St. Mary's Anglican Girls' School

Year 12

Atomic Physics

Test

2009

Constants
See Constants Sheet

Name _____

Marks _____/ **47**

Instructions
- Please state all answers accurate to **three significant figures**.
- Please show **all** working to obtain **all** marks.

1. Is electromagnetic radiation a wave or a particle? Explain with examples.

(3 marks)

2. A particular metal has a work function equal to green light. Explain what will happen and why if …

Situation	Result / Observation /Explanations
Weak red light is shone on the surface	
Intense red light is shone on the surface on a hot day.	
Purple light is shone on the surface	
UV light is shone on the surface.	

(2 marks)

3. How could you set up an experiment to see what colours of while light are absorbed by a green leaf?

(3 marks)

4. Circle which one of the following ordered pairs is not part of the electromagnetic spectrum?

(1 mark)

Wavelength	**Frequency**	
450 nm	6.67×10^{14} Hz	
550 nm	5.45×10^{14} Hz	
650 nm	2.32×10^{14} Hz	

5. In response to a complaint about electric / hybrid cars being too quiet and consequently a potential hazard to pedestrians, a car designer at Toyota has decided to paint a car with special paint that glows (to increase visibility).

a) The painted car is left in the sun for a few hours and then driven into a pitch dark garage. In the garage the paint work gives of a pale green light for a few minutes afterwards. What is happening at the atomic scale to produce this light?

(3 marks)

b) Is the light only produced when it is dark? Explain.

(2 marks)

c) The car is now parked outside all day. After sunset, will the car continue to glow all night until dawn? Explain.

(2 marks)

6. A scientist is analysing a photon with a wavelength of 828.0 Å.

a) What is the frequency of this photon?

(1 mark)

b) How much energy does it contain in eV?

(1 mark)

c) This photon is absorbed by an electron in the ground state of an atom. The atom has an ionisation energy of 12.2 eV. What will be the velocity of the electron as it is ejected from the surface of the atom?

(3 marks)

d) Write a definition of ionisation energy.

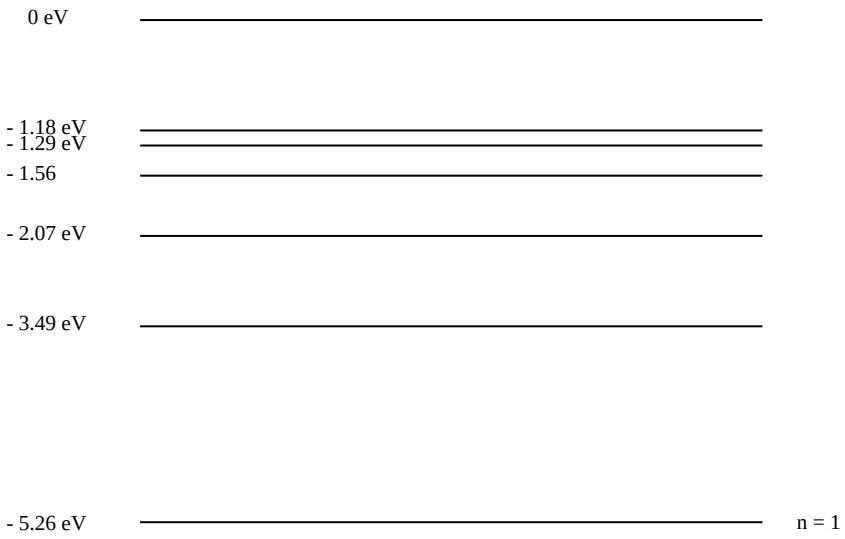
(1 mark)

e) Do electrons exist closer to the nucleus of an atom than n = 1 (ground state level)?

(1 mark)

Yes No (Please circle one)

7. The diagram below shows the energy levels of an unknown (unidentified) atom.



a) Label the above energy level diagram with "n" numbers for the rest of the levels shown.

(1 mark)

b) An electron moving at 1.16×10^6 m s^{-1} strikes an electron in the ground state and is scattered. With what energy(s) (in eV) could this scattered electron leave?

