Cambridge Assessment International Education

Example Responses – Paper 4

Cambridge International AS & A Level

Physics 9702

For examination from 2022

Cambridge Pathway

Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge International AS & A Level Physics 9702.

This booklet contains responses to all questions from June 2022 Paper 42, which have been written by a Cambridge examiner. Responses are accompanied by a brief commentary highlighting common errors and misconceptions where they are relevant.

The question papers and mark schemes are available to download from the School Support Hub.

9702 June 2022 Question Paper 42

9702 June 2022 Mark Scheme 42

Past exam resources and other teaching and learning resources are available from the School Support Hub.

Question 1

1 (a) (i) Define gravitational potential at a point.

Gravitational potential is defined as the work done per unit mass in moving that mass from infinity to the point.

[2]

(ii) Starting from the equation for the gravitational potential due to a point mass, show that the gravitational potential energy E_P of a point mass m at a distance r from another point mass M is given by

$$E_P = -\frac{GMm}{r}$$

where G is the gravitational constant.

potential $= -GM/r$

$\therefore E_P =$ potential $\times m = (-GM/r) \times m = -GMm/r$.

[1]

(b) Fig. 1.1 shows the path of a comet of mass 2.20×10^{14} kg as it passes around a star of mass 1.99×10^{30} kg.

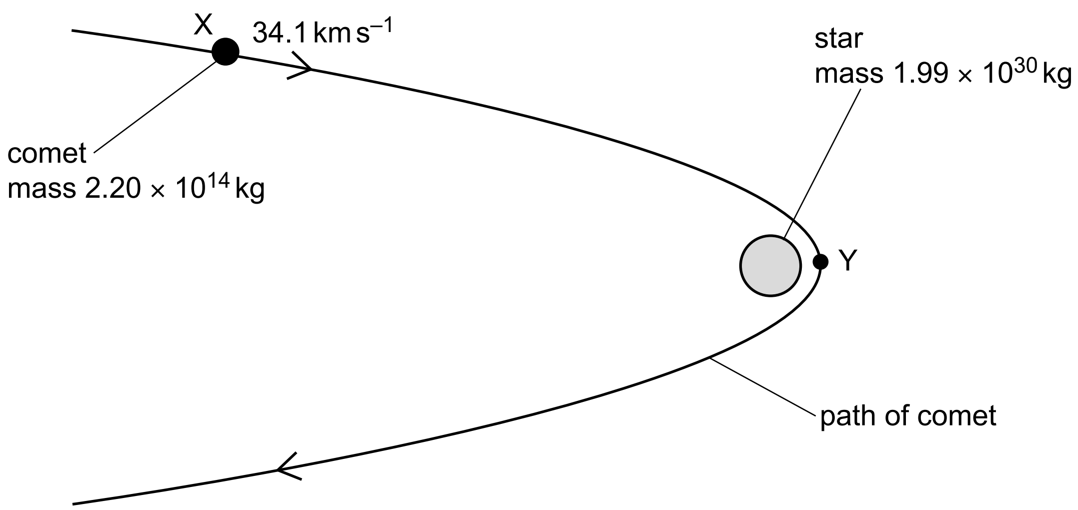

Fig. 1.1 (not to scale)

At point X, the comet is 8.44×10^{11} m from the centre of the star and is moving at a speed of $34.1\ \text{km s}^{-1}$.

At point Y, the comet passes its point of closest approach to the star. At this point, the comet is a distance of 6.38×10^{10} m from the centre of the star.

Both the comet and the star can be considered as point masses at their centres.

(i) Calculate the magnitude of the change in the gravitational potential energy ΔE_P of the comet as it moves from position X to position Y.

$\Delta E_p = 6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times 2.20 \times 10^{14} \times [1/(6.38 \times 10^{10}) - 1/(8.44 \times 10^{11})]$

ΔE_P = ... 4.23×10^{23} .... J [2]

(ii) State, with a reason, whether the change in gravitational potential energy in **(b)(i)** is an increase or a decrease.

The gravitational force acting on the comet moves it closer to the star, increasing the kinetic energy of the comet and therefore decreasing its potential energy. The change in (b)(i) is therefore a decrease. [1]

Examiner comment

A common misunderstanding here was to think that the change must be a decrease because potential energy is negative. These candidates seemed to be unaware that the change would be a decrease, regardless of where the arbitrary zero for potential energy was taken and it is only this arbitrary zero (at infinity) that makes the potential energy negative. If potential energy was measured from the surface of the star, it would be a positive quantity but the change would still be a decrease.

(iii) Use your answer in **(b)(i)** to determine the speed, in $km\,s^{-1}$, of the comet at point Y.

$\Delta E_P = \frac{1}{2}m(v_2^2 - v_1^2)$

$\therefore 4.23 \times 10^{23} = \frac{1}{2} \times 2.20 \times 10^{14} \times (v2 - 34100^2)$

$\therefore v = 70800\ m\,s^{-1} = 70.8\ km\,s^{-1}$

speed = ...70.8 km.................... $km\,s^{-1}$ [3]

Examiner comment

Common errors here were to neglect the power of ten conversions from $km\,s^{-1}$ to $m\,s^{-1}$ (and back again), and not to include the initial kinetic energy of the comet. Candidates were expected to realise that the precision of their answers should be consistent with the precision of the data supplied in the question. In this question, the data provided is given to three significant figures, and so that is also the precision expected in the answer.

(c) A second comet passes point X with the same speed as the comet in **(b)** and travelling in the same direction. This comet is gradually losing mass. The mass of this comet when it passes point X is the same as the mass of the comet in **(b)**.

Suggest, with a reason, how the path of the second comet compares with the path shown in Fig. 1.1.

