CHEMOLOGY EDUCATION SERVICES

Name:________________________

2011 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	16	40	40
2. Interactions of Light and Matter	13	30	30
3.1 Synchrotron and its applications	10	20	20
3.2 Photonics	10	20	20
3.3 Sound	10	20	20

Directions to students
This booklet is 20 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 **16 questions**.
A total of **40 marks** is available for Area 1.

David has come across a sample of the radioactive isotope Hansenium and decides to investigate it. He places the sample near a magnetic field and shoots the various particles being emitted from the Hansenium through the field, tracking their paths. The results for particles A, B and C are shown in Figure 1.

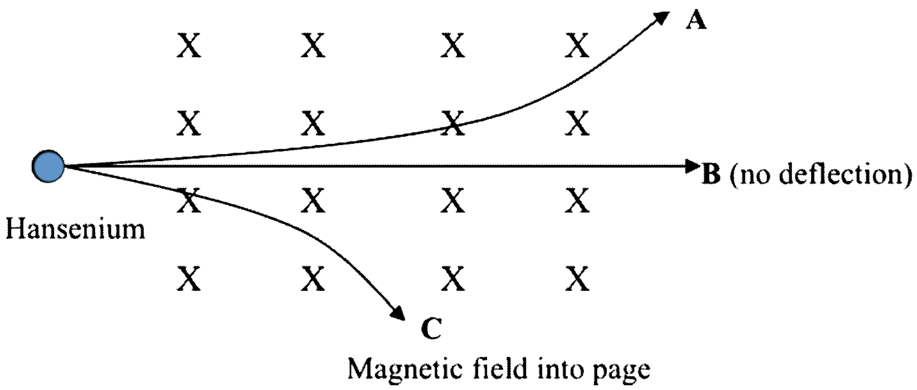

Figure 1

Question 1

Which of the following is true of the charges on particles A, B and C?

A. A is positive, B has no charge, C is negative
B. A and C have no charge and B is positive
C. There is insufficient information to determine the charges on A, B and C
D. A is negative, B has no charge, C is positive
E. A has no charge, B is positive and C is negative **3 marks**

Question 2
Justify your answer for Question 1.

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3 marks

Now that he has hired the magnetic field for the day, David decides to perform another experiment with it. He suspends a loop of wire (which he has artfully crafted from an old coat hanger) in the field, and rotates it at a frequency of 6Hz. The loop is square, with side length 4cm, and the magnetic field strength is 0.5T. David's apparatus is shown in Figure 2 below.

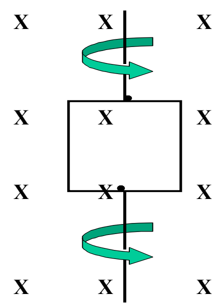

Figure 2

Question 3

Calculate the magnetic flux through the loop when it is in the position shown in Figure 2.

Wb

2 marks

Question 4

Calculate the magnetic flux through the loop if it rotated 90 degrees and lay parallel to the magnetic field.

Wb

2 marks

Question 5

What is the magnitude of the average EMF generated in the loop as it completes a quarter of a rotation from the position shown above?

V

4 marks

Area 1 - continued

Simon has settled down for the evening to watch his favourite television show, Q & A. The Australian mains power supply to which Simon's TV is connected is 240V RMS at 50Hz. Simon's television has a power rating of 400W.

Question 6

What is the peak voltage of the power supply?

V

2 marks

Question 7

Explain what is meant by RMS voltage and how it relates to equivalent DC voltage.

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3 marks

Question 8

What is the RMS current in Simon's television?

A

2 marks

Question 9

What is the average current in the television for one complete cycle?

A

2 marks

Simon gets very excited by the topics being discussed by the panel on Q & A and decides that he wants to get more involved and have his opinions heard. He switches on his laptop computer and joins the Q & A Twitter discussion online.
His computer's AC adapter uses a transformer to convert the 240V RMS mains voltage to 12V RMS for use by his computer. The input current is 0.3A RMS.

Area 1 - continued

Question 10

What is the ratio of number of turns in the primary coil to number of turns in the secondary coil for this transformer?

2 marks

Question 11

What is the RMS current through the secondary coil of the transformer?

A

2 marks

Many transformers used in AC adapters for laptop computers carry safety warnings stating that they should only be used indoors and in dry locations, and should not be opened due to the risk of electric shock.

Question 12
Explain why such a safety warning would be necessary.

3 marks

Deen and Helen are investigating power generation principles, and have placed a rectangular coil of 25 turns between the poles of a magnet as shown in Figure 3 below. The magnet creates a uniform magnetic field of flux density 0·4 T.