(4 marks)

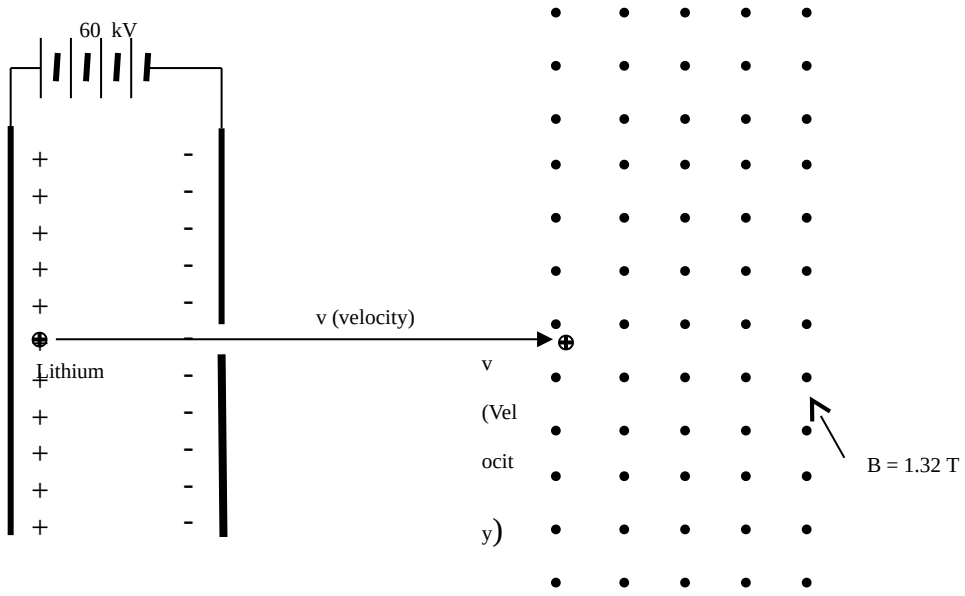
c) Calculate the frequency of all photons from this process that belong to the Paschen series.

(2 mark)

d) If the ionisation energy of all the atoms on the periodic table were measured and then averaged, the average ionisation energy would be approximately 8 eV. Using this information, is the energy level diagram above for a metal or non metal? Give reasons.

(2 mark)

8. A lithium ion (Li^{+}) of mass 1.164777×10^{-26} kg is shot from a particle accelerator of potential difference 60 kV into a uniform magnetic field of 1.32 T.



a) What is the velocity of the Lithium ion on leaving the particle accelerator?

(2 marks)

b) Draw the pathway taken by the Lithium ion onto the diagram.

(1 mark)

c) What is the centripetal force on the lithium ion?

(2 marks)

d) What is the radius of curvature of the lithium ion?

(3 marks)

e) If the lithium ion lost 2 electrons instead of one to form Li^{2+}, what would be the ratio of the diameter of Li^{2+} : the diameter of Li^{+}. Note - Assume that they both have the same mass.

