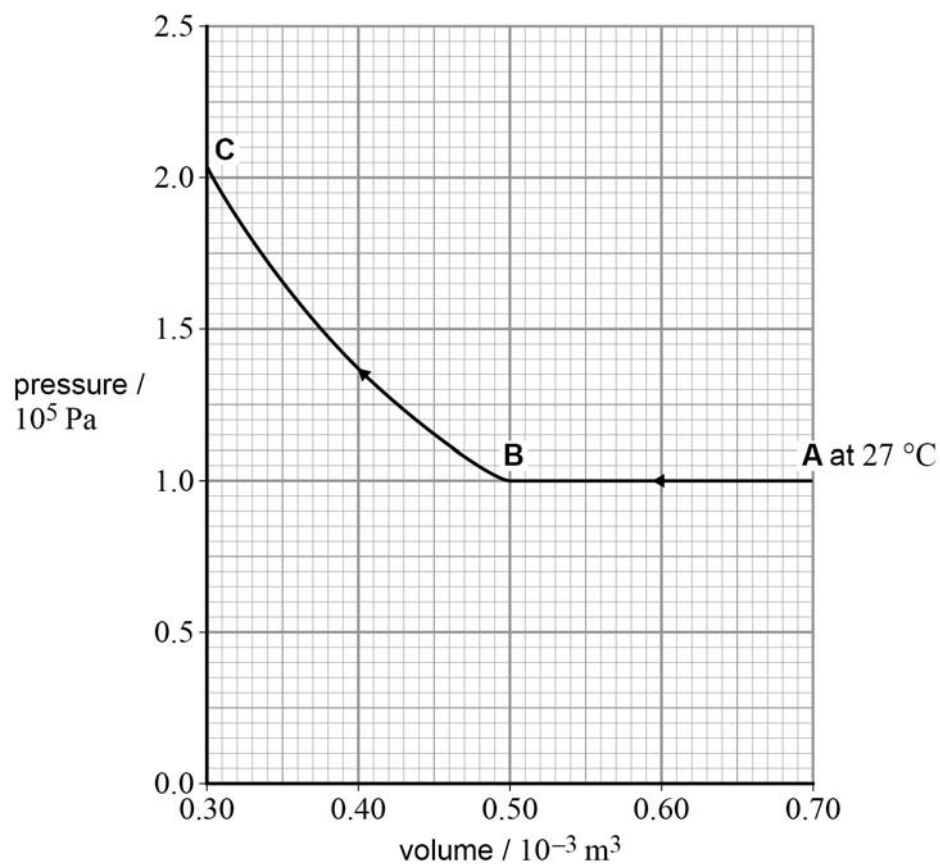
[1 mark]

The volume of the gas molecules is negligible compared to the volume occupied by the gas (the molecules are point masses).

Figure 1 shows how the pressure changes with volume for a fixed mass of an ideal gas.

At **A** the temperature of the gas is 27°C . The gas then undergoes two changes, one from **A** to **B** and then one from **B** to **C**.

Figure 1



0 1 . 2

Calculate the number of gas molecules trapped in the cylinder using information from the initial situation at **A**.

[2 marks]

$$N = pV / kT$$

$$N = (1.0 \times 10^5 \times 0.70 \times 10^{-3}) / (1.38 \times 10^{-23} \times 300)$$

$$T = 27 + 273 = 300 \text{ K}$$

number of molecules = 1.7×10^{22}

0 1 . 3

Calculate, in K, the change in temperature of the gas during the compression that occurs between **A** and **B**.

[2 marks]

At constant pressure, $V / T = \text{constant}$, so $T_B = T_A V_B / V_A$

$$T_B = 300 \times 0.50 / 0.70 = 214 \text{ K}$$

$$\text{Change} = 214 - 300 = -86 \text{ K (a decrease of 86 K)}$$

change in temperature = -86 K

0 1 . 4

Deduce whether the temperature of the gas changes during the compression from **B** to **C**.

[2 marks]

If T were constant (B to C), $p_B V_B = p_C V_C$ would hold.

$$p_B V_B = 1.0 \times 10^5 \times 0.50 \times 10^{-3} = 50 \text{ J}$$

$$p_C V_C = 2.05 \times 10^5 \times 0.30 \times 10^{-3} = 61 \text{ J}$$

$$\text{Or: } T_C = p_C V_C T_B / (p_B V_B) = 61.5 \times 214 / 50 = 263 \text{ K}$$

If T were constant, $p_C = 50 / 0.30 \times 10^{-3} = 1.7 \times 10^5 \text{ Pa only.}$

pV is not equal at B and C (p_C is higher than $1.7 \times 10^5 \text{ Pa}$), so the temperature at C is higher: the temperature changes (increases).

Question 1 continues on the next page

Turn over ►



0 1 . 5

Compare the work done on the gas during the change from **A** to **B** with that from **B** to **C** on **Figure 1**.

[3 marks]

$$A \text{ to } B: W = p\Delta V = 1.0 \times 10^5 \times (0.70 - 0.50) \times 10^{-3} = 20 \text{ J}$$

$$B \text{ to } C: W = \text{area under the curve from } 0.50 \text{ to } 0.30 \times 10^{-3} \text{ m}^3$$

$$1 \text{ small square} = 0.01 \times 10^{-3} \text{ m}^3 \times 0.1 \times 10^5 \text{ Pa} = 0.1 \text{ J}$$

$$\text{about } 283 \text{ small squares, so } W \approx 283 \times 0.1 = 28 \text{ J (28.3 J)}$$

The work done on the gas from A to B is equal to the area under the graph between A and B, which is 20 J.

The work done on the gas from B to C is the area under the curve from B to C, which is about 28 J.