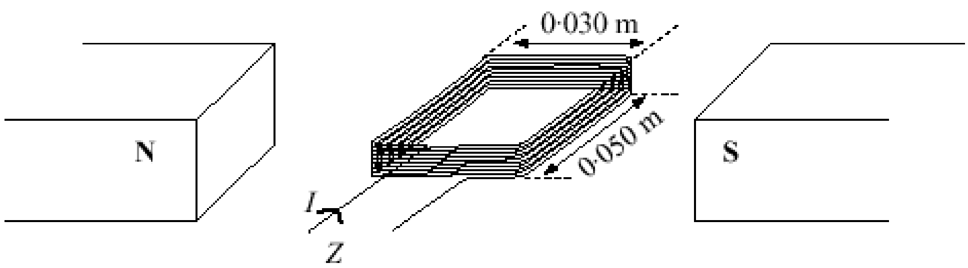

Figure 3

Deen and Helen now pass a current of 3A through the coil.

Question 13

When Deen turns the current on, the coil is stationary in a position parallel to the plane of the magnetic field. The **net** force on the coil is 0 N, yet the coil begins rotating. Explain why this occurs.

3 marks

Question 14

Calculate the torque that acts on the coil when it is in the position shown above.

N

2 marks

Question 15

If viewed from position Z, in what direction will the coil rotate?

2 marks

A device is placed at Z to allow current to be supplied to the coil so that the coil rotates continuously.

Question 16

Name the device and explain how it works.

3 marks

Area 1 – continued

AREA 2 – Interactions of light and matter

Specific Instructions for Area 2

Area 2 consists of **13 questions**.
There are **30 marks** 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

Gwen and Tanya are intrigued by Young's double slit interference experiment, and have set up the equipment as shown in Figure 1 to investigate further.

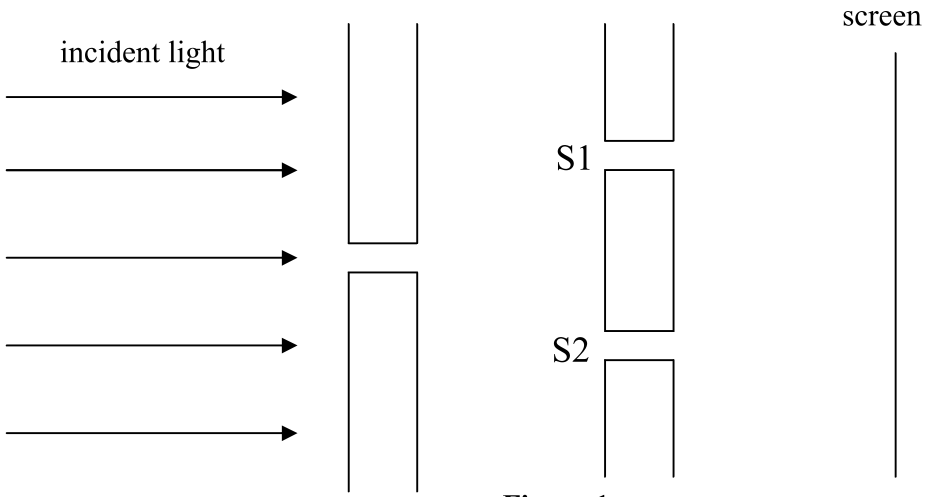

Figure 1

Question 1

Explain why a single slit is used in front of the double slit in this experiment.

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2 marks

Question 2

Sketch the interference pattern that would be observed on the screen.

2 marks

Area 2 - continued

Question 3

Explain how such a pattern is created by the double slit experiment.

3 marks

Question 4

What physical changes would cause the spacing of the observed pattern to change?

2 marks

Question 5

Does Young's experiment support the wave or particle model of light? Support your answer.

3 marks

Question 6

If the incident light is laser light of wavelength 540nm, calculate the path difference at the first nodal line.

nm

2 marks

Gwen replaces the monochromatic laser light with a white light source. She predicts that this will produce bands of colour on the screen with a central white band. Tanya agrees about the bands of colour, but predicts that the central band will be coloured rather than white.

Question 7

Which of the girls is correct? Justify your answer.

3 marks

Area 2 – continued

Ireni and Lisa are investigating the photoelectric effect. They place a piece of caesium as photocathode in an evacuated, clear glass tube. They illuminate the surface of the metal with monochromatic light of different frequencies and measure the maximum kinetic energy of ejected electrons. Some of their results are shown in the table in Figure 2.

Colour	Frequency (Hz)	Photon energy (eV)	Max electron KE (eV)	Max current (mA)
Red	4.8×10^{14}	2.0		
Green	5.4×10^{14}		0.1	0.2
Blue	7.3×10^{14}	3.0	0.9	
UV1	10.1×10^{14}	4.2	2.1	4.2
UV2	12×10^{14}			

Figure 2

Question 8

What is the energy of a single photon of the green monochromatic light?

eV

2 marks

Question 9

Use the table in Figure 2 to estimate the work function for caesium metal.

eV

2 marks

Question 10

The maximum electron current for the blue monochromatic light depends on:

A. the photon energy of the incident light
B. the frequency of the incident light
C. the wavelength of the incident light
D. the intensity of the incident light

2 marks

Area 2 - continued

Question 11

Using the space below, graph maximum KE of emitted photoelectrons against frequency.

2 marks

Question 12

By extrapolating your graph in Question 11, determine the maximum kinetic energy of the photoelectrons for the red and UV2 sources. If no electrons are emitted, write NONE.