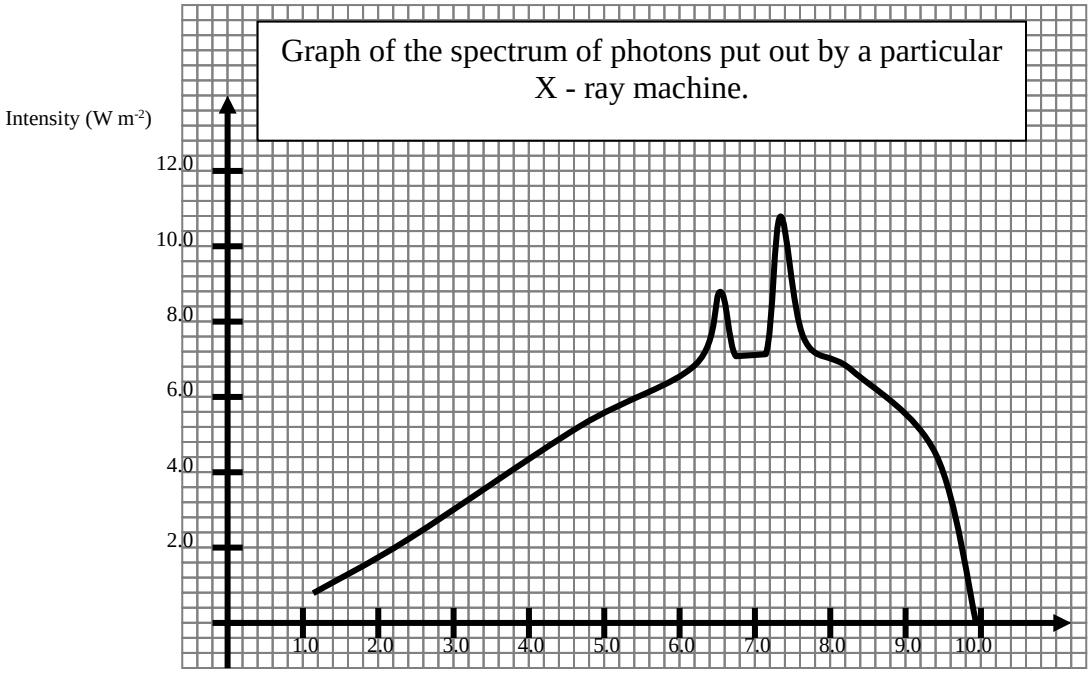
(1 mark)

9.a) The shortest wavelength that a particular X ray machine can make is 0.2 nm. What would be the minimum potential difference required in the particle accelerator section of an X - ray machine in order to produce a photon with this wavelength?

(2 marks)

b) Should the below graph be calibrated in m or in J? Explain.

(2 marks)



(x 10^{-16})

c) Are the peaks in the graph visible to the naked eye? Explain with the support of calculations.

(2 marks)

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Answers

Name _____

Marks _____/ **47**

Instructions

- Please state all answers accurate to **three significant figures**.
- Please show **all** working to obtain **all** marks.

1. Is electromagnetic radiation a wave or a particle? Explain with examples.

(3 marks)

Both

Wave- can't explain the photo electric effect.

Particle – can't explain interference and refraction.

2. A particular metal has a work function equal to green light. Explain what will happen and why if …

Situation	Result / Observation /Explanations
Weak red light is shone on the surface	No Effect Not enough energy to ionise.
Intense red light is shone on the surface on a hot day.	No Effect Not enough energy to ionise.
Purple light is shone on the surface	Effect = electrons emitted from the surface Enough energy to ionise
UV light is shone on the surface.	Effect = electrons emitted from the surface Enough energy to ionise

(2 marks)

3. How could you set up an experiment to see what colours of while light are absorbed by a green leaf?

(3 marks)

Start with an incandescent continuous source

Shine the white light onto the leaf

Collect the reflected or transmitted light

Pass the light through a non parallel sided prism

Project onto a screen an measure intensity along the spectrum on the screen.

4. Circle which one of the following ordered pairs is not part of the electromagnetic spectrum?

(1 mark)

Wavelength	**Frequency**	
450 nm	6.67 x 10^{14} Hz	3.00 x 10^{8} m/s
550 nm	5.45 x 10^{14} Hz	2.99 x 10^{8} m/s
650 nm	2.32 x 10^{14} Hz	**1.50 x 10^{8} m/s**

5. In response to a complaint about electric / hybrid cars being too quiet and consequently a potential hazard to pedestrians, a car designer at Toyota has decided to paint a car with special paint that glows (to increase visibility).

a) The painted car is left in the sun for a few hours and then driven into a pitch dark garage. In the garage the paint work gives of a pale green light for a few minutes afterwards. What is happening at the atomic scale to produce this light?

(3 marks)

- **Phosphorescent. (not UV)**
- Visible spectrum of higher energy photons promote electrons to **meta stable** excited state.
- Electrons fall some time later > 9.00 x 10^{-9} s causing a glow. **(correct up down process)**

b) Is the light only produced when it is dark? Explain.