So more work is done on the gas from B to C than from A to B: about 8 J (8.3 J) of additional work is done on the gas from B to C.



Turn over for the next question

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

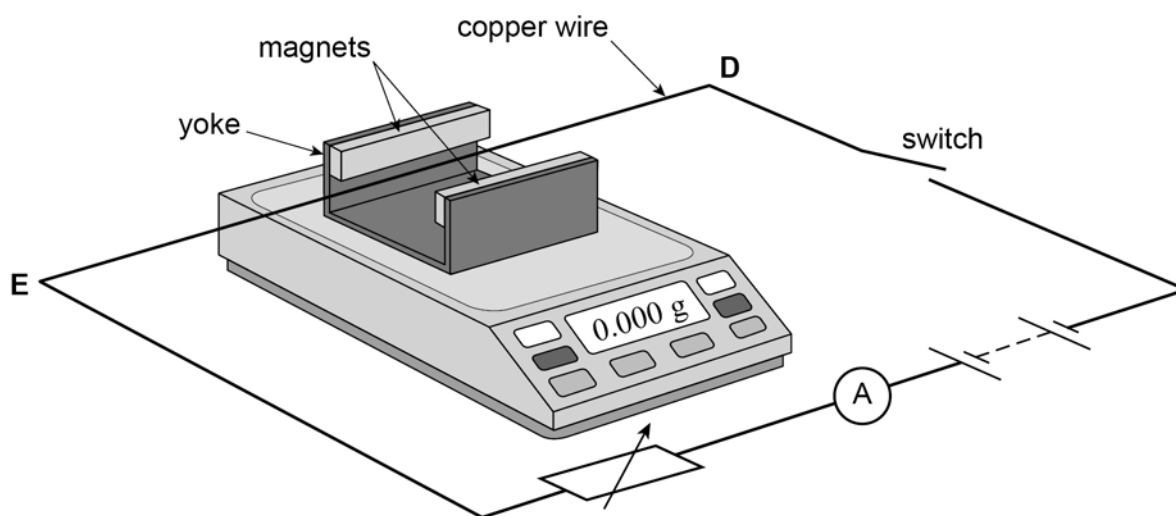
Turn over ►



0 2

Figure 2 shows two magnets, supported on a yoke, placed on an electronic balance.

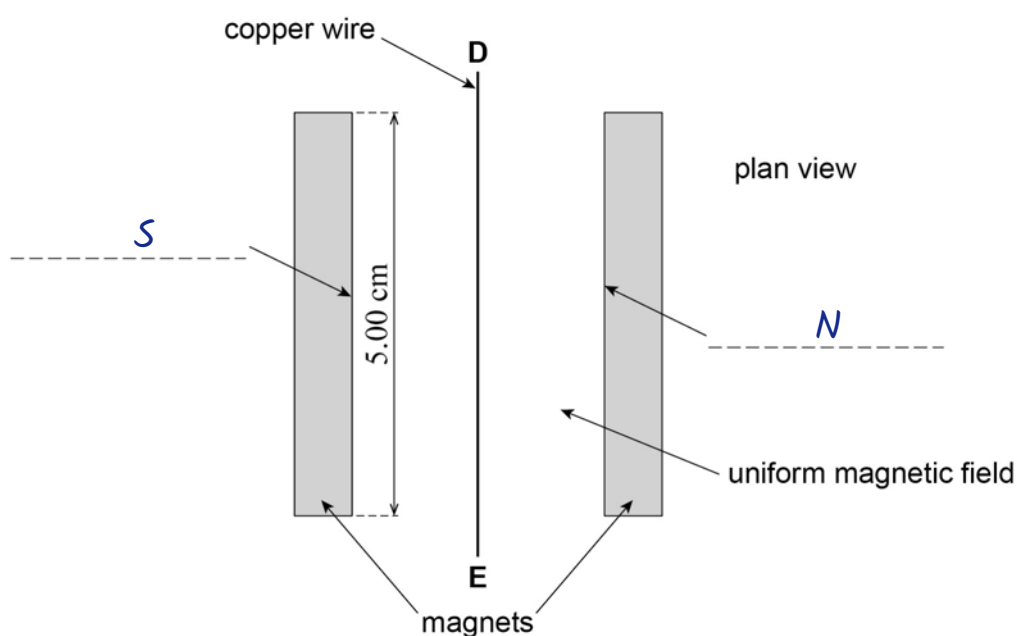
Figure 2



The magnets produce a uniform horizontal magnetic field in the region between them. A copper wire **DE** is connected in the circuit shown in **Figure 2** and is clamped horizontally at right angles to the magnetic field.

Figure 3 shows a simplified plan view of the copper wire and magnets.

Figure 3



When the apparatus is assembled with the switch open, the reading on the electronic balance is set to 0.000 g. This reading changes to a positive value when the switch is closed.



0 2 . 1

Which of the following correctly describes the direction of the force acting on the wire **DE** due to the magnetic field when the switch is closed?

Tick (✓) the correct box.

[1 mark]

towards the left magnet in **Figure 3**

☐

towards the right magnet in **Figure 3**

☐

vertically up

☒

vertically down

☐

0 2 . 2

Label the poles of the magnets by putting **N** or **S** on each of the two dashed lines in **Figure 3**.

[1 mark]

0 2 . 3

Define the tesla.

[1 mark]

*One tesla is the magnetic flux density that produces a force of 1 N
on a wire of length 1 m carrying a current of 1 A perpendicular to
the field.*

0 2 . 4

The magnets are 5.00 cm long. When the current in the wire is 3.43 A the reading on the electronic balance is 0.620 g.

Assume the field is uniform and is zero beyond the length of the magnets.