Red:	eV
UV2:	eV

2 marks

Question 13

Calculate the de Broglie wavelength of an electron after it accelerates through a potential difference of 2kV.

m

3 marks

Area 2 - continued

AREA 3.1 – Synchrotron and its applications

Specific Instructions for Area 3.1
Area 3.1 consists of **10 questions**. **Answer all questions on the multiple choice answer sheet provided.** Marks are indicated at the end of each question. 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

Bebe is directing a beam of X-rays with energy 12keV at a sheet of thin metal foil. The X-rays are scattered by the foil.

Question 1

What is the wavelength of the X-rays?

A. 1×10^{-10}
B. 2×10^{-12}
C. 3×10^{-10}
D. 1×10^{-14}

2 marks

Question 2

Which of the following is the best estimate for the energy of X-rays that have undergone Thomson scattering?

A. 12keV
B. 20keV
C. 0keV
D. 6keV

2 marks

Bebe and her assistant Sophie now direct a beam of X-rays with a range of wavelengths at a perfect crystal, as shown in Figure 1.

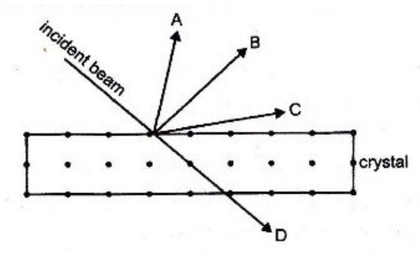

Figure 1

Area 3.1 - continued

Due to Bragg diffraction, one of the beams will be monochromatic.

Question 3

The beam in Figure 1 that contributes to Bragg diffraction is:

A. beam A
B. beam B
C. beam C
D. beam D **2 marks**

Bebe now rotates the sample, and Bragg diffracted X-rays of wavelength 32pm are detected exiting the sample at a minimum angle of 7^0 to the surface.

Question 4

What is the spacing between layers of the crystal?

A. 2.6×10^{-10} m
B. 1.3×10^{-10} m
C. 2.6×10^{-12} m
D. 1.3×10^{-12} m **2 marks**

Dynae is about to visit Australia's synchrotron and is reading up about its operation in preparation for her visit. At the end of the information booklet is a multiple choice quiz to test her knowledge. Unsure of the answers, she needs some help to complete the quiz.

Question 5

In the synchrotron, electrons are accelerated to speeds of approximately 99.9% of the speed of light by the

A. linac
B. electron gun
C. undulator
D. circular booster **2 marks**

Question 6

The electron beam is confined to a circular orbit by a series of

A. beamlines
B. RF cavities
C. bending magnets
D. linear accelerators **2 marks**

Area 3.1 - continued

Dynae reads about one example where an electron is accelerated through a potential difference of 2.5kV.

Question 7

What is the kinetic energy of the electron after this acceleration.

A. 4.0×10^{-16} J
B. 8.0×10^{-16} J
C. 4.0×10^{-8} J
D. 8.0×10^{-8} J

2 marks

Question 8

What is the speed achieved by the electron.

A. 3.0×10^{7} m/s
B. 3.4×10^{7} m/s
C. 2.3×10^{7} m/s
D. 4.2×10^{7} m/s

2 marks

The electron then travels at right angles to a region of uniform magnetic field in which the field strength is 4.2×10^{-3}T.

Question 9

What is the force on the electron?

A. 4.4×10^{-14}N
B. 9.6×10^{-14}N
C. 1.0×10^{-14}N
D. 2.0×10^{-14}N

2 marks

Question 10

How would the answer to Question 9 above change if the electron were travelling in a path parallel to the magnetic field?

A. the force would not change
B. the force would double
C. the force would halve
D. the force would be zero

2 marks

Area 3.1 - continued

AREA 3.2 – Photonics

Specific Instructions for Area 3.2
Area 3.2 consists of **10 questions**.
Answer all questions on the multiple choice answer sheet provided.
There are **20 marks** 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

Jen and David are driving home from a Bikram Yoga class and notice that the lights in the traffic lights at the end of their street have now been replaced with LED-based lamps. The wavelength of the orange light produced by a typical LED is 540nm.

Question 1

Which of the following are advantages of using LEDs as a light source in traffic lights (one or more answers)?

A. A single LED can produce light in a wide range of colours
B. LEDs are very cheap to buy compared to incandescent lights
C. LEDs are very efficient at converting electricity into light energy
D. LED have much longer life spans than incandescent bulbs **2 marks**

Question 2

What is the energy gap of the material from which the orange LED is made?

A. 3.7×10^{-19}J
B. 4.8×10^{-19}J
C. 8.3×10^{-19}J
D. 5.2×10^{-19}J **2 marks**

Question 3

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

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

Area 3.2 – continued

Another device widely used to produce light is the laser.

Question 4

Choose the **best** description of the way in which a laser produces light.

A. Electrons emit photons as they drop from higher to lower energy levels
B. Atoms are stimulated to release their energies by interacting with photons of the same energy
C. Atoms are heated to produce light energy
D. Electrons are forced into higher energy levels within the atom, emitting photons of light as a result

2 marks

Question 5

Which **one or more** of the following is a correct statement about the light produced by a red LED light as compared to that produced by a red laser light?