The mass of the comet cancels out in the equations relating potential and kinetic energies. Therefore, the change in mass does not affect the path of the comet. [1]

[Total: 10]

Examiner comment

This response could alternatively be reasoned in terms of force and acceleration, rather than energy. For example, an alternative response could be 'The force acting on the comet changes by the same factor as the change in the mass. So the acceleration of the comet at any point, given by the ratio force / mass, is unchanged and so the path of the comet does not change'.

Question 2

2 **(a)** State Coulomb's law.

The force between two point charges is proportional to the product of the charges and inversely proportional to the square of their separation.

[2]

(b) Positronium is a system in which an electron and a positron orbit, with the same period, around their common centre of mass, as shown in Fig. 2.1.

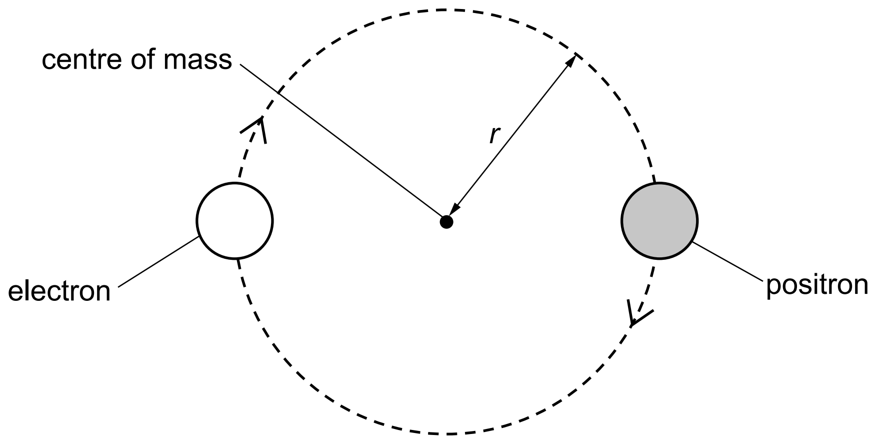

Fig. 2.1 (not to scale)

The radius r of the orbit of both particles is 1.59×10^{-10} m.

(i) Explain how the electric force between the electron and the positron causes the path of the moving particles to be circular.

The force on each particle is always perpendicular to the velocity of the particle and therefore causes the direction of movement of the particle to change but does not change its speed.

[2]

Examiner comment

Many candidates did not address this question, and instead focussed on why there was a force between the particles.

(ii) Show that the magnitude of the electric force between the electron and the positron is 2.28×10^{-9} N.

$F = e^2 / 4\pi\varepsilon_0 x^2$

$= (1.60 \times 10^{-19})^2 / [4\pi \times 8.85 \times 10^{-12} \times (2 \times 1.59 \times 10^{-10})^2]$

$= 2.28 \times 10^{-9}$ N

[2]

Examiner comment

- In 'show that' questions, the marks are not awarded for arriving at an answer because the answer involved is given in the question paper. The marks are awarded for showing the full substitution of values into correct equations that lead to the answer to be demonstrated. As a general rule, the numbers used in substitution should be directly quoted from the data provided, without any intermediate mental arithmetic that is not written down.
- Candidates were required, in their substitutions into the Coulomb equation, to demonstrate that the charge on each particle is the elementary charge, that the distance between the particles is double the radius of their orbits, and to include the full numerical substitution of the permittivity of free space. Where candidates were not awarded marks, this was due to their omission of the value of ε_0 and the late insertion of an unexplained factor of 4 to compensate for the use of the incorrect distance for *x*.

(iii) Use the information in **(b)(ii)** to determine the period of the circular orbit of the two particles.

$F = mr\omega^2$

$\omega = 2\pi / T$, and so $F = 4\pi^2 mr / T^2$

$T = \sqrt{[4\pi^2 \times 9.11 \times 10^{-31} \times 1.59 \times 10^{-10} / (2.28 \times 10^{-9})]}$

period = 1.58×10^{-15} s [3]

(c) Positronium is highly unstable, and after a very short period of time it becomes gamma radiation.

(i) Describe how gamma radiation is formed from the two particles in positronium.

The positron is the antiparticle of the electron. Therefore, when the electron and positron collide, pair annihilation occurs in which their combined mass is completely converted into the energy of gamma photons. [3]

Examiner comment

Candidates generally answered this question well, but there were a few common misconceptions. One was that some candidates thought that both positrons and electrons were antiparticles. Another was that candidates did not convey that what makes pair annihilation unique is that all of the mass of the particles is converted into energy. Candidates needed to appreciate that the conversion of some mass into energy is something that accompanies every nuclear process, including fission, fusion and radioactive decay. A vague reference to 'mass being converted into energy' was not considered enough for marks to be awarded in a question about the process of annihilation.

(ii) State **one** medical application of the process described in **(c)(i)**.

PET scanning [1]

[Total: 13]

Question 3

3 **(a)** Define specific latent heat of vaporisation.

Specific latent heat of vaporisation is defined as the thermal energy per unit mass to change the state of a substance from liquid to gas without change of temperature. [2]

(b) The specific latent heat of vaporisation of water at atmospheric pressure of 1.0×10^5 Pa is $2.3 \times 10^6\,\mathrm{J\,kg^{-1}}$. A mass of 0.37 kg of liquid water at 100 °C is provided with the thermal energy needed to vaporise all of the water at atmospheric pressure.

(i) Calculate the thermal energy q supplied to the water.

$q = mL = 0.37 \times 2.3 \times 10^6 = 8.5 \times 10^5$ J

q = 8.5×10^5 J [1]

(ii) The mass of 1.0 mol of water is 18 g. Assume that water vapour can be considered to behave as an ideal gas.

Show that the volume of water vapour produced is $0.64\,\mathrm{m^3}$.

Amount of gas n is given by $n = (370 / 18)$ mol

$pV = nRT$

$\therefore V = [(370 / 18) \times 8.31 \times (100 + 273)] / (1.0 \times 10^5) = 0.64\ \mathrm{m^3}$.