Calculate the magnetic flux density between the magnets.

[2 marks]

$$F = BIl \text{ and } F = mg, \text{ so } B = mg / Il$$

$$B = (0.620 \times 10^{-3} \times 9.81) / (3.43 \times 0.0500)$$

$$B = 6.08 \times 10^{-3} / 0.1715 = 0.0355 \text{ T}$$

magnetic flux density = 0.035 T

5

Turn over ►

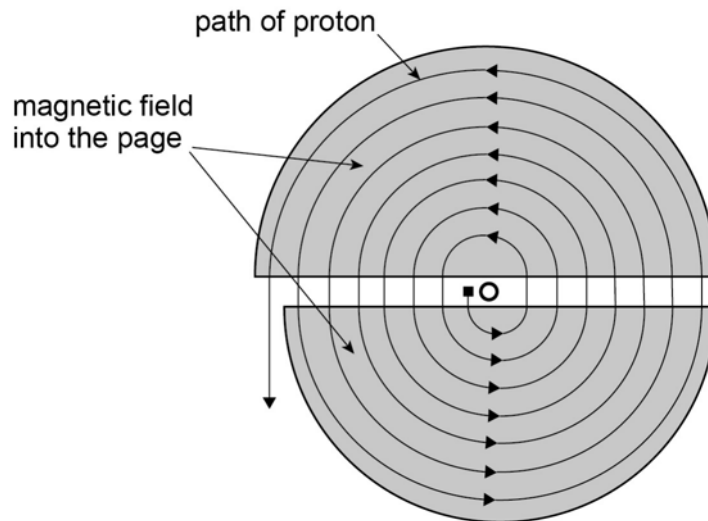


0 3

A cyclotron has two D-shaped regions where the magnetic flux density is constant. The D-shaped regions are separated by a small gap. An alternating electric field between the D-shaped regions accelerates charged particles. The magnetic field causes the charged particles to follow a circular path.

Figure 4 shows the path followed by a proton that starts from O.

Figure 4



0 3 . 1

Explain why it is **not** possible for the magnetic field to alter the speed of a proton while it is in one of the D-shaped regions.

[1 mark]

The magnetic force on the proton is always perpendicular to its direction of motion (velocity), so it can only change the direction of the proton, not its speed: no work is done on the proton by the field.



0 3 . 2

Derive an expression to show that the time taken by a proton to travel round one semi-circular path is independent of the radius of the path.

[3 marks]

The magnetic force provides the centripetal force:

$$BQv = mv^2 / r \quad \text{so} \quad r = mv / BQ \quad \text{and} \quad v = BQr / m$$

$$\text{Time for a semicircle: } t = \text{distance} / \text{speed} = \pi r / v$$

$$\text{Substitute } v = BQr / m: \quad t = \pi r \times m / (BQr)$$

$$t = \pi m / BQ$$

This does not contain r , so t is independent of the radius.

0 3 . 3

The maximum radius of the path followed by the proton is 0.55 m and the magnetic flux density of the uniform field is 0.44 T.

Ignore any relativistic effects.

Calculate the maximum speed of a proton when it leaves the cyclotron.

[2 marks]

$$v = BQr / m$$

$$v = 0.44 \times 1.6 \times 10^{-19} \times 0.55 / 1.67 \times 10^{-27}$$

$$v = 3.87 \times 10^{-20} / 1.67 \times 10^{-27}$$

maximum speed = 2.3×10^7 m s⁻¹

Turn over for the next question

6

Turn over ►



0	4
---	---

The core of a thermal nuclear reactor contains a number of components that are exposed to moving neutrons.

0	4	.	1
---	---	---	---

State what happens to a neutron that is incident on the moderator.

[1 mark]

*The neutron undergoes (elastic) collisions with the moderator nuclei,
so it loses kinetic energy and slows down.*

0	4	.	2
---	---	---	---

State what happens to a neutron that is incident on a control rod.

[1 mark]

The neutron is absorbed by the control rod.

0	4	.	3
---	---	---	---

A slow-moving neutron is in collision with a nucleus of an atom of the fuel which causes fission.

Describe what happens in the process.

[3 marks]

*The slow neutron is absorbed by a uranium-235 nucleus, forming an
unstable uranium-236 nucleus.*

*This causes the nucleus to split into two smaller daughter nuclei
(fission fragments).*

*Several (two or three) fast-moving neutrons are also released, along
with energy.*



0 4 . 4

A thermal nuclear reactor produces radioactive waste.

State the source of this waste and discuss some of the problems faced in dealing with the waste at various stages of its treatment.

Your answer should include:

- the main source of the most dangerous waste
- a brief outline of how waste is treated
- problems faced in dealing with the waste, with suggestions for overcoming these problems.

[6 marks]

Source: the most dangerous, highly radioactive (high level) waste is the spent fuel rods, which contain the fission fragments produced by the fission of uranium-235, plus plutonium.

Treatment: the spent fuel rods are removed remotely and placed in cooling ponds of water close to the reactor for several years. Then the unused uranium and plutonium are separated out to be recycled. The high level waste is vitrified (made into solid glass), then sealed in stainless steel containers (and concrete), and finally stored deep underground.

Problem 1: the spent fuel is very hot because of the radioactive decay. Solution: it is kept in cooling ponds, where the water removes the heat.

Problem 2: the waste is highly radioactive. Solution: the water in the ponds absorbs the radiation and shields workers, and the rods are handled remotely so that there is no human contact with the waste.

Problem 3: liquid high level waste could leak. Solution: it is vitrified into solid glass and sealed in stainless steel barrels.

Problem 4: the waste stays radioactive for thousands of years.

Solution: it is stored in containers that stay stable for a long time, deep underground in geologically stable areas.

