CHEMOLOGY EDUCATION SERVICES

Name:________________________

2009 PHYSICS UNIT 4 TRIAL EXAM

Time allowed: 1 hour 30 minutes

QUESTION AND ANSWER BOOKLET

Structure of booklet

Area of study	*Number of questions*	*Marks available*	*Suggested time (minutes)*
1. Electric Power	18	40	40
2. Interactions of Light and Matter	13	30	30
3.1 Synchrotron and its applications	9	20	20
3.2 Photonics	9	20	20
3.3 Sound	9	20	20

Directions to students
This booklet is 23 pages long.
You should answer all questions in Areas of Study 1 and 2.
You should answer all questions in your selected Detailed Study in Area of Study 3.
(Note: You should choose only **ONE** Detailed Study and answer **only** questions from that Study)
You may use an A4 page of notes annotated on both sides.
There is a total of 90 marks available.
It is suggested that you spend about 1 minute per mark.

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.AREA 1 – ELECTRIC POWER

Specific Instructions for Area 1

Area 1 consists of **18 questions**.
A total of **40 marks** is available for Area 1.

Igor is in charge of a tall tower and has attached a lightning rod of length 12m to the top of the tower for protection. Being a precise young man who takes pride in his work, he has managed to erect the rod so that it is perfectly vertical, as shown in Figure 1. It is in a region where the Earth's electrical field has a magnitude of 30μT.
During a particularly violent thunderstorm, lightning strikes the rod and causes a stream of electrons to rush down its length.

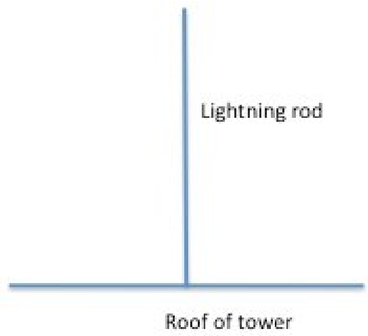


Figure 1

Question 1

In which direction does the Earth's magnetic field push the rod?
(Assume that the Earth's magnetic field is horizontal)

A. North
B. South
C. East
D. West

2 marks

Question 2

If the current in the rod was 2×10^4A, what was the magnitude of the force on the rod?

2 marks

Area 1 - continued

During the storm, the lightning rod is knocked about so that it no longer stands vertically, but instead tips over a little towards the north so that it makes an angle of 25^o to the horizontal.
Another lightning bolt hits the rod, causing a current to pass through it that is identical to the one described above.

Question 3

The new magnetic force on the lightning rod would be:

A. Identical to before
B. Zero
C. Less than before, but non-zero
D. Greater than before

2 marks

Mat the bartender has decided to make his bar look more attractive by hanging up strings of lights in the window to attract more patrons. The arrangement of lights he uses for this purpose is shown in Figure 2 below. Mat turns the lights on and the arrangement of lights works perfectly and draws 48W of power.

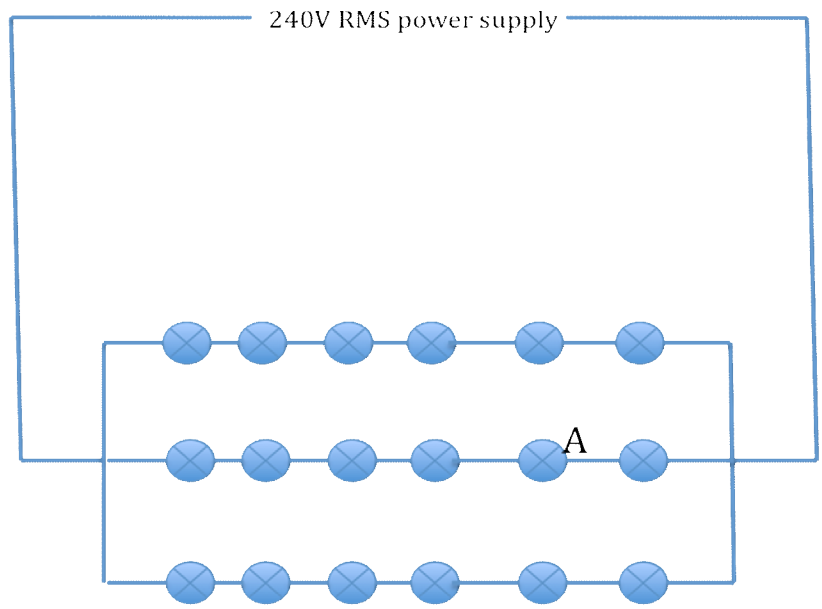


Figure 2

Area 1 - continued

Question 4

What RMS current is drawn from the 240 RMS supply?

A

2 marks

Question 5

What RMS current is flowing through globe A?

A

2 marks

Question 6

What is the RMS voltage across each globe?

V

2 marks

Question 7

What is the power rating of each globe?

W

2 marks

Question 8

Globe A is now removed from the arrangement.
Which of the following best describes the result of this action?

A. None of the globes are lit
B. The middle row of lights does not light at all but the other two rows are brighter than before
C. All of the other globes light normally
D. The middle row of lights does not light at all, but the other two rows are the same brightness as before.

2 marks

Area 1 - continued

Tanya and Chiara are keen Physics student who are currently investigating the operation of a simple alternator. They have connected coil ABCD so that it can rotate clockwise in a uniform magnetic field of 0.3T. The dimensions of the coil are 0.4 by 0.5m and it has 25 turns. Their apparatus is shown in Figure 3.

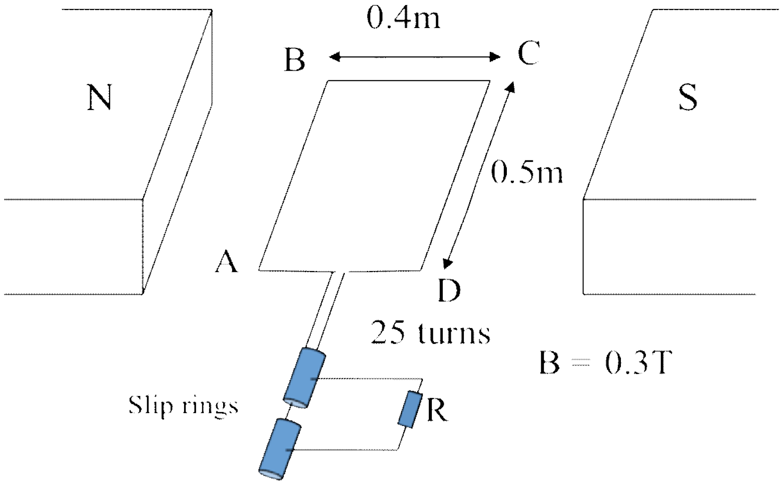


Figure 3

Question 9

With the coil orientated as shown in Figure 3, what is the magnitude of magnetic flux through each turn of the coil?