[3]

Examiner comment

This was an example of a ‘show that’ question, where the correct substitution of the data in the question was being examined. The common mistake made by candidates in this question was to not show how the number of moles of gas was calculated from the data in the question.

(iii) Assume that the initial volume of the liquid water is negligible compared with the volume of water vapour produced.

Determine the magnitude of the work done by the water in expanding against the atmosphere when it vaporises.

work done = $p\Delta V = 1.0 \times 10^5 \times 0.64 = 6.4 \times 10^4$ J

work done = 6.4×10^4 J [2]

(iv) Use your answers in **(b)(i)** and **(b)(iii)** to determine the increase in internal energy of the water when it vaporises at 100 °C. Explain your reasoning.

The water does work against atmosphere as it expands, so the work done on the water is negative.

$\therefore$ increase in internal energy = $(8.5 - 0.64) \times 10^5 = 7.9 \times 10^5$ J.

increase in internal energy = 7.9×10^5 J [2]

Examiner comment

When a question asks candidates to explain their reasoning, that means that working and often some sort of explanation is required. In this case, the requirement was for candidates to explain why the work done in **(iii)** was subtracted from, rather than added to, the thermal energy supply in **(i)** when applying the first law of thermodynamics.

(c) Use the first law of thermodynamics to suggest, with a reason, how the specific latent heat of vaporisation of water at a pressure greater than atmospheric pressure compares with its value at atmospheric pressure.

If the process is happening at the same temperature, then the volume of the gas produced is inversely proportional to the pressure. Therefore the product $p\Delta V$ will be unchanged and so the work done by the water during vaporisation will also be unchanged. The change in internal energy of the water must be the same irrespective of pressure, and so the thermal energy required to cause vaporisation (and hence the specific latent heat) will remain unchanged.

[2]

[Total: 12]

Examiner comment

- This was a 'suggest' question, which meant that there was no single required 'correct' answer. 'Suggest' questions invite candidates to apply their knowledge of the syllabus to contexts that may be unfamiliar and which push the limits of the syllabus.
- Candidates needed to give a coherent argument involving the effect of greater pressure on the three terms related by the first law of thermodynamics. Marks were available to candidates for reasoning the effect of greater pressure on the work done by the water in any of three ways, provided the effect was coherently argued. The consequential effect on the thermal energy transfer (through making the point that the change in internal energy remains constant) then needed to be consistent with the argument presented for the effect on the work done.
  A fourth possible argument which candidates could be awarded marks for was one that argued in terms of a higher temperature being needed for the boiling process, and a greater change in internal energy therefore being required.
- A question that asks for an application of the first law of thermodynamics is going to require discussion of the work done, thermal energy transferred and change in internal energy of the system being considered. Whichever route the candidate chose for the argument in this case, it was not possible to be awarded full marks without consideration of all three of these quantities.

Question 4

4 **(a)** State what is meant by resonance.

When an oscillating system is subjected to an external driving force with a frequency equal to the natural frequency of the system, the system will oscillate with maximum amplitude. [2]

(b) Fig. 4.1 shows a heavy pendulum and a light pendulum, both suspended from the same piece of string. This string is secured at each end to fixed points.

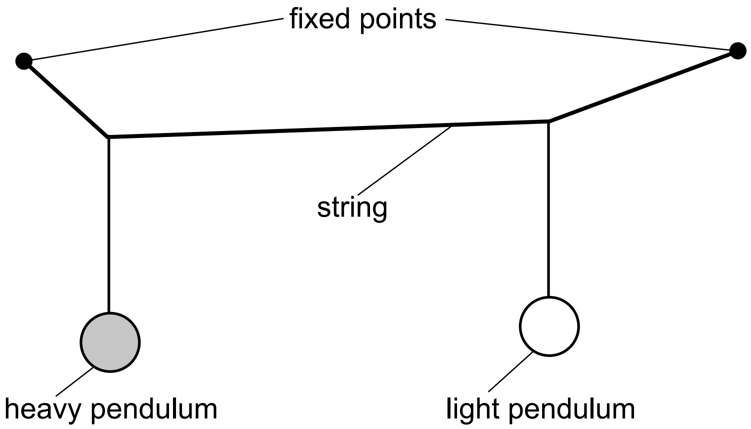

Fig. 4.1

Both pendulums have the same natural frequency.
The heavy pendulum is set oscillating perpendicular to the plane of the diagram. As it oscillates, it causes the light pendulum to oscillate.

Fig. 4.2 shows the variation with time *t* of the displacements of the two pendulums for three oscillations.