Extra space is available on the next page if needed

Turn over ►



Problem 5: transporting waste is a danger to the public. Solution: it is moved in crash resistant, thick, strong casks, or it is processed on site.



0 5 . 1

Calculate the binding energy, in MeV, of a nucleus of $^{59}_{27}\text{Co}$.nuclear mass of $^{59}_{27}\text{Co} = 58.93320 \text{ u}$ **[3 marks]**

$$\Delta m = Zm_p + Nm_n - M_{\text{Co}} \quad (Z = 27, N = 59 - 27 = 32)$$

$$\Delta m = 27 \times 1.00728 + 32 \times 1.00867 - 58.93320$$

$$\Delta m = 27.19656 + 32.27744 - 58.93320 = 0.54080 \text{ u}$$

$$\text{Binding energy} = 0.5408 \times 931.5 \text{ MeV}$$

$$= 503.8 \text{ MeV}$$

binding energy = 504 (503.8) MeV**Question 5 continues on the next page****Turn over ►**

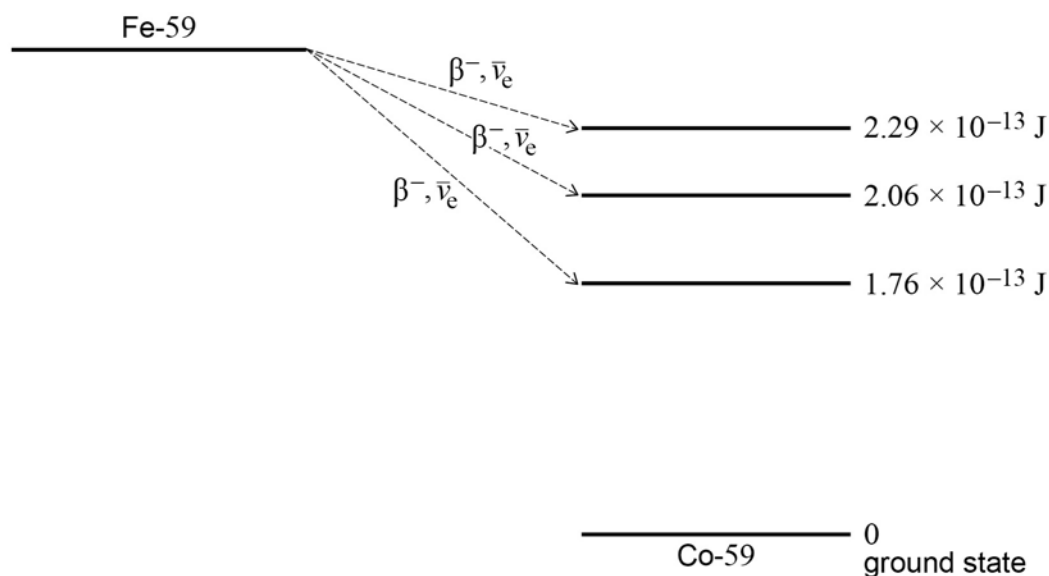
0 5 . 2

A nucleus of iron Fe-59 decays into a stable nucleus of cobalt Co-59. It decays by β^- emission followed by the emission of γ -radiation as the Co-59 nucleus de-excites into its ground state.

The total energy released when the Fe-59 nucleus decays is 2.52×10^{-13} J.

The Fe-59 nucleus can decay to one of three excited states of the cobalt-59 nucleus as shown in **Figure 5**. The energies of the excited states are shown relative to the ground state.

Figure 5



Calculate the maximum possible kinetic energy, in MeV, of the β^- particle emitted when the Fe-59 nucleus decays into an excited state that has energy above the ground state.

[2 marks]

Smallest energy gap to an excited state (2.29 is not needed):

$$KE_{\max} = 2.52 \times 10^{-13} - 1.76 \times 10^{-13} = 7.6 \times 10^{-14} \text{ J}$$

$$KE_{\max} = 7.6 \times 10^{-14} / 1.60 \times 10^{-13} = 0.475 \text{ MeV}$$

maximum kinetic energy = 0.48 MeV



0 5 . 3

Following the production of excited states of $^{59}_{27}\text{Co}$, γ -radiation of discrete wavelengths is emitted.

State the maximum number of discrete wavelengths that could be emitted.

[1 mark]

maximum number = 6

0 5 . 4

Calculate the longest wavelength of the emitted γ -radiation.

[3 marks]

Longest wavelength = smallest energy (smallest gap):

$$E = 2.29 \times 10^{-13} - 2.06 \times 10^{-13} = 2.3 \times 10^{-14} \text{ J}$$

$$\lambda = hc / E = 6.63 \times 10^{-34} \times 3.00 \times 10^8 / 2.3 \times 10^{-14}$$

$$\lambda = 8.65 \times 10^{-12} \text{ m}$$

longest wavelength = 8.6×10^{-12} m

9

Turn over for the next question

Turn over ►



0 6 . 1

State what is represented by gravitational field lines.

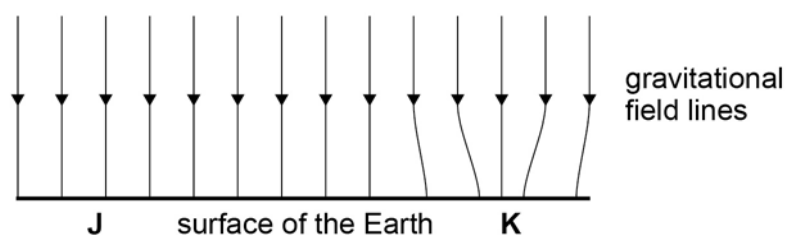
[1 mark]

*They show the direction of the force on a mass placed in the field
(the direction a stationary mass would move).*

0 6 . 2

Figure 6 shows the gravitational field above a small horizontal region on the surface of the Earth.