Wb

2 marks

The coil now rotates through 90^0 in a clockwise direction.

Question 10

What is the magnitude of magnetic flux through the coil after it has rotated through 90^0?

Wb

2 marks

The coil is now rotated at a constant rate of 50Hz in a clockwise direction.

Question 11

What is the average voltage developed across resistor R when the coil rotates through 90^0 from its position perpendicular to the field?

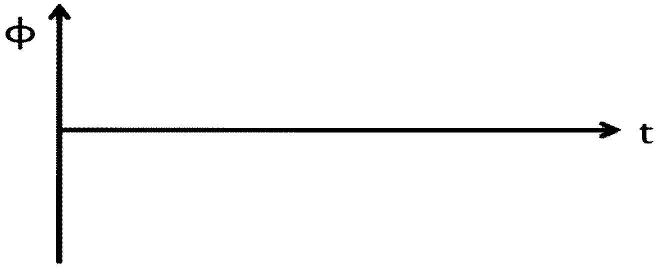
V

3 marks

Area 1 - continued

Question 12

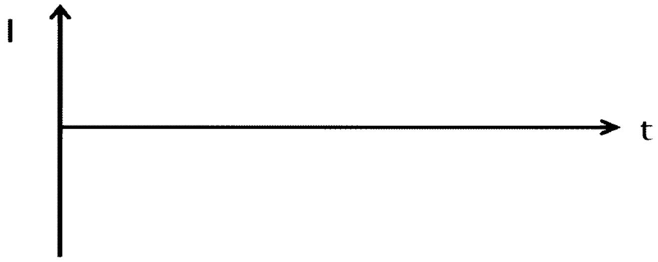
Sketch a graph of the variation of flux through the coil as a function of time as it rotates. Take t=0 to be the starting position of the coil perpendicular to the field, and take N to S as positive.



3 marks

Question 13

Under the same conditions as above, sketch the graph of the variation of current flowing from A to B in the coil as a function of time.



3 marks

Marrianne and Jules have bought a holiday house and want to connect the house to an electricity supply. They check through the appliances in the house and find that they all require 240V RMS AC and that the expected maximum power demand is 9000W.
After researching the local power supplies, they discover that the house is 1.3km away from the nearest supply and at this point there is a choice of either a high voltage 11000V RMS AC supply or a lower voltage 240V RMS AC supply.
They are keen to avoid purchasing a transformer and so are leaning towards using a 1.3km supply line to the 240V RMS supply.

Question 14

Calculate the current flowing through a heater rated at 2000W when connected to the 240V RMS supply.

A

2 marks

Area 1 - continued

Marrianne goes ahead and connects the house to the 240V supply using connecting lines with total resistance 1.8Ω. Jules turns some appliances on in the house to test the supply and the current is measured to be 25A.

Question 15

Calculate the power loss in the connecting lines under the test conditions described above.

W

2 marks

Question 16

What is the voltage at the house when the current is 25A?

V

2 marks

Question 17

What is the peak-to-peak voltage at the 11000V RMS supply point?

V

2 marks

Question 18

Explain why using the 11000V RMS supply with a step-down transformer rather than the 240V RMS supply would deliver the same power to the house with a significant reduction in power loss in the connecting lines.

3 marks

Area 1 – continued

AREA 2 – Interactions of light and matter

Specific Instructions for Area 2

Area 2 consists of 13 questions.
A total of 30 marks is available for Area 2.

Specific data for Area 2:
Planck's constant = 6.63×10^{-34} Js
Charge on an electron = 1.6×10^{-19} C
Speed of light = 3.0×10^{8} m/s
Mass of an electron = 9.1×10^{-31} kg

Dominica has discovered a piece of caesium metal, which has a work function of 2.1eV. She is currently illuminating it with green light of wavelength 540nm.

Question 1

What is the energy of a photon of this green light?

eV

2 marks

Question 2

What is the maximum kinetic energy of the electrons ejected from the surface of the metal as the green light strikes it?

eV

2 marks

The caesium metal is now illuminated by violet light and the maximum energy of photoelectrons is found to be 2.8eV.

Question 3

What is the maximum speed of these photoelectrons?

m/s

2 marks

Area 2 - continued

Dominica now turns up the intensity of the incident violet light. She suspects that incident light of a greater intensity will produce electrons of a higher maximum kinetic energy.

Question 4

Is Dominica correct?
Explain your answer and state whether it supports the wave or particle model of light.

4 marks

Philip and Henry are investigating Young's Double Slit Experiment and set up the apparatus shown in Figure 1. They are using a He-Ne laser which has a wavelength of 632nm. The beams B1 and B2 meet at the fifth bright band.

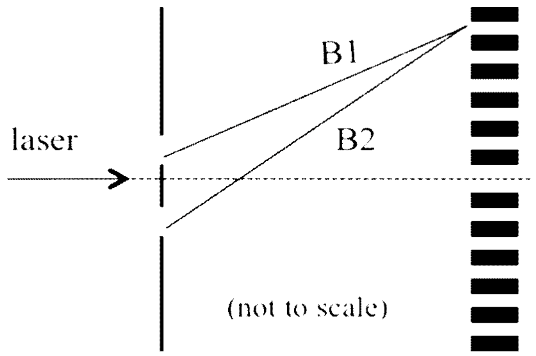


Figure 1

Question 5

Calculate the path difference between lines B1 and B2.

m

2 marks

Area 2 – continued

Question 6

Explain the formation of the dark and light bands, referring in your answer to the wavelike nature of light.

3 marks

Question 7

Which **one or more** of the following would cause the pattern of dark and light bands to be closer together?

A. Decreasing the distance between the slits
B. Increasing the wavelength of the laser light
C. Decreasing the distance between the slits and the wall
D. Increasing the intensity of the laser light

2 marks

Question 8

Describe what would happen to the pattern of dark and light bands if Philip and Henry replaced the red laser with a blue one.