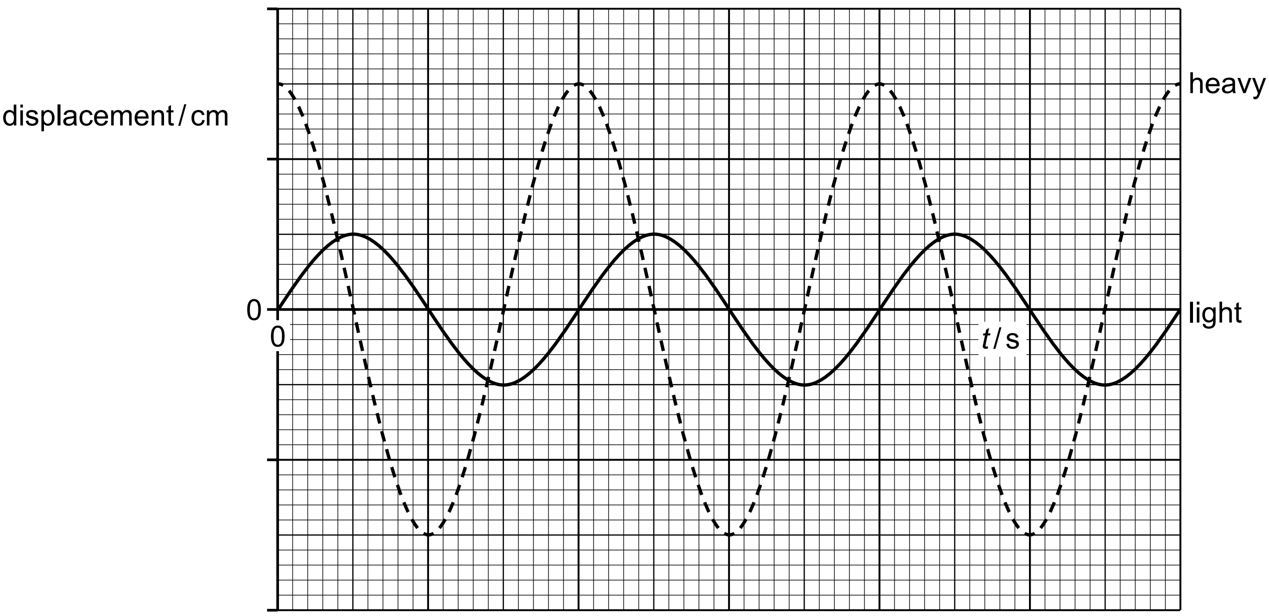

Fig. 4.2

The variation with *t* of the displacement *x* of the light pendulum is given by

$$x = 0.25 \sin 5.0\pi t$$

where *x* is in centimetres and *t* is in seconds.

(i) Calculate the period *T* of the oscillations.

$T = 2\pi / \omega = 2\pi / 5.0\pi = 0.40$ s

$T =$ ....0.40........ s [2]

(ii) On Fig. 4.2, label both of the axes with the correct scales. Use the space below for any additional working that you need.

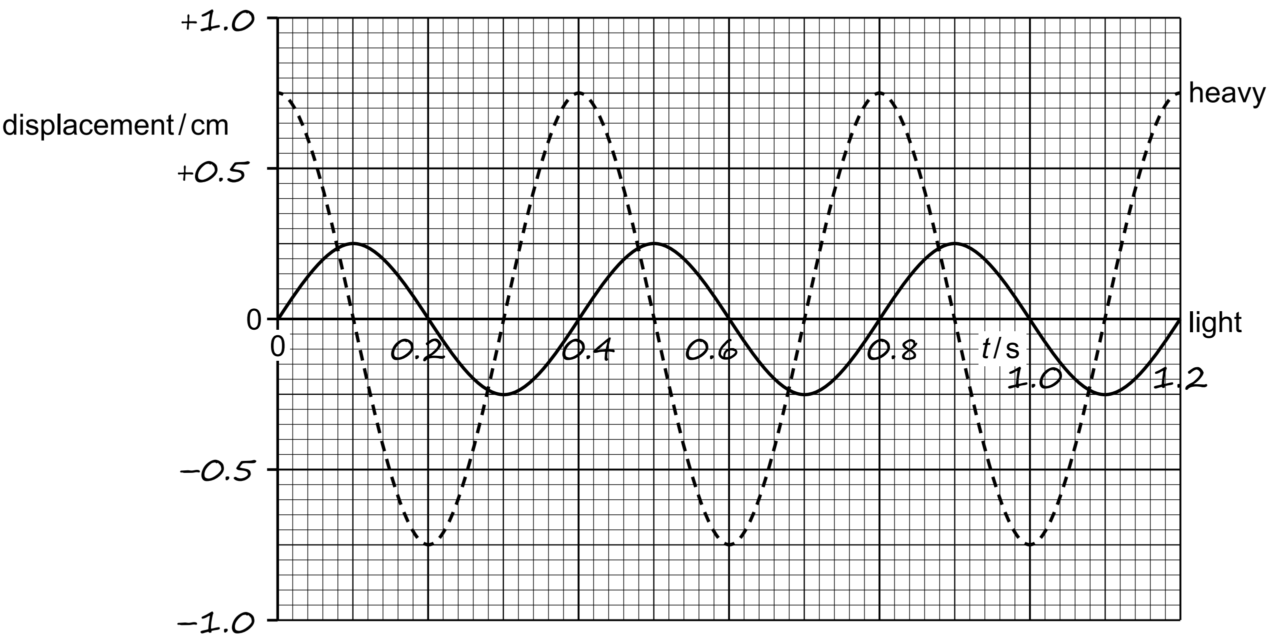

Fig. 4.2

(iii) Determine the magnitude of the phase difference ϕ between the oscillations of the light and heavy pendulums. Give a unit with your answer.

$\emptyset = 2\pi\Delta t / T = 2\pi \times 0.10 / 0.40 = 1.6$ rad

$\phi =$ ....1.6........ unit ....rad.... [2]

[Total: 8]

Question 5

5 **(a)** Define the capacitance of a parallel plate capacitor.

Capacitance of a parallel plate capacitor is defined as the charge on one plate per unit potential difference between the plates.

[2]

(b) Two capacitors, of capacitances C_1 and C_2, are connected in parallel to a power supply of electromotive force (e.m.f.) E, as shown in Fig. 5.1.

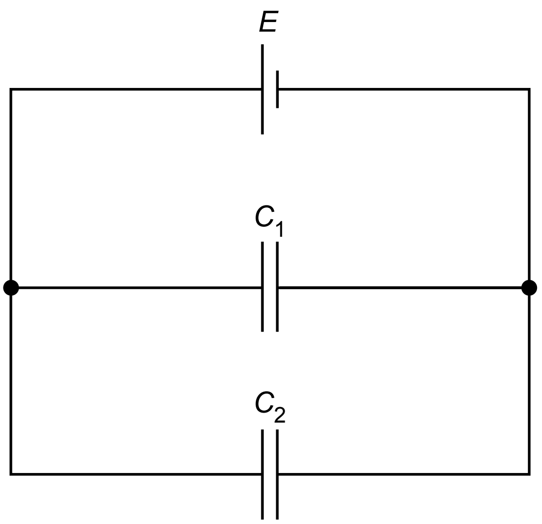

Fig. 5.1

Show that the combined capacitance C_T of the two capacitors is given by

$$C_T = C_1 + C_2.$$

Explain your reasoning. You may draw on Fig. 5.1 if you wish.

p.d. across C_1 = p.d. across C_2 = supply p.d. = E.