A. The red laser light is more intense than the red LED light
B. The red laser light is less coherent than the red LED light
C. The red LED light has more divergence than the red laser light
D. The red LED light is more monochromatic than the red laser light

2 marks

A step-index multimode optical fibre is being used for a short-distance telecommunication link. The fibre has a core of Ge-doped silica glass with a refractive index of 1.49 and a cladding of refractive index 1.46.

Question 6

What is the critical angle of the core-cladding boundary of this fibre.

A. 38.5^0
B. 78.5^0
C. 49.3^0
D. 84.2^0

2 marks

Question 7

What is the acceptance angle for this fibre in water (n=1.33)?

A. 26^0
B. 48^0
C. 72^0
D. 13^0

2 marks

Area 3.2 – continued

Lynne is a brilliant surgeon who was a pioneer in the use of fibre optics in endoscopic keyhole surgery. In this application, optical fibre bundles are used to image objects inside the human body.

Question 8

The best estimate of the number of fibres in the central bundle of the endoscope is:

A. 150
B. 1
C. 500
D. 10000

2 marks

Light may be lost as it travels down optical fibres, with much attenuation being due to absorption and Rayleigh Scattering.

Question 9

Attenuation due to absorption is caused by (one or more answers):

A. impurities in the optical fibre
B. variations in density of the optical fibre
C. resonance
D. a monochromatic light source

2 marks

Question 10

Which of the following wavelengths would suffer the least attenuation due to Rayleigh scattering?

A. 1500nm
B. 800nm
C. 1250nm
D. 570nm

2 marks

Area 3.2 – continued

AREA 3.3 – Sound

Specific Instructions for Area 3.3
Area 3.3 consists of **10 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 $4\pi r^2$

Anna and Joel are having a quiet drink outside a café. The water glasses from which they are drinking are 12cm high, flat-bottomed cylinders. A sudden gust of wind blows over the top of Anna's glass, producing a resonant note.
The depth of water in Anna's glass is 4cm, and that in Joel's glass is 8cm, as shown in Figure 1 below.

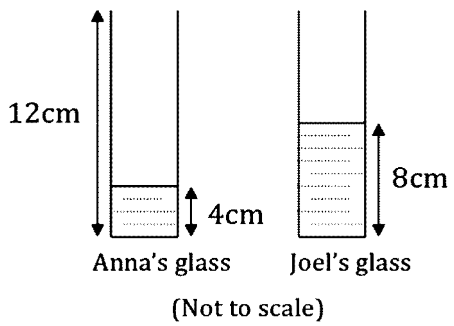

Figure 1

Question 1

What is the frequency of the fundamental mode of the resonance produced by the wind blowing over Anna's glass?

A. 1240Hz
B. 1030Hz
C. 264Hz
D. 843Hz

2 marks

Question 2

The fundamental resonant frequency produced by Joel's glass would be:

A. double the frequency of Anna's
B. half the frequency of Anna's
C. the same frequency as Anna's
D. four times the frequency of Anna's

2 marks

Area 3.3 - continued

Suzie joins Anna and Joel at the café, bringing with her a tall glass that is larger than theirs, which is also filled with water.
Joel holds a 256 Hz tuning fork (which he keeps in his pocket for just such an occasion) above the cylinder, then gradually lowers the water height. Suzie observes that the sound produced becomes quite loud for the first time when the length of the air column is 32cm. Joel now selects a tuning fork of a different frequency and vibrates it above the 32cm long air column. It also produces a loud sound.

Question 3

What is a possible frequency for the second tuning fork?

A 83 Hz
B 512 Hz
C 128 Hz
D 768 Hz

2 marks

Question 4

Resonance is best described as:

A. A frequency to which the human ear is very sensitive
B. The vibration of a glass due to the Brownian motion of its component atoms
C. An amplification due to the superposition of a travelling wave with its reflection
D. A group of frequencies which are pleasing to the ear when played together

2 marks

Kate Maree is performing in the Australian production of Mary Poppins and is currently belting out a Supercalifragilisticexpialidocious note. Patrick is in the audience at a point 20m from Kate Maree and measures the sound intensity of her spectacular note to be 3.1×10^{-4} Wm^{-2}.

Question 5

What is the sound intensity level of Kate Maree's note at this point?

A. 31dB
B. 85dB
C. 44dB
D. 82dB

2 marks

Area 3.3 - continued

Question 6

What is the total acoustic power being produced?
(assume that the sound spreads out uniformly in a spherical manner)

A. 43W
B. 72W
C. 4.9W
D. 1.6W

2 marks

Question 7

What would be the **increase** in sound intensity level at a point 10m from Kate Maree?

A. 12dB
B. 6dB
C. 91dB
D. 0dB

2 marks

Sean is a sound technician working on the stage show Mary Poppins. He organises hand-held microphones for the singers to use and also sets up loudspeakers in the audience so that the amplified sound may be transmitted out to the audience.