3 marks

Area 2 - continued

Philip and Henry have become quite intrigued with the wave properties of matter and set up an experiment in which they direct a beam of x-rays of wavelength 250pm onto a thin aluminium foil, as shown in Figure 2.
The x-rays scatter from the foil onto photographic film.

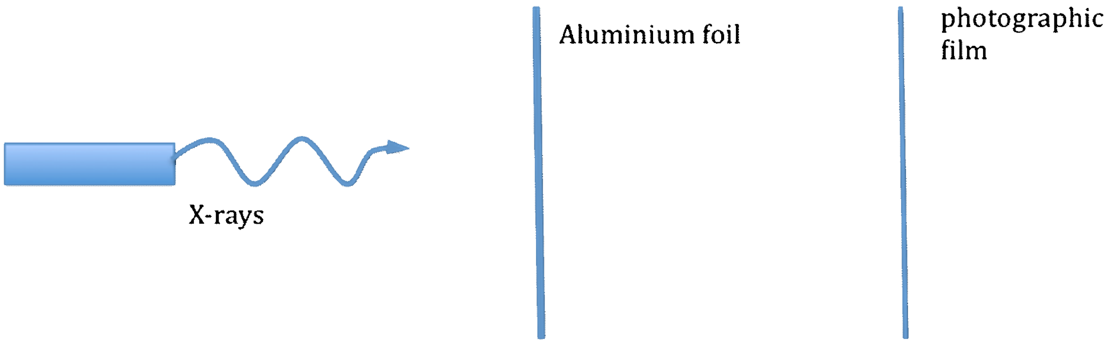


Figure 2

After passing through the foil, the x-rays form a diffraction pattern as shown on the left hand side of Figure 3.
Philip and Henry then repeat the experiment using a beam of electrons rather than x-rays, and the resulting diffraction pattern is shown on the right of Figure 3.

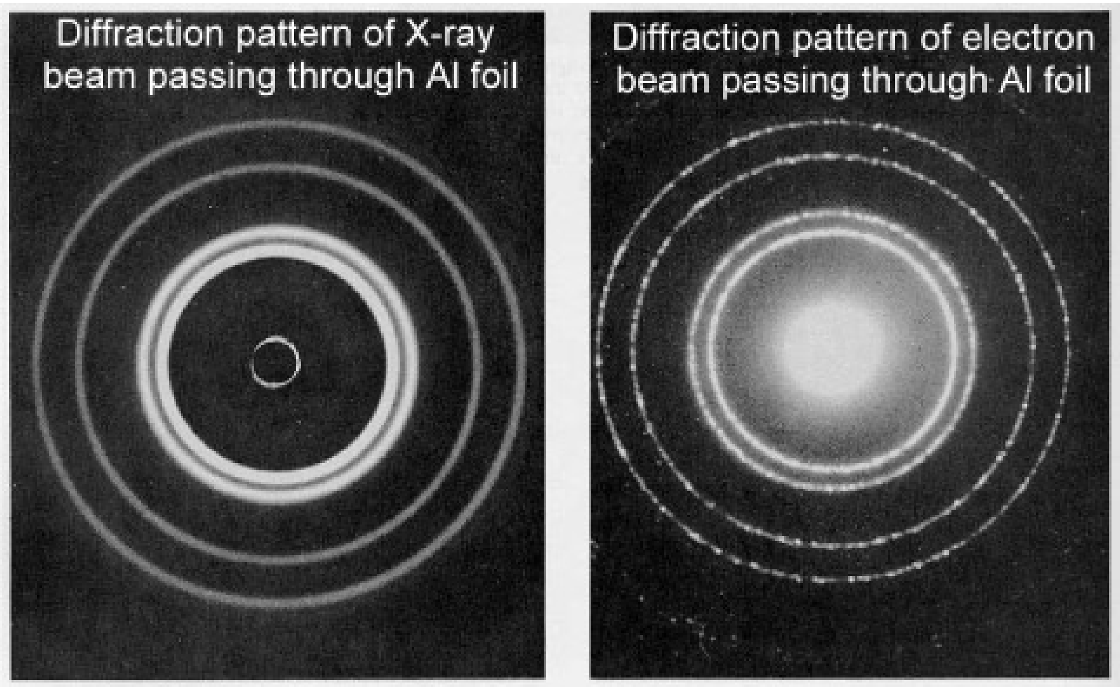


Figure 3

Area 2 - continued

Question 9

Which of the following **best** explains why it is possible to compare x-ray and electron diffraction patterns?

A. Electrons and x-rays both travel in orbitals around the nucleus of an atom
B. Electrons can exhibit wave-like properties
C. X-rays can exhibit particle-like properties
D. Electrons and x-rays are both forms of quarks

2 marks

Question 10

Which of the following **best** explains why the scattering of electrons and x-rays produce very similar diffraction patterns?

A. They have the same velocity
B. They have the same frequency
C. They have the same energy
D. They have the same wavelength

2 marks

Question 11

Calculate the energy of the x-rays.

eV

2 marks

Question 12

Estimate the momentum of the electrons.
(Assume the two diffraction patterns are identical)

kgm/s

2 marks

Area 2 - continued

Question 13

Light can exhibit both wave and particle properties.
Which **one or more** of the following properties does light sometimes show?

A. momentum
B. energy
C. charge
D. mass

2 marks

AREA 3.1 – Synchrotron and its applications

Specific Instructions for Area 3.1

Area 3.1 consists of **9 questions**. **Answer all questions on the multiple choice answer sheet provided.**
A total of **20 marks** is available for area 3.1.

Specific data for Area 3.1:
Charge on an electron = 1.6×10^{-19} C
Mass of an electron = 9.1×10^{-31} C
Planck's constant = 6.63×10^{-34} Js
Speed of light = 3.0×10^{8} m/s

Roxanne is training to work as a tour guide in the Australian Synchrotron Facility and is currently learning the purpose of several key elements within the synchrotron. She creates a multiple-choice quiz to test herself but has forgotten the correct answers.
Using the answer key below, choose the **best** correct multiple choice answer so that Roxanne can successfully complete her training.

ANSWER KEY:

A. to accelerate particles to speeds close to the speed of light
B. to increase the energy of the electrons
C. to confine electrons to a circular orbit
D. to accelerate electrons and cause them to release synchrotron radiation

Question 1

What is the function of the storage ring?