Figure 6



Suggest why the field lines converge over a small area at **K**.

[2 marks]

*The lines are closer together at K, so the gravitational field is
stronger there.*

*This is because the material under the surface at K has a higher
density than the surrounding material (more mass at K).*

0 6 . 3

A ball travelling at constant speed passes position **J** moving towards position **K** in **Figure 6**.

Assume friction is negligible.

Explain any change in the speed of the ball as it approaches **K**.

[2 marks]

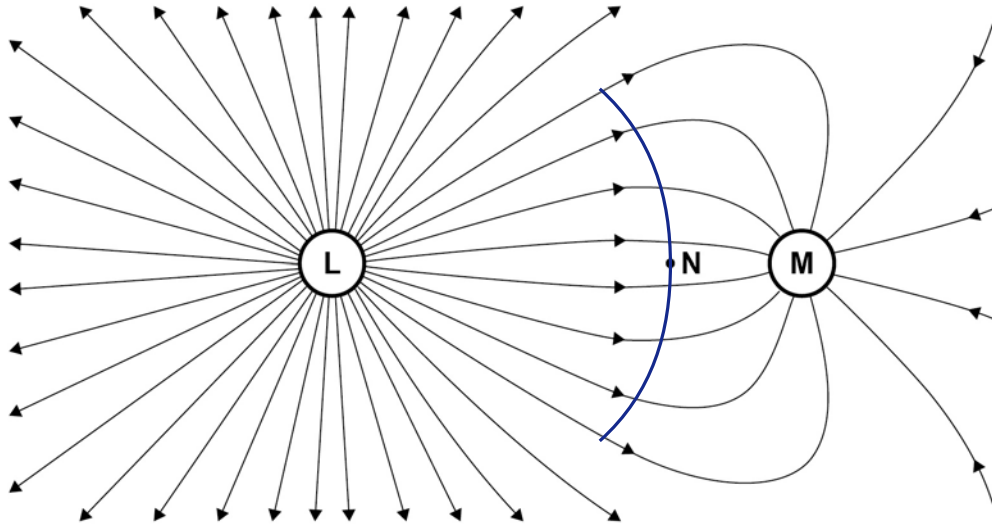
*The ball will speed up (accelerate) as it moves towards K, because
the angled field lines between J and K have a horizontal component
of force towards the right, towards K.*



0 6 . 4

Figure 7 shows lines of force for the electric field surrounding two charged objects **L** and **M**.

Figure 7



Explain why the lines of force shown in **Figure 7** cannot represent a gravitational field.

[1 mark]

A gravitational field only shows attraction, so all lines of force would point towards a mass, but here the arrows point away from L.

0 6 . 5

State which object **L** or **M** has a charge with the greater magnitude.

object L

State which object **L** or **M** has a positive charge.

object L

[1 mark]

0 6 . 6

Draw, on **Figure 7**, an equipotential line that passes through point **N**. Do **not** extend your line beyond the given field lines.

[2 marks]

9

Turn over ►



07.1

Derive an expression to show that for satellites in a circular orbit

$$T^2 \propto r^3$$

where T is the period of orbit and r is the radius of the orbit.**[2 marks]***Gravitational force provides the centripetal force:*

$$GMm / r^2 = m\omega^2 r \quad \text{and} \quad \omega = 2\pi / T$$

$$GMm / r^2 = m(2\pi / T)^2 r$$

$$\text{so } T^2 = (4\pi^2 / GM) r^3$$

$$4\pi^2 / GM \text{ is a constant, so } T^2 \propto r^3$$

07.2

Pluto is a dwarf planet. The mean orbital radius of Pluto around the Sun is 5.91×10^9 km compared to a mean orbital radius of 1.50×10^8 km for the Earth.

Calculate in years the orbital period of Pluto.

[2 marks]

$$T^2 \propto r^3 \quad \text{so} \quad (T_P / T_E)^2 = (r_P / r_E)^3$$

$$(T_P / 1.00)^2 = (5.91 \times 10^9 / 1.50 \times 10^8)^3$$

$$T_P^2 = 39.4^3 = 61\,163$$

$$T_P = \sqrt{61\,163} = 247 \text{ yr}$$

orbital period of Pluto = 247 yr

0 7 . 3

A small mass released from rest just above the surface of Pluto has an acceleration of 0.617 m s^{-2} .

Assume Pluto has no atmosphere that could provide any resistance to motion.

Calculate the mass of Pluto.

Give your answer to an appropriate number of significant figures.

$$\text{radius of Pluto} = 1.19 \times 10^6 \text{ m}$$

[3 marks]

$$g = GM / r^2 \quad \text{so} \quad M = gr^2 / G$$

$$M = 0.617 \times (1.19 \times 10^6)^2 / 6.67 \times 10^{-11}$$

$$M = 8.74 \times 10^{11} / 6.67 \times 10^{-11} = 1.31 \times 10^{22} \text{ kg (3 s.f.)}$$