Question 8

The best explanation for how a loudspeaker generates sound waves from electrical signals is:

A. Electrical energy produces movement of the coil
B. Movement of the coil is produced through a series of mechanical levers
C. Interaction between current and magnetic field produce movement of the coil
D. Movement of the coil is induced via magnetic resonance

2 marks

Area 3.3 - continued

Question 9

The best description of the nature of the sound waves produced by the loudspeaker is:

A. the motion of the speaker cone produces transverse waves, with the air in front of the speaker moving up and down at the speed of sound
B. the motion of the speaker cone produces transverse waves, with the air particles moving away from the speaker at the speed of sound
C. the movement of the speaker cone produces a longitudinal wave, with compressions and rarefactions in the air moving away from the speaker at the speed of sound
D. the movement of the speaker cone produces a longitudinal wave, with compressions and rarefactions moving backwards and forwards in front of the speaker at the speed of sound

2 marks

Question 10

Which of the following microphone types would Sean most likely use for this purpose?

A. crystal
B. dynamic
C. electret-condenser
D. velocity?

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 2011 PHYSICS UNIT 4 TRIAL EXAM

AREA OF STUDY 1 - Electric Power

Question 1

A is positive, B has no charge, C is negative.
Thus, the correct answer is **A ANS**

Question 2

Using the right hand slap, rule, the force on a positively charged particle in this field (field into the page) would be upwards. Since A deviates upwards from its straight-line course, it must be a positively charged particle. Similarly, since C deviates downwards, the net force on it must be in a downward direction and thus it must be negatively charged. B is not deflected at all by the magnetic field, and thus must be uncharged.

Question 3

Flux Φ = BA
= 0.5 x (0.04 x 0.04)
= **8×10^{-4} Wb ANS**

Question 4

Since the loop of foil is now parallel to the field, area perpendicular to the field (A) = 0.
Thus, flux = BA = 0 also. **$\Phi = 0$ ANS**

Question 5

$\varepsilon = n\Delta\phi/\Delta t$
After ¼ rotation, the area of the loop of foil perpendicular to the field = 0. Thus ϕ at that point = 0 also, as calculated above.
$\Rightarrow \quad \Delta\phi = 8 \times 10^{-4}$
f = 6 Hz
Thus, period, T = 1/6 = 0.17 seconds for one rotation.

Thus, ¼ rotation takes 0.17/4 = 0.042 seconds.

Magnitude of $\varepsilon = n\Delta\phi/\Delta t$

$= 1 \times 8 \times 10^{-4} / 0.042$

$=$ **1.9×10^{-2} V** **ANS**

Question 6

At any time, Vpeak $= \sqrt{2}$ Vrms

$= \sqrt{2} \times 240 =$ **340 V ANS**

Question 7

An RMS voltage value is the equivalent constant DC supply voltage which would be required to provide the same power as the AC voltage supply. A 240V RMS AC supply is equivalent to a 240V DC supply, but the AC actually varies between +340 and -340V.

Question 8

P = VI

Thus, in Simon's television,

400 = 240I, So I = **1.7A RMS ANS**

Question 9

In AC (alternating current), the current changes direction every half cycle. Thus, the **average** current for one whole cycle will be 0A, as the positive current and negative current in the cycle will cancel out. Thus, **0A ANS**

Question 10

N1/N2 = V1/V2 = 240/12 = **20 ANS**

Question 11

N1/N2 = I_2/I_1

Thus, 20 = $I_2/0.3$

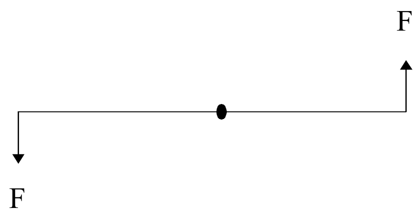
So, I_2 = **6A ANS**

Question 12

One coil in the transformer is connected directly to the 240V supply, and thus any contact with this coil may result in a current path to Earth through your body and thus a dangerous electric shock. If the coil is in contact with water, this may conduct the current and create an eectrocution risk for anyone in contact with the water.

Question 13

The net force on the coil is zero, but the **torque** on it is not zero. The two opposite sides of the coil experience forces acting down and up respectively, which combine to give a torque of 2Fd in an anticlockwise direction. This causes the coil to rotate.



Question 14

$F = nBIl$
$= 25 \times 0.4 \times 3 \times 0.05$
$= \mathbf{1.5\ N}$
Using the right hand slap rule, the direction of the force is **anticlockwise.**
Thus, the torque on the coil is **1.5 N anticlockwise** **ANS**

Question 15

The unbalanced torque on the coil is **anticlockwise**, and thus the coil will rotate in this direction as viewed from Z.

Question 16

A **commutator** ensures that the direction of current through the loop changes every half turn.
The loop should rotate continuously in the same direction. In the example shown, there is a force on the coil that causes it to rotate. When the coil reaches a point where it is perpendicular to the field, the torque is zero. The coil is carried through this position by its momentum, but it is necessary to reverse the current to maintain torque in the same direction and thus get a steady rotation of the coil in one direction.