2 marks

Question 2

What is the function of the booster ring?

2 marks

Question 3

What is the purpose of the electron linac?

2 marks

Question 4

What is the function of the bending magnets?

2 marks

Area 3.1 - continued

Scott is working in the new synchrotron and is currently bombarding a material of work function 3.2eV with X-rays of wavelength 0.3nm. An electron is ejected from the material with kinetic energy 27eV.

Question 5

The wavelength of the scattered photon is closest to:

A. 3.5nm
B. 0.3nm
C. 0.5nm
D. 3.2nm

4 marks

Question 6

This experiment is an example of:

A. Diffuse scattering
B. Compton scattering
C. Thompson scattering
D. Rasheed scattering

2 marks

In one of Scott's experiments, an electron is accelerated through a potential difference of 2.1kV.

Question 7

Calculate the kinetic energy of the electron after this acceleration.

A. 3.4×10^{-16}
B. 3.6×10^{-16}
C. 6.3×10^{-16}
D. 4.3×10^{-16}

2 marks

Question 8

Calculate the speed achieved by the electron.

A. 3.4×10^{7} m/s
B. 2.7×10^{7} m/s
C. 2.1×10^{7} m/s
D. 3.7×10^{7} m/s

2 marks

Area 3.1 - continued

The electron then travels at right angles to a uniform magnetic field of strength 2.5×10^{-3}T.

Question 9

What is the force on the electron?

A. 1.1×10^{-14}N
B. 1.9×10^{-14}N
C. 2.2×10^{-14}N
D. 4.2×10^{-14}N

2 marks

AREA 3.2 – Photonics

Specific Instructions for Area 3.2

Area 3.2 consists of 9 questions. **Answer all questions on the multiple choice answer sheet provided.** A total of **20 marks** is available for Area 3.2.

Specific data for Area 3.2:
Planck's constant = 6.63×10^{-34} Js
Speed of light in a vacuum = 3.0×10^{8} m/s
Charge on an electron = 1.6×10^{-19} C

Taryn and Annabelle are working on a production of The Mikado and part of the set involves an array of LEDs which light up during the show to spectacular effect.
One particular LED has a band gap energy of 1.9eV and is currently unlit. Ben, the stage manager, has applied a variable DC input across the LED and increases the voltage until at 1.9V a current flows and the LED lights up.

Question 1

What is the wavelength of light emitted by the LED?

A. 460 nm
B. 320 nm
C. 650 nm
D. 570 nm **2 marks**

Question 2

If Ben increases the DC voltage across the LED, which of the following is true? (**one or more** answers)

A. The current through the LED decreases
B. The wavelength of the emitted light increases
C. The current through the LED increases
D. The wavelength of the emitted light remains constant **2 marks**

LEDs are available in different colours, depending the their band gap energy.

Question 3

Which of the following lists LED colours in **decreasing** value of band gap energy?

A. blue, red, green
B. green, red, blue
C. red, blue, green
D. blue, green, red **2 marks**

Area 3.2 - continued

The production also uses a red HeNe laser for lighting effects.

Question 4

Three features of the red HeNe laser light that are superior to the red LED light are:

A. monochromatic, more intense, coherent
B. monochromatic, less intense, more divergent
C. coherent, less intense, less divergent
D. coherent, more divergent, monochromatic **2 marks**

Kylie and Sophie are also stage managers for The Mikado and are using optical fibes in one of their communication systems. The graph of attenuation of a particular fibre vs wavelength is shown in Figure 1.

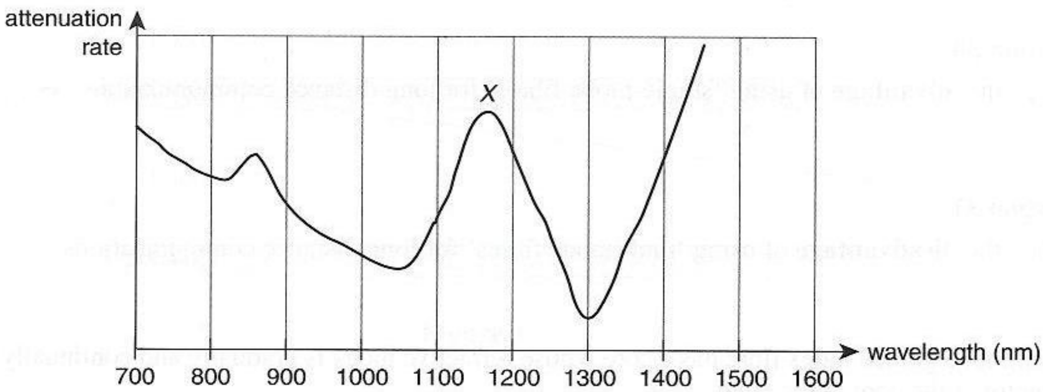


Figure 1

Question 5

Of the following, the **best** possible explanation for the peak at point X could be:

A. A frequency highly suitable for transmission
B. A frequency unsuitable for transmission
C. A loss of signal due to resonance caused by impurities
D. A surge of electricity through the system **2 marks**

Question 6

At which wavelength is loss of signal minimized?

A. 1500 nm
B. 1300 nm
C. 700 nm
D. 1180 nm **2 marks**

Area 3.2 - continued

Question 7

Which two frequencies, in Hz, would be suitable for transmission along this fibre?

A. 3.17×10^{14} and 3.98×10^{14}
B. 5.73×10^{14} and 4.86×10^{14}
C. 2.31×10^{14} and 2.86×10^{14}
D. 1.39×10^{14} and 1.77×10^{14}

4 marks

Kylie and Sophie test transmission of light signals down a single-mode optical fibre from the theatre to a rehearsal room several kilometers away.
Kylie transmits an infrared (IR) pulse of wavelength 1200nm at exactly the same time as Sophie transmits a red pulse (R) of wavelength 670nm.

Question 8

Which of the following is correct?

A. The IR pulse arrives at he other end of the fibre **before** the RD pulse
B. Both pulses arrive at the other end of the optical fibre at the same time
C. The IR pulse arrives at the other end of the fibre **after** the RD pulse
D. Neither pulse arrives at the other end of the fibre

2 marks

Sophie notices that there seems to be more attenuation to the RD pulse than to the IR pulse after travelling through the fibre.