(2 marks)

No.

Electrons are continuously rising and falling.

Glow is just more apparent in the dark.

c) The car is now parked outside all day. After sunset, will the car continue to glow all night until dawn? Explain.

(2 marks)

Majority of electrons will fall within 30 minutes.

Depends on the type of phosphorescent chemical.

No it will not glow all night.

6. A scientist is analysing a photon with a wavelength of 828.0 Å.

a) What is the frequency of this photon?

(1 mark)

$f = c / \lambda$

$f = 3 \times 10^{8} / 828 \times 10^{-10}$

$f = 3.62 \times 10^{15}$ Hz

b) How much energy does it contain in eV?

(1 mark)

$E = hf$

$E = 6.63 \times 10^{-34} \times 3.62 \times 10^{15}$

$E = 2.402 \times 10^{-18}$ J

E = 15.0 eV

c) This photon is absorbed by an electron in the ground state of an atom. The atom has an ionisation energy of 12.2 eV. What will be the velocity of the electron as it is ejected from the surface of the atom?

(3 marks)

15 – 12.2 = difference = 2.8 eV

2.9 eV = 4.48×10^{-19} J

$E = \frac{1}{2} m v^{2}$

$v = (4.48 \times 10^{-19} \times 2 / 9.11 \times 10^{-31})^{1/2}$

$v = 9.90 \times 10^{5}$ m s^{-1}

d) Write a definition of ionisation energy.

(1 mark)

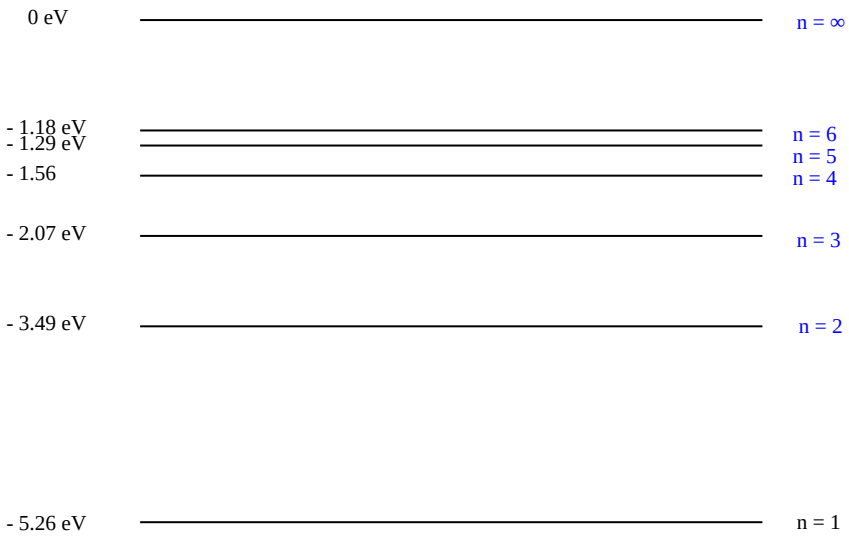
The smallest amount of energy to completely remove the most loosely held (valance) electron from a neutral atom. i.e. n = 1 to n = ∞.

e) Do electrons exist closer to the nucleus of an atom than n = 1 (ground state level)?

(1 mark)

(Yes) No (Please circle one)

7. The diagram below shows the energy levels of an unknown (unidentified) atom.



a) Label the above energy level diagram with "n" numbers for the rest of the levels shown.

(1 mark)

b) An electron moving at 1.16×10^6 m s^{-1} strikes an electron in the ground state and is scattered. With what energy(s) (in eV) could this scattered electron leave?

(4 marks)

$E = \frac{1}{2} mv^2$
$E = 0.5 \times 9.11 \times 10^{-31} (1.16 \times 10^6)^2$
$E = 6.13 \times 10^{-19}$ J = E = 3.83 eV

n = 1 → n = 2 (1.77 eV)
n= 1 → n = 3 (3.19 eV)
n = 1 → n = 4 (3.70 eV) only up to this one.
n = 1 → n = 5 (3.97 eV) Too far.