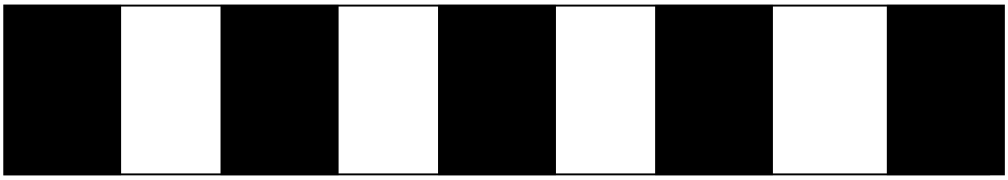
AREA OF STUDY 2 – Interactions of Light and matter.

Question 1

The single slit is used before the double slit so that light which passes through the single slit acts as light from a single point source. Thus, when this light passes through the double slits, the emerging waves are in phase with each other and have constant phase (ie: they are coherent).

Question 2

The interference pattern formed on the screen will be one of alternating bright and dark bands. (Note – dark bands are bright regions – middle band must be bright/antinode)



Question 3

A dark region is created by a region of destructive interference**, where the superposition of 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 4

Use the equation $W = \lambda L/d$,
where d = distance between the slits, L = distance from the slits to the wall, W = the fringe spacing and λ = wavelength of the light.
Thus, in order for the spacing of the fringes to change W must change – this will happen if we alter λ , L or d.
So, in order to change the pattern spacing, Gwen and Tanya could change the wavelength of the light, the distance between the slits or the distance from the slits to the wall.

Question 5

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.

Question 6

The first nodal line is the first point at which destructive interference occurs. Thus, the path difference will be $\lambda/2$.
Since λ = 540nm, $\lambda/2$ = 540/2 = **270nm ANS**

Question 7

Gwen is correct – the centre of the central band will be white, as every wavelength will have a path difference of zero at this point.
You could argue that Tanya has a point as well, since the edges of the central band could show some colour effects as the different wavelengths will cancel differently as you move away from the centre of the central band.

Question 8

$E = hf = (6.63 \times 10^{-34}) \times (5.4 \times 10^{14})$
$= 3.6 \times 10^{-19}$ J $= (3.6 \times 10^{-19})/(1.6 \times 10^{-19})$ = **2.24 eV ANS**

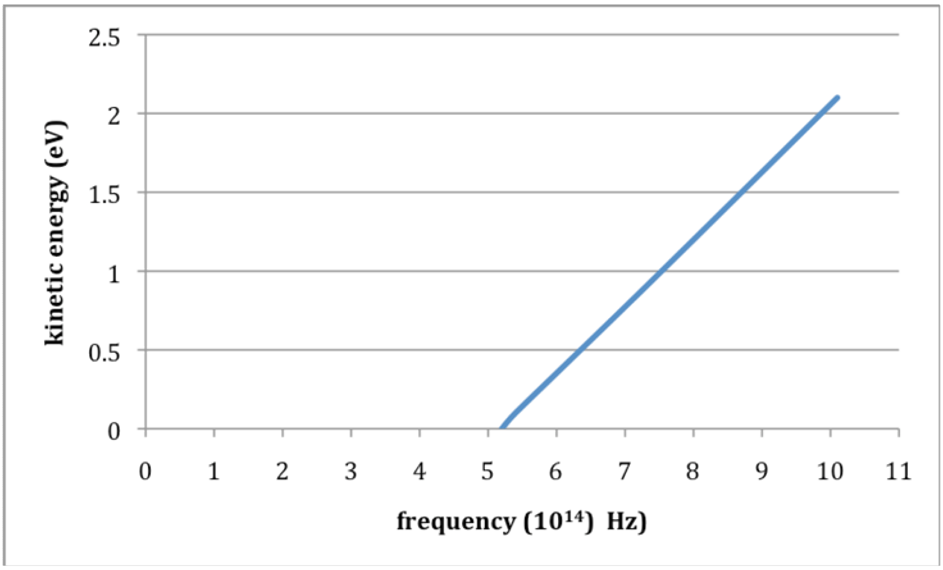
Question 9

Using the results for blue light, work function (the minimum amount of energy that an electron needs to escape the surface of the metal) can be calculated.
Work function = photon energy – max energy of photoelectron = 3.0 – 0.9 = **2.1 eV ANS**
(Confirm with the only other frequency which has both bits of information, UV1:
Work function = 4.2 – 2.1 = 2.1 eV)