Question 9

Which of the following is the most likely cause of this?

A. total internal reflection has not occurred for the RD pulse
B. there is more absorption of the longer wavelength IR pulse
C. the acceptance angle is greater for the IR pulse
D. there is more Rayleigh scattering for the shorter wavelength RD pulse

2 marks

AREA 3.3 – Sound

Specific Instructions for Area 3.3

Area 3.3 consists of **9 questions**. **Answer all questions on the multiple choice answer sheet provided.**
A total of **20 marks** is available for Area 3.3.

Specific data for Area 4:
Speed of sound in air = 330m/s
Area of a sphere is $4\pi r^2$

Ray and Cass are waiting for a train and listening to an announcement over the loudspeaker system. This system consists of 4 speakers at the top of a pole, as shown in Figure 1, which effectively emit sounds equally in all directions.
At Ray's position, 6m away from the speakers, the sound intensity produced by the speakers is 4×10^{-3} Wm^{-2}.

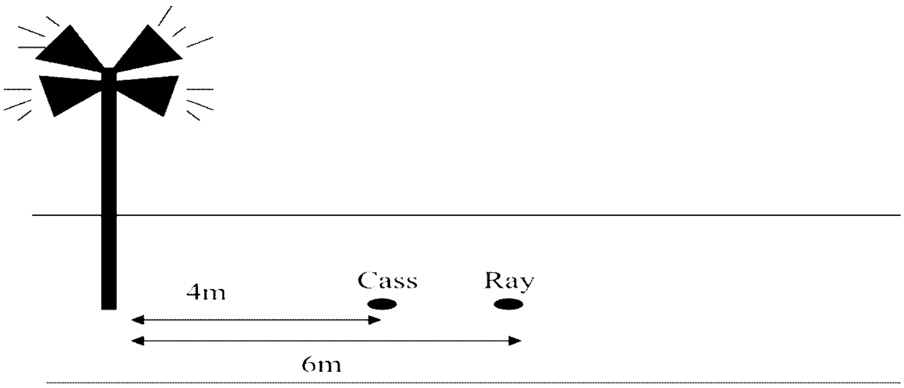


Figure 1

Question 1

What is the corresponding sound intensity level due to the speakers at Ray's position?

A. 64dB
B. 96dB
C. 38dB
D. 83dB **2 marks**

Question 2

What is the total acoustic power being produced by the speaker system?
(assume that the sound spreads out uniformly and that the area of a sphere is $4\pi r^2$)

A. 1.8W
B. 3.7W
C. 6.2W
D. 2.3W **3 marks**

Area 3.3 - continued

Cass is standing closer to the speakers than Ray, at a point 4m from them.

Question 3

What would be the **increase** in sound intensity level (compared to Ray's position) for Cass?

A. 5.6dB
B. 2.9dB
C. 9.6dB
D. 3.5dB

3 marks

Cass notices that there is another speaker pole at the other end of the platform producing exactly the same output. Both systems are currently broadcasting a long note of frequency 440Hz,which warns of an incoming train. While this note is sounding, Cass walks in a straight line PQR, parallel to the line between two speakers, as shown in Figure 2.

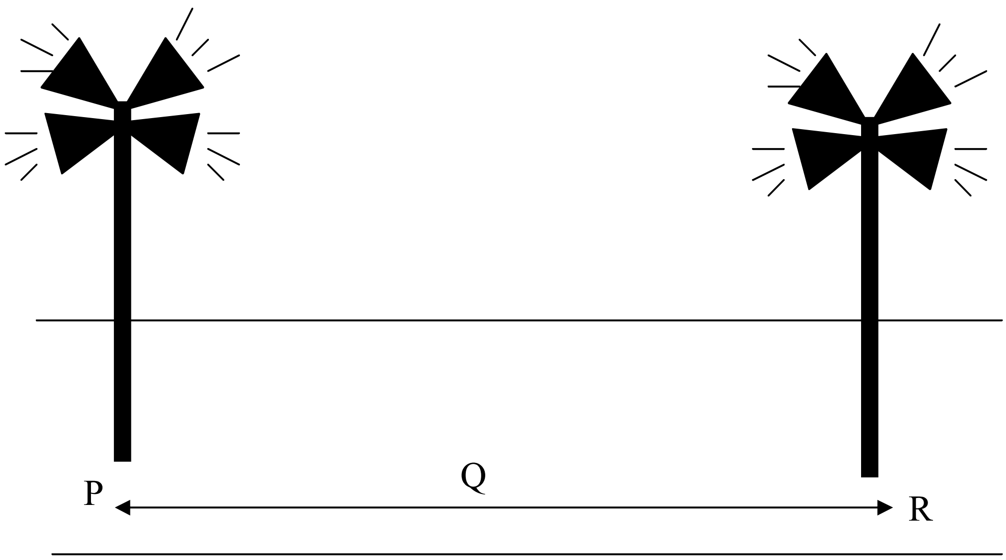


Figure 2

Question 4

Which option best describes what Cass is likely to hear as she walks along the line PQR?

A. A continuous loud note
B. A series of loud and soft sounds
C. No sound from the speakers at all
D. A chord resulting from a series of harmonics sounding together

2 marks

Area 3.3 - continued

Al and Oscar are in charge of providing microphones for a production of The Mikado and are studying the different types of microphones available.

For the following questions, use the answer key:

A. electromagnetic induction
B. capacitance
C. inversion
D. piezoelectric effect

Question 5

Which of the physical principles above is involved in a crystal microphone?

2 marks

Question 6

Which of the physical principles above is involved in an electret-condenser microphone?

2 marks

Question 7

Which of the physical principles above is involved in a dynamic microphone?

2 marks

Oscar and Al are now sitting in the centre of the sound control booth monitoring the show. They are surrounded by small speakers, S, part of the surround sound system in the control booth. The dialogue in the show (300-3000Hz) is reproduced by the central speaker, while the sub-woofer reproduces sounds below 100Hz. They follow the action on stage by watching a live feed on a TV screen, which is positioned in front of the central speaker. This configuration is shown in Figure 3.