3.83 – 0 = **3.83 eV** (elastic scattering)
3.83 – 1.77 = **2 06 eV**
3.83 – 3.19 = **0.64 eV**
3.83 – 3.70 = **0.13 eV**

c) Calculate the frequency of all photons from this process that belong to the Paschen series.

(2 mark)

n = 4 → n = 3
1.56 – 2.07 = 0.51 eV = 8.16×10^{-20} J
$E = hf$
$8.16 \times 10^{-20} = 6.63 \times 10^{-34} \times f$
$f = 1.23 \times 10^{14}$ Hz (Infra Red)

d) If the ionisation energy of all the atoms on the periodic table were measured and then averaged, the average ionisation energy would be approximately 8.00 eV. Using this information, is the energy level diagram above for a metal or non metal? Give reasons.

(2 mark)

Metals have lower ionisation energies (chemistry)

5.26 eV is less than 8.00 eV so, chances are, it is a metal.

8. A lithium ion (Li^{+}) of mass 1.164777×10^{-26} kg is shot from a particle accelerator of potential difference 60 kV into a uniform magnetic field of 1.32 T.

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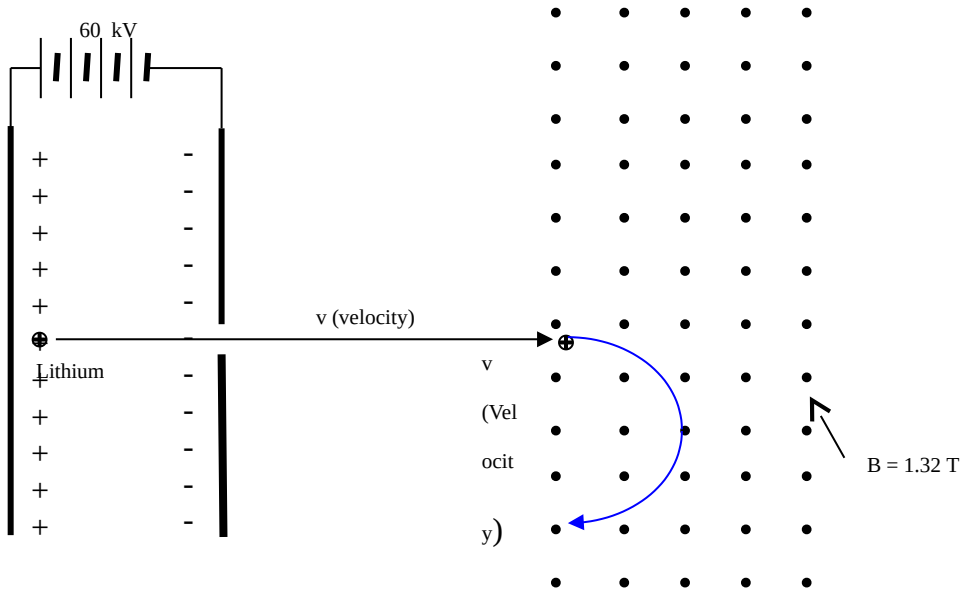


a) What is the velocity of the Lithium ion on leaving the particle accelerator?

(2 marks)

$qV = ½ m v^2$
$v = (2qV / m)^{1/2}$
$v = (2 \times 1.6 \times 10^{-19} \times 60\,000 / 1.164777 \times 10^{-26})$
$v = 1.28 \times 10^{6}$ m/s

b) Draw the pathway taken by the Lithium ion onto the diagram.

(1 mark)

c) What is the centripetal force on the lithium ion?

(2 marks)

$F = q v B$
$F = 1.6 \times 10^{-19} \times 1.284 \times 10^{6} \times 1.32$
$F = 2.71 \times 10^{-13}$ N

d) What is the radius of curvature of the lithium ion?