Question 10

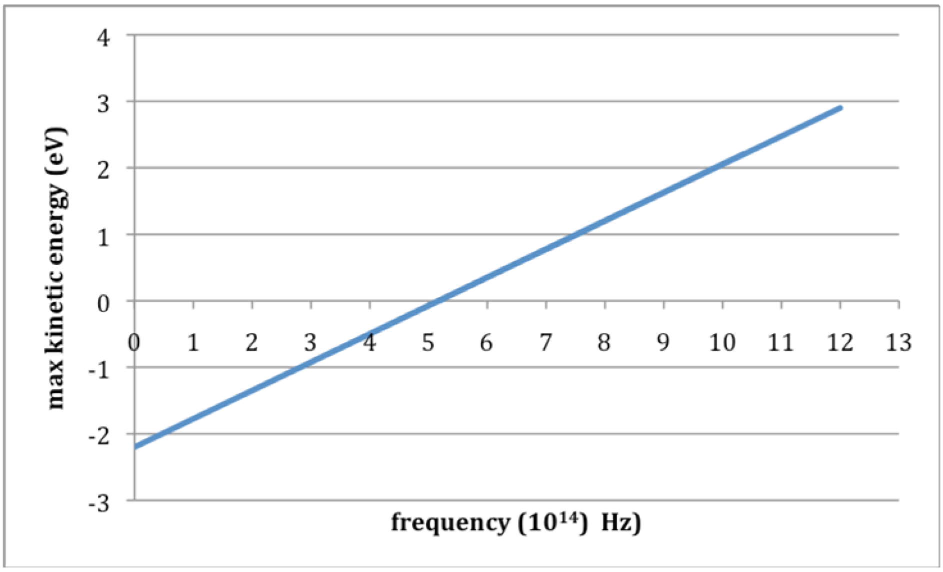
Once the threshold frequency has been reached, the maximum current depends on the number of photons incident on the metal, ie: **the intensity of the incident light.** Thus, **D ANS**

Question 11



Question 12

Extrapolating the graph:



The frequency of the red light is below the cut-off frequency required for electrons to be ejected (approx 5.2 x 10^{14}Hz, as read from the X-intercept of the graph). Thus, no electrons are ejected. From the graph, the max kinetic energy of electrons ejected by the UV2 source frequency is approx 2.9eV.

Thus, **Red: NONE; UV2: 2.9eV ANS**

Question 13

$p = h/\lambda$.
Thus, $\lambda = h/p$, and $p = \sqrt{(2Em)}$ (since $p=mv$ and $E= KE = \frac{1}{2} mv^2$)
$\lambda = (6.63 \times 10^{-34}) / \sqrt{(2 \times 2\times10^3 \times 1.6\times10^{-19} \times 9.1\times10^{-31})}$
= 2.8×10^{-11} m ANS

AREA OF STUDY 3.1 – Synchrotron and its applications

Question 1

Energy of incident photon, $E = hf = hc/\lambda$
Thus, $12000 (1.6 \times 10^{-19}) = (6.63 \times 10^{-34}) (3 \times 10^8) / \lambda$
So, $\lambda = 1 \times 10^{-10}$m = 0.1 nm Thus, A ANS

Question 2

Thomson scattering is **elastic** scattering; thus there will be no loss of KE and energy will remain approximately the same.
So, **A ANS**

Question 3

Bragg diffraction involves reflection in a specular fashion (angle of incidence = angle of reflection). Thus, **B ANS**

Question 4

Using Bragg's equation, $2d\sin\theta = n\lambda$
Thus, $d = n\lambda/2\sin\theta$
For n=1, $d = 1(32 \times 10^{-12})/2\sin(7)$ = **1.3×10^{-10} m**
Thus, B ANS

Question 5

In the synchrotron, electrons are accelerated to speeds of approximately 99.9% of the speed of light by the **linac**. Thus, **A ANS**

Question 6

The electron beam is confined to a circular orbit by a series of **bending magnets**.
Thus, **C ANS**

Question 7

KE = ½ mv^2 = eV
= $(1.6 \times 10^{-19})(2.5 \times 10^{3})$
= **4.0×10^{-16} J** Thus, **A ANS**

Question 8

4×10^{-16} = ½ mv^2 = ½ $(9.1 \times 10^{-31})v^2$
Thus, v = **3.0×10^{7} m/s ANS** Thus, **A ANS**

Question 9

F = qvB = evB = $(1.6 \times 10^{-19})(3 \times 10^{7})(4.2 \times 10^{-3})$
Thus, F = **2.0×10^{-14}N** Thus, **D ANS**

Question 10

The full equation for force on the electron due to the magnetic field is
F = qvBsinθ
If the electron is travelling perpendicular to the field, θ = 90, sinθ = 1 and F = qvB.
However, if the electron travels parallel to the field, θ = 0, sinθ = 0 and F = 0.
Thus, if the electron is travelling parallel to the field,
The answer to Question 9 would differ as the **force on the electron would be 0.**
Thus, **D ANS**

AREA OF STUDY 3.2 – Photonics

Question 1

Light emitting diodes are far **more efficient** than incandescent bulbs at converting electricity into visible light, they are rugged and compact, and can often last around 100 times longer than incandescent bulbs. LEDs are fundamentally **monochromatic** emitters, and are thus ideal for applications requiring high-brightness, single-color lamps (eg: automotive tail-lights, turn signals, traffic signals, runway lights at airports, warning lights).
While there is a higher initial cost for LEDs, this can often be recovered quickly due to their higher efficiency in producing light, which is accomplished without the need for filtering.
Thus, **C and D ANS**