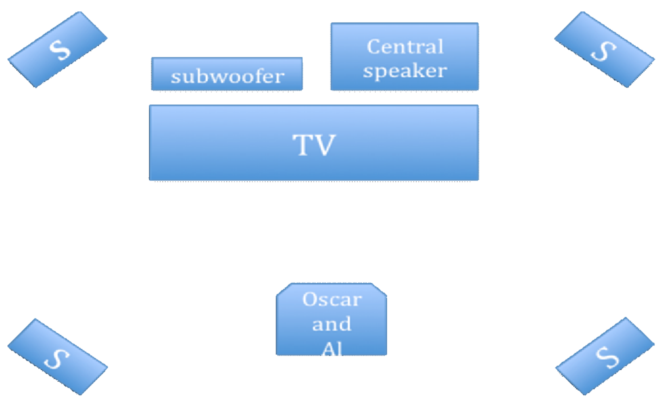


Figure 3

Area 3.3 - continued

Al and Oscar notice that in this configuration the low frequencies sounds can be heard quite clearly, but the dialogue and higher frequency sounds are muffled. When Oscar repositions the central speaker underneath the TV, all frequencies are heard clearly.

Question 8

The wavelength of the 100Hz sound in air is:

A. 3.9m
B. 3.3m
C. 5.4m
D. 4.7m

2 marks

Question 9

The best explanation of why the high frequency sounds are muffled when the central speaker is behind the TV whilst the low frequency sub-woofer sounds can be heard clearly is:

A. Low frequency sounds, having a longer wavelength, diffract more readily around the TV
B. High frequency sounds, having a shorter wavelength, diffract more readily around the TV
C. Low frequency sounds travel at a higher speed than high frequency sounds
D. Low frequency sounds are higher energy than high frequency sounds

2 marks

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PHYSICS Unit 4

MULTIPLE CHOICE ANSWER SHEET

Colour the box after the letter corresponding to your answer.

3.1 Synchrotron & its Applications

1.	A☐	B☐	C☐	D☐
2.	A☐	B☐	C☐	D☐
3.	A☐	B☐	C☐	D☐
4.	A☐	B☐	C☐	D☐
5.	A☐	B☐	C☐	D☐
6.	A☐	B☐	C☐	D☐
7.	A☐	B☐	C☐	D☐
8.	A☐	B☐	C☐	D☐
9.	A☐	B☐	C☐	D☐
10.	A☐	B☐	C☐	D☐

3.2 Photonics

1.	A☐	B☐	C☐	D☐
2.	A☐	B☐	C☐	D☐
3.	A☐	B☐	C☐	D☐
4.	A☐	B☐	C☐	D☐
5.	A☐	B☐	C☐	D☐
6.	A☐	B☐	C☐	D☐
7.	A☐	B☐	C☐	D☐
8.	A☐	B☐	C☐	D☐
9.	A☐	B☐	C☐	D☐
10.	A☐	B☐	C☐	D☐

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PHYSICS Unit 4

MULTIPLE CHOICE ANSWER SHEET

Colour the box after the letter corresponding to your answer.

3.3 Sound

1.	A☐	B☐	C☐	D☐
2.	A☐	B☐	C☐	D☐
3.	A☐	B☐	C☐	D☐
4.	A☐	B☐	C☐	D☐
5.	A☐	B☐	C☐	D☐
6.	A☐	B☐	C☐	D☐
7.	A☐	B☐	C☐	D☐
8.	A☐	B☐	C☐	D☐
9.	A☐	B☐	C☐	D☐
10.	A☐	B☐	C☐	D☐

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SUGGESTED SOLUTIONS TO 2009 PHYSICS UNIT 4 TRIAL EXAM

AREA OF STUDY 1 - Electric Power

Question 1

Use the right hand slap rule and assume the Earth's magnetic field points north. Current is down the rod. Thus, the force will be toward the **west.** **D ANS**

Question 2

F=BIl

Thus, F = $(30 \times 10^{-6})(2 \times 10^{4})(12)$
So, B = **7.2T ANS**

Question 3

The rod is no longer perpendicular to the magnetic field, and so the force will be less than before.
Thus, **C ANS**

Question 4

P = VI (using RMS values given)
Thus, 48 = 240 I
I = **0.2A RMS ANS**

Question 5

Each branch of the parallel circuit has the same resistance, thus 1/3 of the current will run through each branch.
Thus, 0.2/3 = **0.067A RMS ANS**

Question 6

240V must be lost across each parallel path, so every globe receives 1/6 of this voltage.
Thus, V across each globe is 240/6 = **40V ANS**

Question 7

Can use either $P = VI = 40 \times 0.067 = 2.7$
OR P total/18 = 48/18 = **2.7W ANS**

Question 8

The middle row of lights is now an open circuit, but the other branches still function and receive the same voltage as before.
Thus, **D ANS**

Question 9

In this orientation, the coil is parallel to the field and thus area perpendicular to the field is 0.
Thus, Flux ϕ = BA = 0 Wb ANS

Question 10

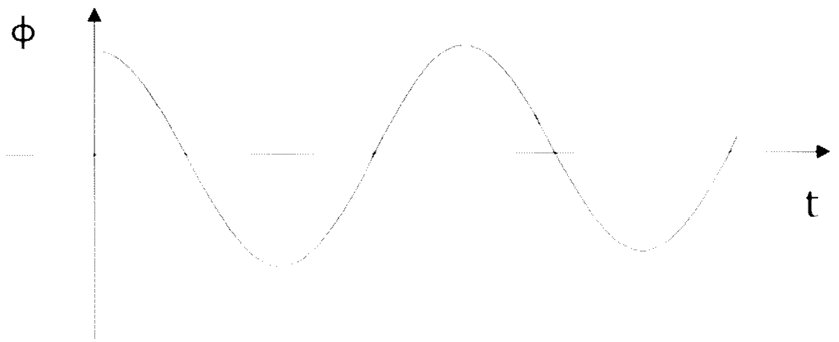
The coil is now perpendicular to the field.
Thus, Flux ϕ = BA = 0.3 x (0.4 x 0.5) = $0.06 = 6 \times 10^{-2}$ Wb ANS

Question 11

$\varepsilon = n\Delta\phi/\Delta t$
During rotation, flux changes from maximum 0.06Wb to 0Wb, thus $\Delta\phi = 0.06$
f = 50Hz, meaning 50 rotations per second.
Thus, period, T = 1/50 for one rotation, so time for a quarter turn is 1/50 x 1/4=1/200=0.005 secs
Magnitude of $\varepsilon = n\Delta\phi/\Delta t = 12(0.06/ 0.005) =$ **300 V ANS**