$$\text{mass of Pluto} = \underline{1.31 \times 10^{22}} \text{ kg}$$

Question 7 continues on the next page

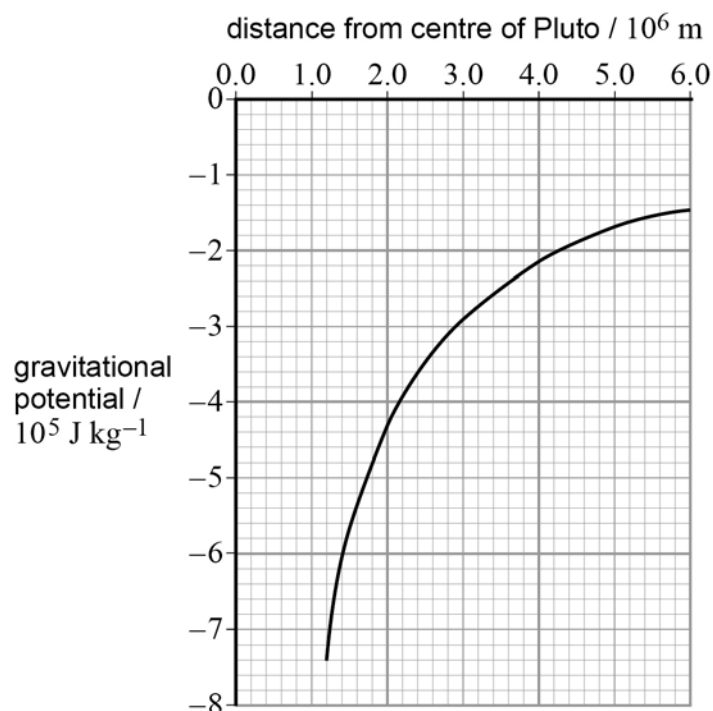
Turn over ►



0 7 . 4

Figure 8 shows the variation in gravitational potential with distance from the centre of Pluto for points at and above its surface.

Figure 8



A meteorite hits Pluto and ejects a lump of ice from the surface that travels vertically at an initial speed of 1400 m s^{-1} .

Determine whether this lump of ice can escape from Pluto.

[3 marks]

$$\text{Initial KE per kg} = \frac{1}{2}v^2 = \frac{1}{2} \times 1400^2 = 9.8 \times 10^5 \text{ J kg}^{-1}$$

$$\text{At the surface } (r = 1.19 \times 10^6 \text{ m}): V = -7.4 \times 10^5 \text{ J kg}^{-1}$$

$$\text{Energy needed per kg to escape (to } V = 0) = 7.4 \times 10^5 \text{ J kg}^{-1}$$

$$\text{Escape speed: } \frac{1}{2}v^2 = 7.4 \times 10^5, \text{ so } v = 1200 \text{ m s}^{-1}$$

$$9.8 \times 10^5 > 7.4 \times 10^5 \quad (1400 > 1200 \text{ m s}^{-1})$$

So the ice has more than enough kinetic energy (initial speed) to escape: the lump of ice can escape from Pluto.

10

END OF SECTION A



Section B

Each of Questions 8 to 32 is followed by four responses, A, B, C and D.

For each question select the best response.

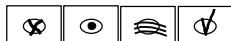
Only **one** answer per question is **allowed**.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD



WRONG METHODS



If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

You may do your working in the blank space around each question but this will not be marked.

0 8

A continuous stream of water falls through a vertical distance of 100 m.
Assume no thermal energy is transferred to the surroundings.
The specific heat capacity of water is $4200 \text{ J kg}^{-1} \text{ K}^{-1}$.

What is the temperature difference of the water between the top and bottom of the waterfall?

[1 mark]

A 0.023 K

☐

B 0.23 K

☒

C 2.3 K

☐

D 4.3 K

☐

Turn over ►



0	9
---	---

A student measures the power of a microwave oven. He places 200 g of water at 23 °C into the microwave and heats it on full power for 1 minute. When he removes it, the temperature of the water is 79 °C.

The specific heat capacity of water is $4200 \text{ J kg}^{-1} \text{ K}^{-1}$.

What is the average rate at which thermal energy is gained by the water?

[1 mark]

A 780 W

☒

B 840 W

☐

C 1.1 kW

☐

D 4.6 kW

☐

1	0
---	---

The composition of a carbon dioxide (CO_2) molecule is one atom of $^{12}_6\text{C}$ and two atoms of $^{16}_8\text{O}$.

What is the number of molecules of CO_2 in 2.2 kg of the gas?

[1 mark]

A 1.0×10^{22}

☐

B 3.0×10^{22}

☐

C 3.0×10^{25}

☒

D 4.7×10^{25}

☐

1	1
---	---

What is the total internal energy of 2.4 mol of an ideal gas which has a temperature of 15 °C?

[1 mark]

A $6.0 \times 10^{-21} \text{ J}$

☐

B $1.4 \times 10^{-20} \text{ J}$

☐

C $4.5 \times 10^2 \text{ J}$

☐

D $8.6 \times 10^3 \text{ J}$

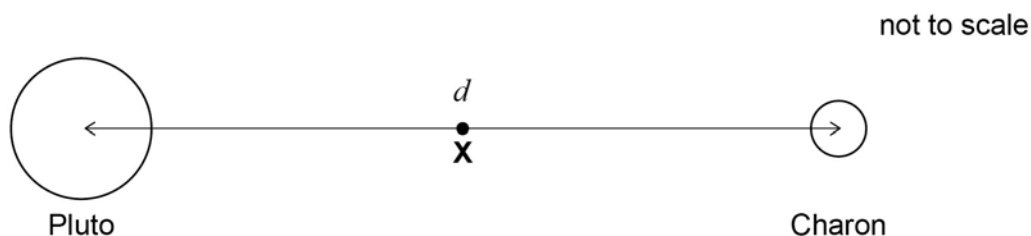
☒

1 2

Charon is a moon of Pluto that has a mass equal to $\frac{1}{9}$ that of Pluto.

The distance between the centre of Pluto and the centre of Charon is d .

X is the point at which the resultant gravitational field due to Pluto and Charon is zero.



What is the distance of **X** from the centre of Pluto?