(3 marks)

$r = mv / qB$
$r = 1.164777 \times 10^{-27} \times 1.284 \times 10^{6} / (1.6 \times 10^{-19} \times 1.32)$
$r = 7.06 \times 10^{-2}$ m

e) If the lithium ion lost 2 electrons instead of one to form Li^{2+}, what would be the ratio of the diameter of Li^{2+} : the diameter of Li^{+}. Note - Assume that they both have the same mass.

(1 mark)

+1 : +2 = 0.0706 m : 0.100 m = 1 : 1.42 Double the charge, increase curvature by √ 2.

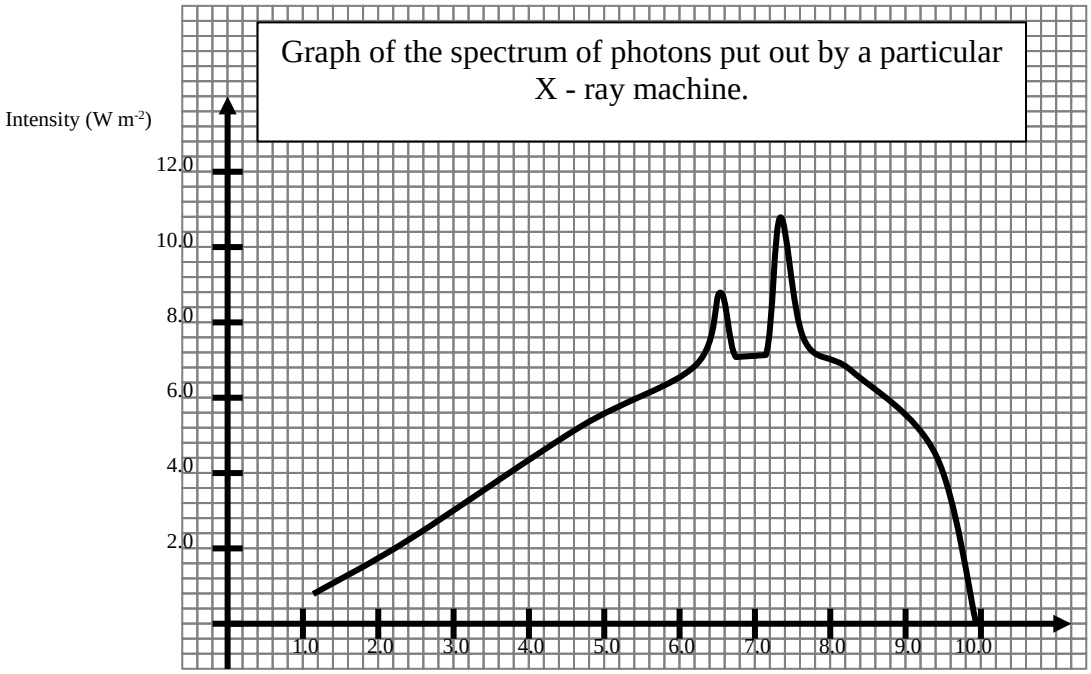
9.a) The shortest wavelength that a particular X ray machine can make is 0.2 nm. What would be the minimum potential difference required in the particle accelerator section of an X - ray machine in order to produce a photon with this wavelength?

(2 marks)

$qV = hc / \lambda$
$V = hc / \lambda q$
$V = 6.63 \times 10^{-34} \times 3 \times 10^{8} / (0.2 \times 10^{-9} \times 1.6 \times 10^{-19})$
$V = 6.22 \times 10^{3}$

b) Should the below graph be calibrated in m or in J? Explain.

(2 marks)



(x 10^{-16})

joules

The direction of the graph shows higher energy on the right.

c) Are the peaks in the graph visible to the naked eye? Explain with the support of calculations.

(2 marks)

No
Convert 7.4×10^{-16} J to a frequency or wavelength.
$E = hf$.
7.4×10^{-16} J $= 6.63 \times 10^{-34} \times f$
$f =$ **1.12×10^{18} Hz** = beyond visible spectrum. (Is an x ray).