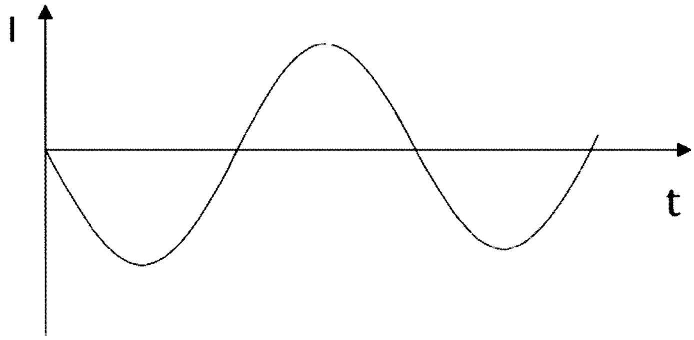
Question 12

The flux will alternate between maximum (coil perpendicular to the field) at t=0 and minimum values (coil parallel to the field) in a sinusoidal fashion.



Question 13

Since $\varepsilon = n\Delta\phi/\Delta t$ the emf should vary as the gradient of the flux (ie: a sine graph starting at a minimum). Also, by Lenz's Law, as flux decreases through the coil, current will flow from B to A (negative) to try to oppose the change and maintain the flux in the coil.
Thus, a negative sine graph starting at a minimum.



Question 14

P = VI
Thus, 2000 = 240I
So, I = **8.3A ANS**

Question 15

Ploss = $I^2R = (25)^2 \times 1.8$ = **1125W = 1.1kW ANS**

Question 16

Vloss = IR = 30 x 1.8 = 54V
Thus, voltage at house = Vtotal – Vloss = 240 – 54 = **186V ANS**

Question 17

Since P loss in wires is given by P loss = I^2R, the lower I can be made, the smaller the power loss (R is fixed once the lines are up). A low I corresponds to a high V (by P = VI), and thus transmission occurring at a relatively high V and low I reduces power losses in the transmission wires.

AREA OF STUDY 2 – Interactions of Light and matter.

Question 1

$E = hc/\lambda = (6.63 \times 10^{-34})(3\times10^{8}) / (540\times10^{-9})$
$= 3.68 \times 10^{-19}$ J = $(3.68 \times 10^{-19})/(1.6\times10^{-19})$ = **2.3eV ANS**

Question 2

Work function of caesium is 2.1eV – the minimum energy required to remove an electron from the surface of the metal.
Thus, the maximum KE of ejected electrons will be 2.3 – 2.1 = **0.2eV ANS**

Question 3

KE = $\frac{1}{2} mv^2$
Thus, $(2.8)(1.6\times10^{-19}) = \frac{1}{2}(9.1 \times 10^{-31}) v^2$
So, v = **9.9×10^5 m/s ANS**

Question 4

Dominica is incorrect.
In the photoelectric effect, a photon of light gives up all of its energy to an electron in the metal, possibly giving it enough energy to break free of the surface of the metal. If the photon's energy is great enough, any excess energy above that required for the electron to break free appears as kinetic energy of the electron.
Increasing the intensity of light has no effect on the KE of the electrons. This is because the energy given to each electron depends on the energy, and hence the frequency, of the incident light. If a frequency above the threshold is used, then increasing the intensity of the light will result in a greater number of photons reaching the metal, but the frequency of the light, and thus the energy of the photons, will remain unchanged. Thus, increasing the intensity of the light (for a frequency above the threshold) will result in a greater number electrons being emitted, but will have no effect on the kinetic energy of these electrons.
These observations support the particle model of light, since with a wave model the incident energy would build up until electrons were released, whereas in reality light of a specific minimum frequency is required for electron ejection.

Question 5
The path difference to the fifth bright band is $5\lambda = 5(632 \times 10^{-9})$ = **3.2×10^{-6}m ANS**

Question 6
Young's experiment supports the **wave model of light**. The interference pattern produced on the screen is evidence of constructive and destructive interference, which is the result of the superposition of waves as they meet in phase or out of phase.
A dark region is created by a region of destructive interference (nodes), where the superposition of light waves causes cancelling (waves out of phase). The bright regions are regions of constructive interference where an antinode is formed when the waves meet in phase and reinforce.

Question 7

$W = \lambda L/d$, where W is the fringe spacing, λ is the wavelength of the laser light, d is distance between the slits, and L is distance from the slits to the wall.
Thus, in order for the spacing of the fringes to be smaller (pattern of fringes closer together), W must be smaller - we must either **decrease** λ or L, or **increase** d.
So, the only correct possibility is **C ANS**

Question 8

The frequency of blue light is higher than the frequency of red light, and thus λ(blue) is shorter than λ(red).
Since amount of diffraction $\approx \lambda/w$, blue light (with its shorter wavelength) will undergo less diffraction than red, and thus the diffraction pattern for blue light would be less spread.

Question 9

Diffraction is a wave property, so this is the **best** explanation.
Thus, **B ANS**

Question 10

This is **best** explained by x-rays and electrons having the same wavelength (diffraction being a wave property). Thus, **D ANS**

Question 11

$E = hc/\lambda = (6.63 \times 10^{-34})(3\times10^{8}) / (250\times10^{-12})$
$= 3.96 \times 10^{-16}$ J = $(7.96 \times 10^{-16})/(1.6\times10^{-19}) = 4972 =$ **<u>5keV ANS</u>**

Question 12

If the patterns are identical, so are the wavelengths.
Thus, use λ = 250pm
$p = h/\lambda$.
$= (6.63 \times 10^{-34}) / (250 \times 10^{-12})$
<u>= 2.7×10^{-24} kgm/s ANS</u>

Question 13

Photons do not have charge or mass.
Thus, **<u>A and B ANS</u>**

AREA OF STUDY 3.1 – Synchrotron and its applications

Question 1

The **storage ring** is a donut-shaped ring into which the booster ring channels electrons. The electrons orbit the ring for hours at a time, at speeds close to that of light, with a series of magnets making them bend around corners as they travel through the ring. As the electrons change direction, they release **synchrotron radiation**. **D ANS**

Question 2

The **circular booster ring** uses an accelerating, or radio frequency (rf) chamber through which electrons pass every time they orbit the ring, giving them a boost of energy as they continue to accelerate around their circular path. **B ANS**