[1 mark]

A $\frac{2}{9}d$

☐

B $\frac{2}{3}d$

☐

C $\frac{3}{4}d$

☒

D $\frac{8}{9}d$

☐

1 3

The distance between the Sun and Mars varies from 2.1×10^{11} m to 2.5×10^{11} m.

When Mars is closest to the Sun, the force of gravitational attraction between them is F .

What is the force of gravitational attraction between them when they are furthest apart?

[1 mark]

A $0.71F$

☒

B $0.84F$

☐

C $1.2F$

☐

D $1.4F$

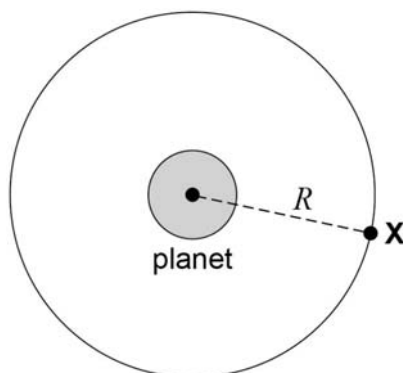
☐

Turn over ►



1	4
---	---

A satellite **X** of mass m is in a concentric circular orbit of radius R about a planet of mass M .



What is the kinetic energy of **X**?

[1 mark]

A $\frac{GMm}{2R}$



B $\frac{GMm}{R}$



C $\frac{2GMm}{R}$

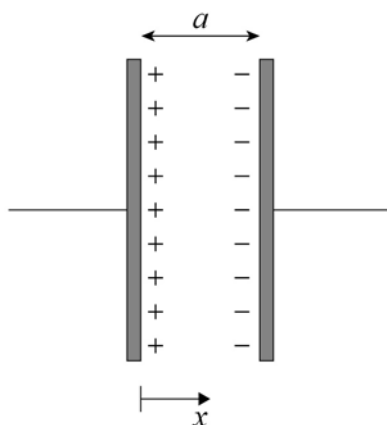


D $\frac{4GMm}{R}$



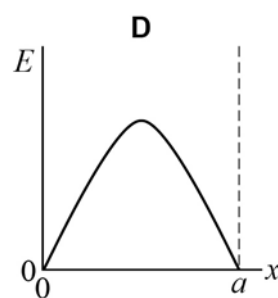
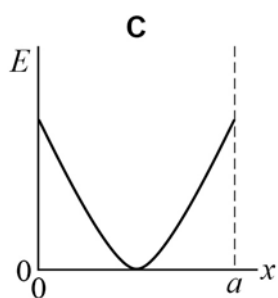
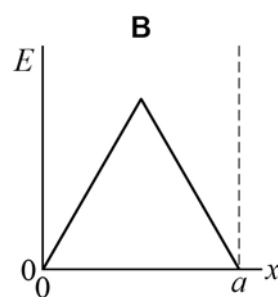
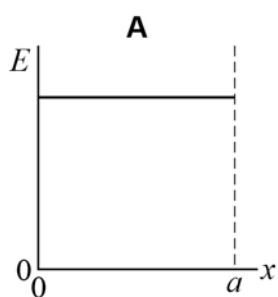
1 5

Two parallel metal plates of separation a carry equal and opposite charges.



Which graph best represents how the electric field strength E varies with the distance x in the space between the two plates?

[1 mark]



- A ☒
- B ☐
- C ☐
- D ☐

Turn over ►



1 6

A particle of mass m and charge q is accelerated through a potential difference V over a distance d .

What is the average acceleration of the particle?

[1 mark]

A $\frac{qV}{md}$

☒

B $\frac{mV}{qd}$

☐

C $\frac{V}{mqd}$

☐

D $\frac{dV}{mq}$

☐**1 7**

An electron moves through a distance of 0.10 m parallel to the field lines of a uniform electric field of strength 2.0 kN C^{-1} .

What is the work done on the electron?

[1 mark]

A zero

☐

B $1.6 \times 10^{-17} \text{ J}$

☐

C $3.2 \times 10^{-17} \text{ J}$

☒

D $1.6 \times 10^{-21} \text{ J}$

☐

1 8

A parallel-plate capacitor is fully charged and then disconnected from the power supply. A dielectric is then inserted between the plates.

Which row correctly identifies the charge on the plates and the electric field strength between the plates?

[1 mark]

	Charge	Electric field strength	
A	Stays the same	Increases	☐
B	Increases	Decreases	☐
C	Increases	Increases	☐
D	Stays the same	Decreases	☒

1 9

A capacitor of capacitance C has a charge of Q stored on the plates. The potential difference between the plates is doubled.

What is the change in the energy stored by the capacitor?

[1 mark]

- A $\frac{Q^2}{2C}$ ☐
- B $\frac{Q^2}{C}$ ☐
- C $\frac{3Q^2}{2C}$ ☒
- D $\frac{2Q^2}{C}$ ☐

Turn over for the next question

Turn over ►



2 0

A capacitor consists of two parallel square plates of side l separated by distance d . The capacitance of the arrangement is C .

What is the capacitance of a capacitor with square plates of side $2l$ separated by a distance $\frac{d}{2}$?

[1 mark]**A** C ☐**B** $2C$ ☐**C** $4C$ ☐**D** $8C$ ☒**2 1**

A capacitor of capacitance $120\ \mu\text{F}$ is charged and then discharged through a $20\ \text{k}\Omega$ resistor.

What fraction of the original charge remains on the capacitor $4.8\ \text{s}$ after the discharge begins?

[1 mark]**A** 0.14☒**B** 0.37☐**C** 0.63☐**D** 0.86☐

2 2

A coil with 20 circular turns each of diameter 60 mm is placed in a uniform magnetic field of flux density 90 mT.