Let Q_1 = charge on C_1, Q_2 = charge on C_2, QT = total charge

$Q_T = Q_1 + Q_2$

$Q = CV$

$\therefore C_TE = C_1E + C_2E = E(C_1 + C_2)$

$\therefore$ Dividing through by E, $C_T = C_1 + C_2$.

[3]

(c) Two capacitors of capacitances 22 μF and 47 μF, and a resistor of resistance 2.7 MΩ, are connected into the circuit of Fig. 5.2.

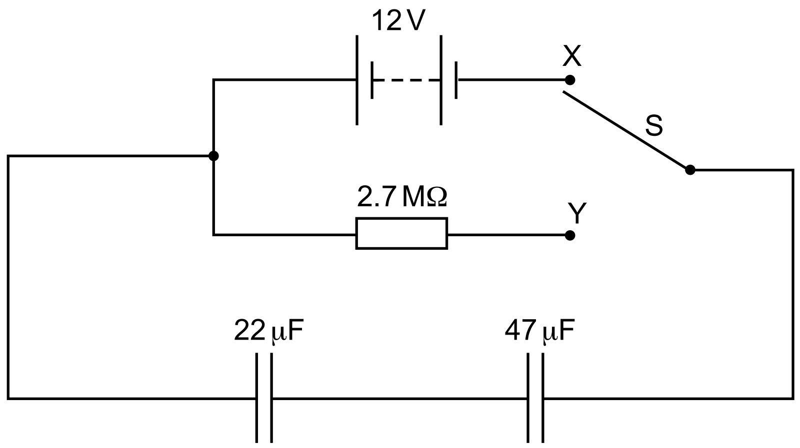

Fig. 5.2

The battery has an e.m.f. of 12 V.

(i) Show that the combined capacitance of the two capacitors is 15 μF.

$1 / C_T = (1 / C_1) + (1 / C_2)$

$\therefore C_T = [(1 / 22) + (1 / 47)]^{-1} = 15\ \mu F$

[1]

(ii) The two-way switch S is initially at position X, so that the capacitors are fully charged.

Use the information in **(c)(i)** to calculate the total energy stored in the two capacitors.

energy $= ½CV^2 = ½ \times 15 \times 10^{-6} \times 12^2 = 1.1 \times 10^{-3}$ J

total energy = 1.1×10^{-3} J [2]

(iii) The two-way switch is now moved to position Y.

Determine the time taken for the potential difference (p.d.) across the 22 μF capacitor to become 6.0 V.

Initial p.d. across 22 μF capacitor $= 12 \times 47 / (47 + 22) = 8.2$ V

$\therefore 6.0 = 8.2 \exp [- t / (2.7 \times 10^6 \times 15 \times 10^{-6})]$

$\therefore t = 13$ s

time = 13 s [3]

Examiner comment

Candidates found it difficult to deal with the initial and final p.d. across the 22 μF capacitor, with the exponential equation mostly used to compare the final p.d. across the capacitor (6.0 V) with the total p.d. across the whole combination (12 V). Another common misconception was to not appreciate that the time constant of the discharge circuit is the product of the resistance and the total capacitance of the circuit.

Question 6

6 **(a)** State the **two** conditions that must be satisfied for a copper wire, placed in a magnetic field, to experience a magnetic force.

1 there must be a current in the wire

2 the wire must be at a non-zero angle to the magnetic field.

[2]

Examiner comment

- It was common for candidates to give, as conditions, facts that were already stated in the information in the question, for example that the wire must be in a magnetic field (stated in the question), and that the wire must be a conductor (something that is already implicit in the fact that the wire is described as made from copper). To be awarded marks, candidates were required to give conditions that were not already clear in the question.
- Another common misconception was for the scenario to be confused with electromagnetic induction. Many candidates stated that the wire must be moving in order for a magnetic force to be exerted on it.

(b) A long air-cored solenoid is connected to a power supply, so that the solenoid creates a magnetic field. Fig. 6.1 shows a cross-section through the middle of the solenoid.

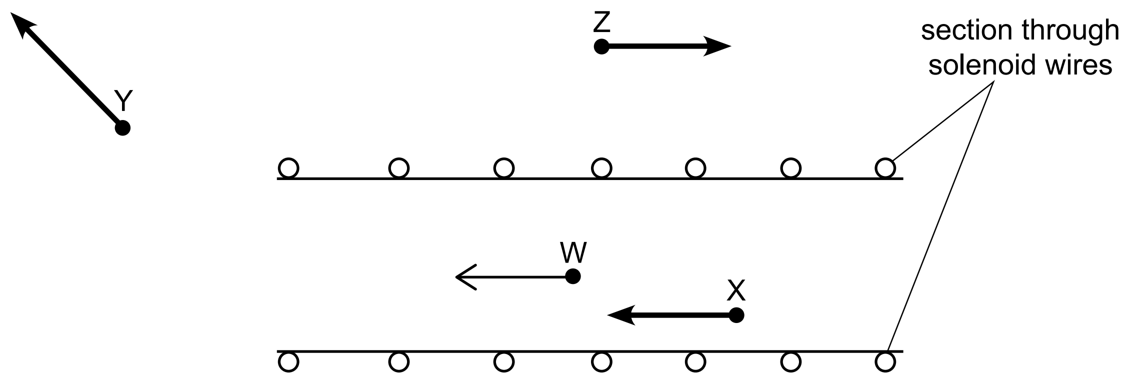

Fig. 6.1

The direction of the magnetic field at point W is indicated by the arrow. Three other points are labelled X, Y and Z.