Question 2

$E = hf = hc/\lambda$
$= (6.63 \times 10^{-34})(3 \times 10^{8}) / (540 \times 10^{-9})$
$= 3.7 \times 10^{-19}$J Thus, A ANS

Question 3

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

Question 4

A laser (Light Amplification by Stimulated Emission of Radiation) produces light by the stimulated emission of radiation.
The best definition is B ANS

Question 5

A laser light is superior to an LED in being more coherent, more monochromatic, more intense and less divergent.
Thus, **A and C ANS**

Question 6

$n_2=1.46$, $n_1=1.49$
$\sin\theta_c = n_2 / n_1$
Thus, $\sin\theta_c = 1.46/1.49$
$\theta_c = 78.5^0$ Thus, **B ANS**

Question 7

$n_{ext} \sin\theta_1 = \sqrt{(n^2_{core} - n^2_{cladding})}$ where θ_1 = angle of acceptance
Thus, $1.33 \sin\theta_1 = \sqrt{(1.49^2 - 1.46^2)}$
So **$\theta_1 = 13^0$** Thus, **D ANS**

Question 8

The best estimate of the number of fibres in the central bundle of the endoscope is 10000. Thus, **D ANS**

Question 9

Absorption occurs due to impurities in the fibre, or resonance.
Thus, A and C ANS

Question 10

Rayleigh Scattering occurs when variation in the density of the optical fibre (usually created in manufacture) cause scattering and loss of light.
Increasing the wavelength decreases the scattering, since Rayleigh Scattering $\alpha\ 1/\lambda^4$
Thus, the longest wavelength suffers the least scattering, **so A ANS**

AREA OF STUDY 3.3 – Sound

Question 1

The column of air is acting as a pipe closed at one end. Thus, it must have a node at the closed end and an antinode at the open end. The fundamental frequency in this case is four times the length of the tube. Thus, for a closed tube, λ fundamental = 4L.
λ fundamental = 4L = 4x8 = 32cm = 0.32m
The corresponding frequency can be calculated from $v = f\lambda$
$\Rightarrow$ 330 = f x 0.32
$\Rightarrow$ f = **1030Hz** Thus, **B ANS**

Question 2

The length of Joel's "pipe" is **double** the length of Anna's.
$\lambda = 4L$, L_A=8cm, L_J=4cm
Thus, $\lambda_A = 2\lambda_J$ (or $\lambda_J=\lambda_A/2$)
Thus, $f_J = v/(\lambda_A/2) = 2v/\lambda_A = 2f_A$
Thus, the frequency of resonance for Joel's is **twice the frequency** of that for Anna's. So, **A ANS**

Question 3

For a closed tube, the first overtone is the third harmonic (only the odd harmonics are possible; f, 3f, 5f….)
Thus, $f_{\text{next possible}} = 3 \times f_{\text{fundamental}}$
= 3 x 256 = **768 Hz. Thus, D ANS**

Question 4

Resonance occurs when the frequency imposed corresponds to the natural frequency of vibration. For example, in a resonant tube, this would depend on column length. When resonance occurs, a standing wave is set up in the tube, consisting of the superposition of the travelling sound wave with its reflection, and an amplification of sound occurs. Thus, **C ANS**

Question 5

Sound level = 10log (I / I_O) , where $I_O = 1.0 \times 10^{-12}$ Wm^{-2}
$\Rightarrow$ sound level = 10 log ($3.1 \times 10^{-4} / 1.0 \times 10^{-12}$)
= **85 dB** Thus**, B ANS**

Question 6

Power = Intensity x area (of a sphere in this case)
= (3.1×10^{-4}) x $4\pi r^2$
= (3.1×10^{-4}) x $4\pi (20)^2$
= **1.6 W** Thus, **D ANS**

Question 7

At a point 10m away, area = $4\pi r^2 = 4\pi(10)^2 = 1257\ m^2$
Thus, $I = P/A = 1.6/1257 = 1.27 \times 10^{-3}\ W/m^2$
So the intensity level = $10 \log (1.27 \times 10^{-3} / 1.0 \times 10^{-12})$
= **91 dB**
Thus, the increase is 91-85 = 6 dB **Thus,** B ANS

Alternatively:

I increased by a factor of $(1.27 \times 10^{-3})/(3.1 \times 10^{-4}) = 4$ times
Thus, the corresponding increase in intensity level is:
$10 \log (4) =$ **6dB ANS**

Question 8

The amplifier's signal is sent to a speaker coil which then contains a varying electric current. Since the coil is within a magnetic field, the interaction between the current and the magnetic field produces movement of the coil. Since the moving coil is attached to the speaker cone, this also moves, vibrating and pushing the air with a series of compressions and rarefactions that we interpret as sound. Thus, **C ANS**

Question 9

The best description of the nature of the sound waves produced by the loudspeaker is that the movement of the speaker cone produces a longitudinal wave, with compressions and rarefactions in the air moving away from the speaker at the speed of sound. Thus, **C ANS**

Question 10

Dynamic microphones are strong and resistant to moisture, as well as responding well in the range of frequencies of the human voice, so they are often used in stage performance by singers or bands.
Thus, **B ANS**