Initially the plane of the coil is perpendicular to the magnetic field lines as shown in **Figure X**.

Figure X

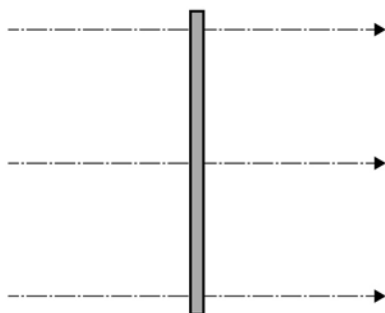
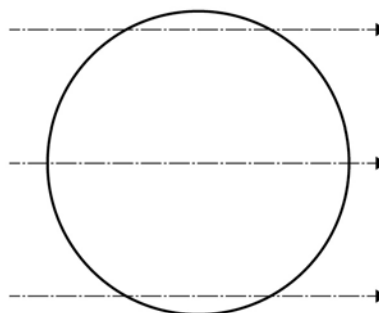


Figure Y



The coil is rotated about a vertical axis by 90° in a time of 0.20 s so that its plane becomes parallel to the field lines as shown in **Figure Y**.

Assume that the rate of change of flux linkage remains constant.

What is the emf induced in the coil?

[1 mark]

A zero

☐

B 1.3 mV

☐

C 25 mV

☒

D 100 mV

☐

2 3

The mean power dissipated in a resistor is $47.5 \mu\text{W}$ when the root mean square (rms) voltage across the resistor is 150 mV.

What is the peak current in the resistor?

[1 mark]

A $2.3 \times 10^{-4} \text{ A}$

☐

B $4.5 \times 10^{-4} \text{ A}$

☒

C $2.3 \times 10^3 \text{ A}$

☐

D $4.5 \times 10^3 \text{ A}$

☐

Turn over ►



2 4

The National Grid is used to transfer electrical energy from power stations to consumers.

What conditions for the transmission voltage and the transmission current give the most efficient transfer of energy through the National Grid?

[1 mark]

	Transmission voltage	Transmission current	
A	High	High	☐
B	High	Low	☒
C	Low	High	☐
D	Low	Low	☐

2 5

A mains transformer has a primary coil of 2500 turns and a secondary coil of 130 turns. The primary coil is connected to a mains supply where V_{rms} is 230 V. The secondary coil is connected to a lamp of resistance 6.0Ω . The transformer is 100% efficient.

What is the peak power dissipated in the lamp?

[1 mark]

- A** 12 W ☐
- B** 24 W ☐
- C** 48 W ☒
- D** 96 W ☐

2 6

The Rutherford scattering experiment led to

[1 mark]

- A** the discovery of the electron. ☐
- B** the quark model of hadrons. ☐
- C** the discovery of the nucleus. ☒
- D** evidence for wave-particle duality. ☐



2 7

A Geiger counter is placed near a radioactive source and different materials are placed between the source and the Geiger counter.

The results of the tests are shown in the table.

Material	Count rate of Geiger counter / s^{-1}
None	1000
Paper	1000
Aluminium foil	250
Thick steel	50

What is the radiation emitted by the source?

[1 mark]

A α only

☐

B α and γ

☐

C α and β

☐

D β and γ

☒
2 8

Nobelium-259 has a half-life of 3500 s.

What is the decay constant of nobelium-259?

[1 mark]

A $8.7 \times 10^{-5} s^{-1}$

☐

B $2.0 \times 10^{-4} s^{-1}$

☒

C $1.7 \times 10^{-2} s^{-1}$

☐

D $1.2 \times 10^{-2} s^{-1}$

☐

Turn over ►



2 9

A pure sample of nuclide **X** containing N nuclei has an activity A .
The half-life of **X** is 6000 years.

A pure sample of nuclide **Y** containing $3N$ nuclei has an activity $6A$.

What is the half-life of nuclide **Y**?

[1 mark]

A 1000 years

☐

B 3000 years

☒

C 12 000 years

☐

D 18 000 years

☐**3 0**

Cobalt-60 has a half-life of 5.27 years.

What is the total activity of 1.0 g of cobalt-60?

[1 mark]

A 4.2×10^{13} Bq

☒

B 2.2×10^{14} Bq

☐

C 2.5×10^{15} Bq

☐

D 1.3×10^{21} Bq

☐

3 1

The radius of a nucleus of the iron nuclide $^{56}_{27}\text{Fe}$ is $4.35 \times 10^{-15} \text{ m}$.

What is the radius of a nucleus of the uranium nuclide $^{238}_{92}\text{U}$?

[1 mark]

A $2.69 \times 10^{-15} \text{ m}$

☐

B $2.89 \times 10^{-15} \text{ m}$

☐

C $6.55 \times 10^{-15} \text{ m}$

☐

D $7.05 \times 10^{-15} \text{ m}$

☒

3 2

Uranium-236 undergoes nuclear fission to produce barium-144, krypton-89 and three free neutrons.

What is the energy released in this process?

Nuclide	Binding energy per nucleon / MeV
$^{236}_{92}\text{U}$	7.5
$^{144}_{56}\text{Ba}$	8.3
$^{89}_{36}\text{Kr}$	8.6

[1 mark]

A 84 MeV

☐

B 106 MeV

☐

C 191 MeV

☒

D 3730 MeV

☐

END OF QUESTIONS



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Copyright Information

For confidentiality purposes, from the November 2015 examination series, acknowledgements of third party copyright material will be published in a separate booklet rather than including them on the examination paper or support materials. This booklet is published after each examination series and is available for free download from www.aqa.org.uk after the live examination series.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team, AQA, Stag Hill House, Guildford, GU2 7XJ.

Copyright © 2017 AQA and its licensors. All rights reserved.