(i) On Fig. 6.1, draw arrows to indicate the direction of the magnetic field at each of the points X, Y and Z. [3]

Examiner comment

Candidates were generally successful when indicating the directions of the magnetic fields at positions X and Z (provided they took sufficient care to ensure that the arrows drawn were actually horizontal). The direction at point Y proved to be more challenging. It was intended that candidates would visualise the magnetic field pattern around the solenoid (which they are expected to know) and then, instead of drawing the whole field pattern, to simply indicate its direction at three particular points.

(ii) Compare the magnitude of the flux density of the magnetic field:

- at X and at W At X and W, the magnetic flux densities are equal.
- at Y and at Z. The flux density is greater at Y than at Z.

[2]

Examiner comment

Building on **(i)**, this question expected an awareness of the density of the lines in the visualised magnetic field diagram. Many candidates found applying this knowledge difficult. In some cases, this was due to misunderstanding the question. Rather than comparing W with X and (separately) Y with Z, these candidates drew a comparison between the flux densities at W and X (deemed 'high') and the flux densities at Y and Z (deemed 'low').

(c) Two long parallel current-carrying wires are placed near to each other in a vacuum.

Explain why these wires exert a magnetic force on each other. You may draw a labelled diagram if you wish.

The current in one wire creates a magnetic field around that wire. The other wire is in this magnetic field. Because the current in the other wire is perpendicular to that field, a force acts on the other wire.

[3]

[Total: 10]

Examiner comment

- Many candidates did not answer the question that was asked. Some candidates answered a question asking about whether the forces were attractive or repulsive, focussing on whether the currents were in the same or opposite directions. Other candidates answered a question about how the two forces compared with each other (and gave responses revolving around Newton's third law). Both of these approaches showed some correct Physics but did not address the question that was asked (which was to explain why the forces are exerted in the first place). Candidates should be advised of the dangers of approaching the exam by trying to memorise mark schemes to previous papers: those mark schemes relate to questions asked in previous papers, not to the questions asked in the paper being taken.
- Space was provided for candidates to draw a diagram if they wished, and it was possible to be given marks for certain marking points from a clear diagram. However, diagrams were often insufficiently labelled for examiners to have any confidence in what lines drawn were intended to represent.

Question 7

7 **(a)** State Faraday's law of electromagnetic induction.

Magnitude of induced e.m.f. is directly proportional to the rate of change of magnetic flux linkage.

[2]

(b) Two coils are wound on an iron bar, as shown in Fig. 7.1.

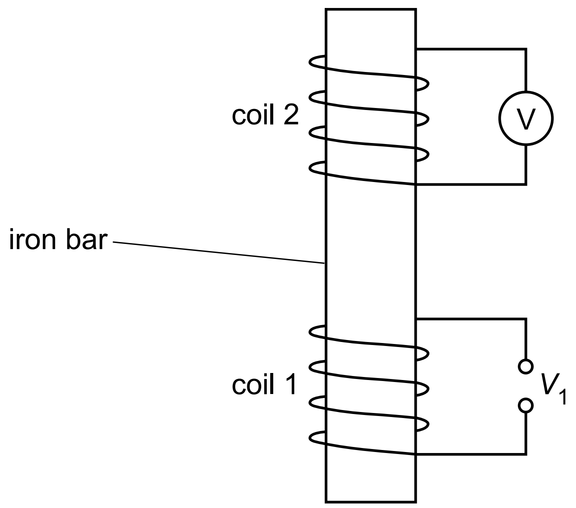

Fig. 7.1

Coil 1 is connected to a potential difference (p.d.) V_1 that gives rise to a magnetic field in the iron bar.

Fig. 7.2 shows the variation with time t of the magnetic flux density B in the iron bar.

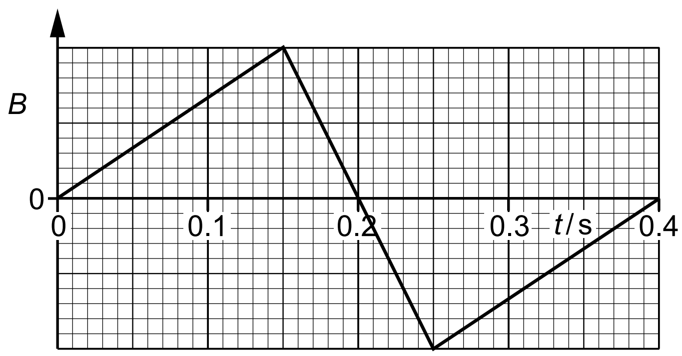

Fig. 7.2

On Fig. 7.3, sketch the variation with t of V_2 between $t = 0$ and $t = 0.40\,s$.

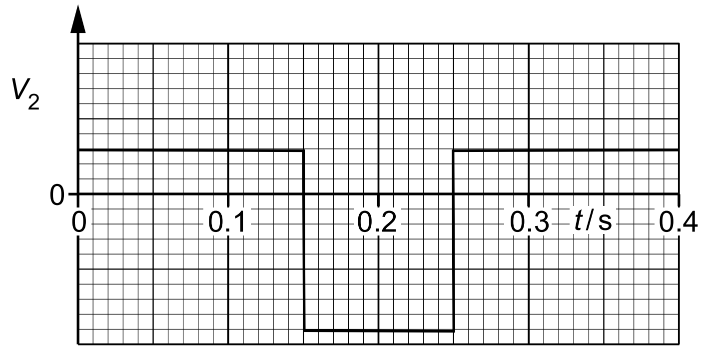

Fig. 7.3

[4]

(c) Coil 2 in **(b)** is now replaced with a copper ring that rests loosely on top of coil 1. The supply to coil 1 is replaced with a cell and a switch that is initially open, as shown in Fig. 7.4.