Question 3

The function of the linear accelerator (**linac**) in the synchrotron is to accelerate particles to speeds close to the speed of light. **A ANS**

Question 4

The bending magnets cause the electron paths to bend and thus confine them to a circular path within the storage ring. **C ANS**

Question 5

Total energy lost by the incident x-ray is 3.2 + 27 = 30.2eV
Energy of incident photon, $E = hf = hc/\lambda$
Thus, $E = (6.63 \times 10^{-34}) (3 \times 10^{8}) / (0.3 \times 10^{-9}) = 6.63 \times 10^{-16}$J = 4143.75eV
Energy of scattered photon = 4143.75 – 30.2 = 4113.55eV = 6.582×10^{-16}J
$6.582 \times 10^{-16} = hc/\lambda = (6.63 \times 10^{-34}) (3 \times 10^{8})/ \lambda$
So, $\lambda = 3.02 \times 10^{-10}$m = 0.302 nm Thus, **B ANS**
(Note: the interaction was all but insignificant for this high energy x-ray)

Question 6

Elastic scattering from layers of atoms is known as **Thomson scattering.**
X-ray photons can also interact with electrons and transfer some of their energy to the electron, resulting in the X-ray photon emerging with a longer wavelength (less energy) and the ejection of an electron. These collisions are **inelastic** and are referred to as **Compton scattering**.
Diffuse scattering occurs when X-rays are directed at a sample with a disordered, random orientation of molecules in its array, producing a pattern of circular rings on the detector.
Rasheed scattering does not exist.

This is an example of **Compton Scattering.** **B ANS**

Question 7

KE = ½ mv^2 = eV
= $(1.6 \times 10^{-19})(2.1 \times 10^{3})$
= **3.4×10^{-16} J**
Thus, **A ANS**

Question 8

3.4×10^{-16} = ½ mv^2 = ½ $(9.1 \times 10^{-31})v^2$
Thus, v = **2.7×10^{7} m/s ANS**
So, B ANS

Question 9

F = qvB = evB = $(1.6 \times 10^{-19})(2.7 \times 10^{7})(2.5 \times 10^{-3})$
Thus, F = **1.1×10^{-14}N ANS**
So, **D ANS**

AREA OF STUDY 3.2 – Photonics

Question 1

$E = hf = hc/\lambda$
Thus, $1.9(1.6 \times 10^{-19}) = (6.63 \times 10^{-34})(3 \times 10^{8}) / \lambda$
So, $\lambda = 6.5 \times 10^{7}$m = 650 nm Thus, **C ANS**

Question 2

Wavelength does not change, as it is set by the energy gap, which is constant for a particular LED. Current will increase, as V = IR, even if R is variable. Thus, **C and D ANS**

Question 3

Decreasing band gap energy corresponds to decreasing photon energy and hence increasing photon wavelength. Thus, order will be blue, green, red. **D ANS**

Question 4

Red laser light is superior to red LED light in that it is monochromatic, less divergent, coherent and more intense. Thus, the only correct answer is **A ANS**

Question 5

The best explanation for the peak at point X is a loss of signal, probably due to resonance caused by impurities (eg: water contamination). Thus, **C ANS**

Question 6

Minimum point read from the graph is 1300 nm. Thus, **B ANS**

Question 7

Wavelengths with least attenuation are 1050 nm and 1300 nm.

$v = f\lambda$
$3 \times 10^{8} = f \times 1050 \times 10^{-9}$ So, $f = 2.86 \times 10^{14}$ Hz
$3 \times 10^{8} = f \times 1300 \times 10^{-9}$ So, $f = 2.31 \times 10^{14}$ Hz

Thus, **C ANS**

Question 8

Long wavelengths tend to travel faster in glass than shorter ones, so the IR pulse will arrive earlier. Thus, **A ANS**

Question 9

Rayleigh scattering dominates at these wavelengths and scattering increases as the wavelength decreases, so there will be more attenuation for the RD pulse. Thus, **D ANS**

AREA OF STUDY 3.3 – Sound

Question 1

Sound level = 10log (I / I_o) , where I_o = 1.0 x 10^{-12} Wm^{-2}

Thus, sound level = 10 log (4 x 10^{-3} / 1.0 x 10^{-12}) = **96 dB So, B ANS**

Question 2

I = 4 x 10^{-3} Wm^{-2}
Power = Intensity x area (of a sphere in this case)
= (4 x 10^{-3}) x $4\pi r^2$ = (4 x 10^{-3}) x $4\pi\,(6)^2 \approx$ **1.8 W Thus, A ANS**

Question 3

4 m away, area = $4\pi r^2$ = $4\pi(4)^2$ = 201 m^2

Thus, I = P/A = 1.8/201 = 9x10^{-3} W/m^2 ANS

So the intensity level = 10 log (9x10^{-3} / 1.0 x 10^{-12}) = 99.5 dBANS
Thus, the increase is 99.5-96 = **3.5 dB ANS**
Alternatively:
I increased by a factor of 8.96x10^{-3}/(4 x 10^{-3}) = 2.25 times
Thus, the corresponding increase in intensity level is:
10 log (2.25) = **3.5dB ANS**

Question 4

Cass is likely to hear an alternating series of loud and soft intensities of sound, caused by interference of the two in-phase waves from the two speakers.
At points where the path difference of the waves travelling from the two speakers is a whole number of wavelengths (p.d. = Nλ, where N is an integer), constructive interference occurs and a loud sound is heard (antinode). At points where the waves are half a cycle out of phase (path difference = (N-1/2) λ) destructive interference occurs and a very soft sound is heard (node).
Cass is walking along a progression of nodes and antinodes, and thus hears a series of loud and soft sounds. Thus, **B ANS**

Question 5

A crystal microphone employs the piezoelectric effect. Thus, **D ANS**

Question 6

An electret-condenser microphone employs capacitance. Thus, **B ANS**

Question 7

A dynamic microphone employs the electromagnetic induction. Thus, **A ANS**

Question 8

$v = f\lambda$.
Thus, $330 = 100\lambda$
So, **$\lambda = 3.3$ m ANS**

Question 9

Low frequency sounds diffract more easily (longer wavelength, amount of diffraction is proportional to λ/w). Thus higher frequency sounds from the central speaker have shorter wavelengths and thus diffract less around the TV and are thus less audible to Al and Oscar.