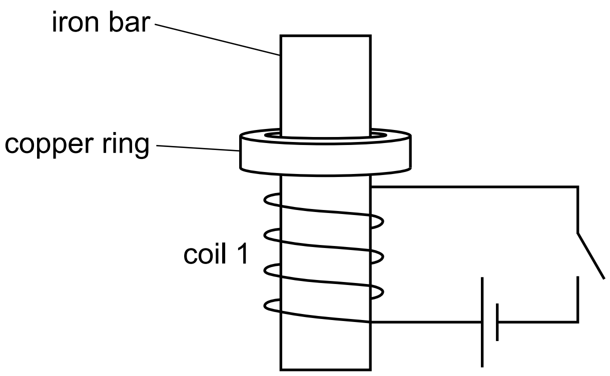

Fig. 7.4

(i) The switch is now closed. As it is closed, the copper ring is observed to jump upwards.

Explain why this happens.

As the switch is closed, the current in coil 1 increases rapidly from zero. This current creates a rapidly changing magnetic field in the iron bar. As the magnetic flux through the ring changes, an e.m.f. is induced in the ring. This e.m.f. causes a current in the ring. This current creates its own magnetic field around the ring. The two fields interact to cause an upwards force on the ring. [3]

Examiner comment

This question about electromagnetic phenomena was one of the most difficult questions for candidates on the paper. One common misconception was that Lenz's law can be used to explain why a phenomenon happens. Lenz's law can only ever be used to predict a direction of an e.m.f. (or something directly or indirectly caused by it, such as a current, magnetic field or force) but it does not explain why the current / field / force is created in the first place. In answering questions such as this, candidates needed to be clear in their minds what causes what, and where it is caused. Vague references to induced currents and e.m.fs, in various random (and often contradictory) sequences, without any consideration of location and causality, could not be awarded marks.

(ii) Suggest, with a reason, what would be the effect of repeating the procedure in **(c)(i)** with the terminals of the cell reversed.

The directions of both the magnetic field due to the coil and the magnetic field created by the current in the ring reverse. Since both fields reverse, the ring still jumps upwards. [1]

[Total: 10]

Question 8

8 **(a)** State **one** piece of experimental evidence for:

(i) the particulate nature of electromagnetic radiation

Photoelectric effect .... [1]

(ii) the wave nature of matter.

Electron diffraction. .... [1]

(b) **(i)** Calculate the de Broglie wavelength λ of an alpha-particle moving at a speed of $6.2 \times 10^7\,\mathrm{m\,s^{-1}}$.

$p = 4 \times 1.66 \times 10^{-27} \times 6.2 \times 10^7 = 4.1 \times 10^{-19}$ Ns

$\therefore \Delta = h / p = 6.63 \times 10^{-34} / 4.1 \times 10^{-19} = 1.6 \times 10^{-15}$ m

λ = ... 1.6×10^{-15} .... m [3]

(ii) The speed v of the alpha-particle in **(b)(i)** is gradually reduced to zero.

On Fig. 8.1, sketch the variation with v of λ.

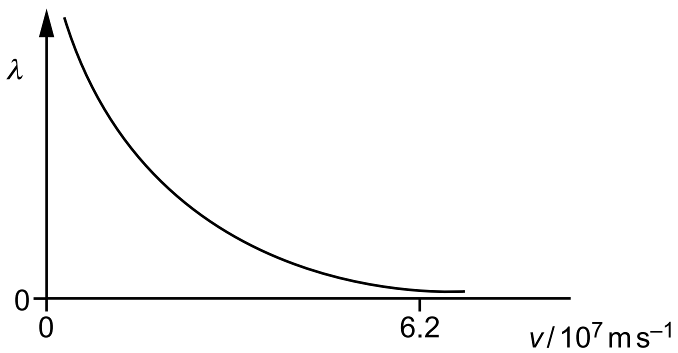

Fig. 8.1

[2]

(c) Suggest an explanation for why people are not observed to diffract when they walk through a doorway.

The de Broglie wavelength of people walking is negligibly small compared with the width of the doorway, so no significant diffraction occurs.

.... [1]

Question 9

9 **(a)** **(i)** State Hubble's law.

Speed of recession of a galaxy from Earth is directly proportional to the distance of the galaxy from Earth.

[2]

(ii) Explain how cosmologists use observations of emission spectra from stars in distant galaxies to determine that the Universe is expanding.

Light in the spectrum from a star is observed to have a wavelength that is greater than the known value. This phenomenon, which is called redshift, provides evidence that the observed star is moving away from the observer.

[2]

Examiner comment

A common misconception was that the wavelength (often referred to as the wavelength 'of the star' rather than of the light in the emission spectrum from it) was continuously increasing. Candidates needed to be clear that when they were describing stars 'moving away', they were describing what they were moving away from. In this question about observations of spectra, the evidence was purely for stars moving away from the observer. The observations gave no information about, as many candidates asserted, stars moving away from each other. The idea that stars were probably moving away from each other was a secondary extrapolation of those direct observations.

(b) Explain how Hubble's law and the idea of the expanding Universe lead to the Big Bang theory of the origin of the Universe.

All galaxies in the Universe are moving away from all other galaxies. Hubble's law tells us that more distant galaxies are moving away at greater speed than nearer galaxies. We can infer from this that there must have been a time in the distant past when all matter in the Universe was very close together at a single point. The trigger for all this matter to start moving away from that point is known as the Big Bang.

[3]

[Total: 7]

Examiner comment

- Some candidates experienced difficulty in switching from the focus in **(ii)** on observations of individual stars from Earth to the behaviour of all the matter in the Universe as a whole. These candidates gave responses that appeared to attribute Earth as the centre of the Universe, with all matter moving away from Earth. Candidates needed to make sure they used the correct terminology. There were many instances of galaxies and stars being described as 'planets'. In some cases, they were each described as 'universes', with all universes moving away from all other universes. Understanding the difference between the types of object found in the Universe (galaxies, stars, planets) was essential for candidates to be awarded marks in questions about cosmology.
- One other difficulty encountered by candidates in answering this question was use of the correct tense. For example, the final part of the exemplar response was often written in the present tense, with no indication that what was being described was in the distant past. Some candidates appeared to convey that they thought the Big Bang is happening at the present time.

Question 10

10 (a) State what is meant by radioactive decay.

Radioactive decay is the spontaneous emission of ionising radiation from an unstable nucleus.

[2]

Examiner comment

When candidates are asked to 'state' or 'explain' the meaning of a technical term, responses that relied on repetition of part or all of the term that was to be explained could not be awarded full marks. In this case, it was common for candidates to give responses that relied on the word 'decay'. For example, 'the decay of an unstable nucleus' relies on the word 'decay', which is part of the term to be explained and so could not be awarded marks.

(b) A radioactive sample consists of an isotope X of half-life T that decays to form a stable product. Only X and the stable product are present in the sample.

At time $t = 0$, the sample has an activity of A_0 and contains N_0 nuclei of X.

(i) On Fig. 10.1, sketch the variation with t of the number N of nuclei of X present in the sample. Your line should extend from time $t = 0$ to time $t = 3T$.

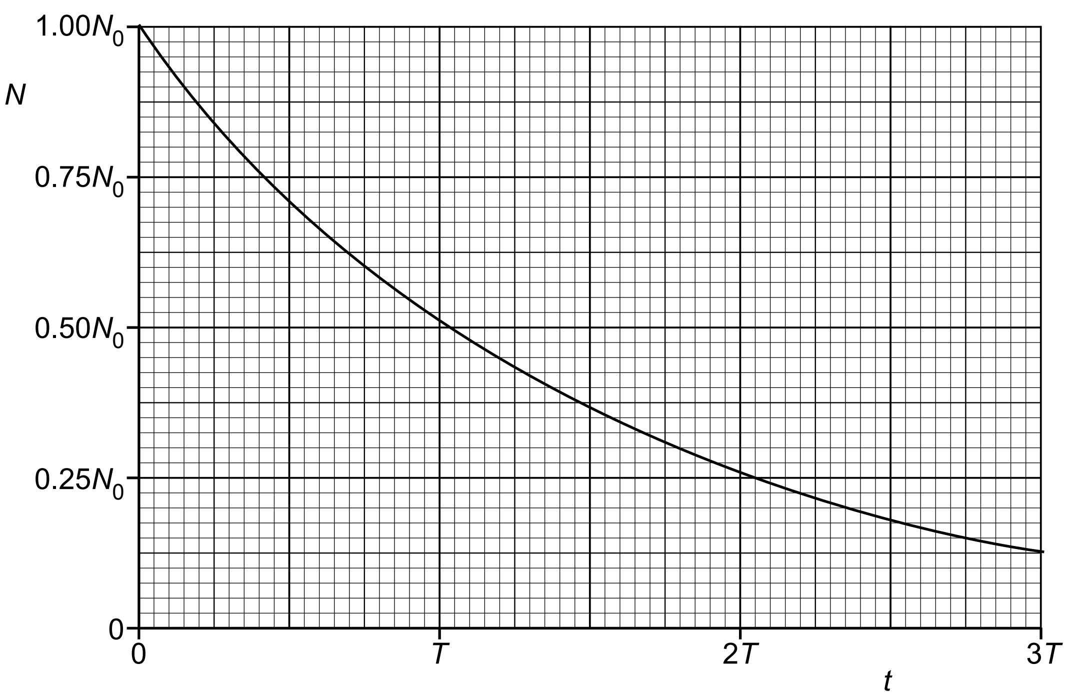

Fig. 10.1

[3]

(ii) On Fig. 10.2, sketch the variation with N of the activity A of the sample for values of N between $N = 0$ and $N = N_0$.

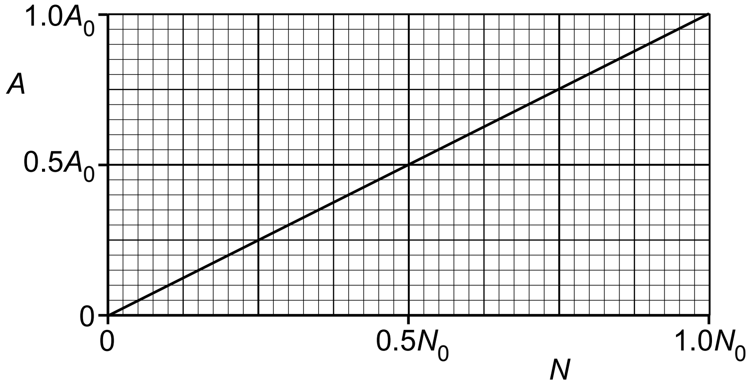

Fig. 10.2

[2]

(c) State the name of the quantity represented by the gradient of your line in:

(i) Fig. 10.1

Activity .... [1]

(ii) Fig. 10.2.

Decay constant .... [1]

(d) For the sample in **(b)**, calculate the fraction $\frac{N}{N_0}$ at time $t = 1.70T$.

$N = N_o \exp(-\ln 2 \times 1.70T / T)$

$\therefore N / N_o = 0.31$

$\frac{N}{N_0}$ = ...0.31............ [2]

[Total: 11]

Examiner comment

Some candidates attempted to read a value for N at time $t = 1.70T$ from their graph in **(i)**. Generally, they were unable to obtain the required answer to the required precision by doing this. The command word 'calculate' ought to have alerted them to the fact that there was a more appropriate approach.

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