Name: TOTAL = / 50

Answer all questions. Write your answer in the spaces provided. Show all working and express all final numerical answers to three (3) decimal places.

Question 1

Mobile phones with Bluetooth technology use microwaves with a frequency of 2.40 GHz.

a) Calculate the wavelength of these microwaves.

(2 marks)

$f = 2.40 \times 10^9\ Hz$

$c = 3 \times 10^8\ ms^{-1}$

$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{2.4 \times 10^9}$

$= 1.25 \times 10^{-1}\ m$

b) If the mobile phone emits 8.5×10^{23} photons in 0.5 seconds, what is the power output (in watts) of the laser? **(3 marks)**

$P = \frac{W}{t}$

$W = hf = 6.63 \times 10^{-34} \times 2.4 \times 10^9$

$= 1.59 \times 10^{-24}\ J$ per photon

$\times 8.5 \times 10^{23} = 1.35\ J$

$P = \frac{1.35}{0.5} = 2.71\ W$

Question 2

A 2.0 mW light source emits a narrow beam that shines on a screen. The wavelength of the light is 633 nm.

(a) Calculate how many photons strike the screen per second.

(3 marks)

$E = hf = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34} \times 3\times10^{8})}{633\times10^{-9}} = 3.14\times10^{-19}$ per photon

$P = 2\times10^{-3}\,W = 2\times10^{-3}\,Js^{-1}$

$2\times10^{-3} \div 3.14\times10^{-19}$

$= 6.37\times10^{15}$ photons

(b) If the power of the beam is doubled, which of the following statements is true?

- **A.** The photons travel faster.
- **B.** Each photon has more energy.
- **C.** More photons hit the screen every second.
- **D.** The frequency of the light is doubled.

[C]

(1 mark)

Question 3

The different colours seen in exploding fireworks are produced by using different elements.

Element	Predominant Colour
Strontium	Red
Barium	**Green**
Copper	**Blue-green**
Sodium	Yellow-**orange**

Given the information above, which of the elements emits **the lowest photon energy** of visible light? Strontium

Briefly explain the reason for your answer.

- $E = hf \therefore E \propto f$
- Red has the lowest f
- Strontium produces red light

$\therefore$ Strontium emits lowest photon energy.

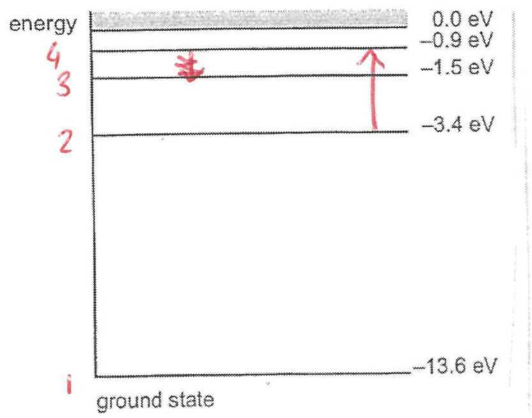
(3 marks)

Question 4

The energy level diagram for a certain element is shown below. The absorption spectrum for the element shows a dark line corresponding to a wavelength of 497 nm.

Which transition will produce this absorption line? **Show the transition on the diagram.**

Justify your answer with appropriate working. **(4 marks)**



$\lambda = 497 \times 10^{-9}$ m

$E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34} \times 3 \times 10^{8})}{497 \times 10^{-9}} = 4.00 \times 10^{-19}$ J

$\div 1.6 \times 10^{-19}$

$= 2.50$ eV

* ~~$-0.9 - 1.5 = -2.4$ eV~~

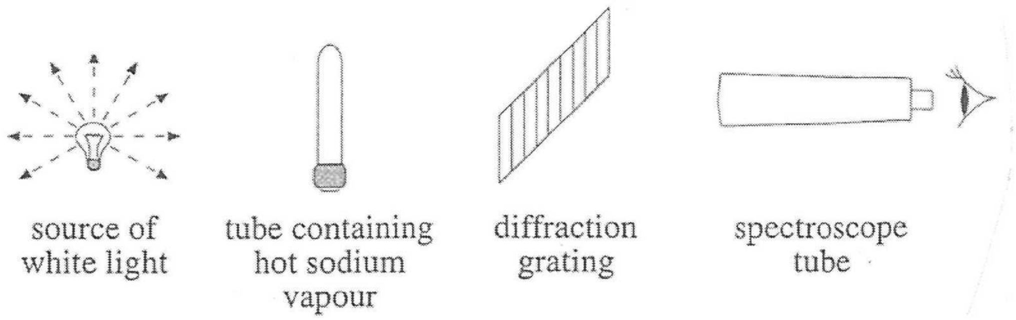
~~∴ Transition is from n = 4 to n = 3.~~

$(-3.4) - (-0.9) = -2.5$ eV

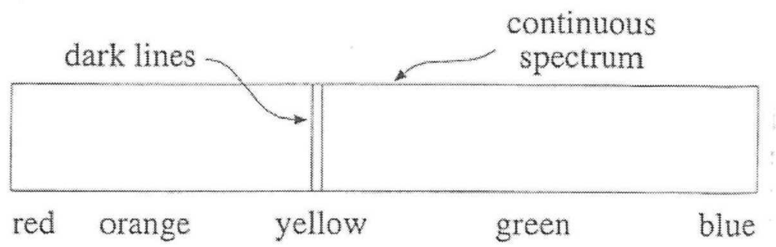
∴ Transition from 2 → 4.

Question 5

White light is passed through a hot sodium vapour and then through a diffraction grating as shown in the diagram below.



The light is then viewed through a spectroscope. Two distinct dark parallel lines are seen in the otherwise continuous spectrum, as shown below.



a) What type of spectrum has been observed? line absorption

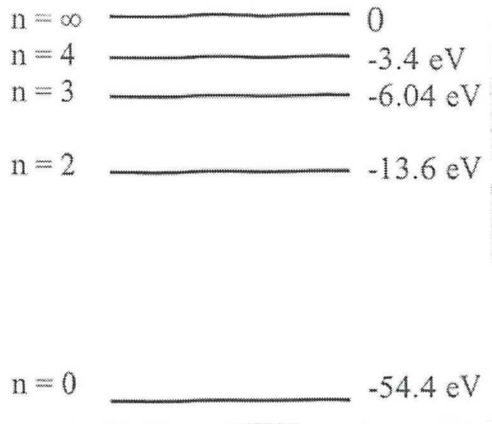
(1 mark)

b) Explain how these dark lines are formed. **(3 marks)**

· Electrons in sodium atoms exist at different energy levels.
· When light is shone through, electrons can transition to higher energy levels by absorbing energy.
· The amount of energy absorbed corresponds to the specific energy of photons
· These photons have the frequency corresponding to the dark, parallel lines.

Question 6

The diagram below shows the energy levels for a helium atom.



a) What is the **ionisation energy** (in joules) of a helium atom?

(2 marks)

$54.4 eV \times 1.6 \times 10^{-19}$

$= 8.70 \times 10^{-18} J$

b) An electron jumps from the n = 4 level to the n= 2 level. Calculate the **wavelength** of the photon emitted?

(3 marks)

$-3.4 - (-13.6) = 10.2 eV \times 1.6 \times 10^{-19}$

$= 1.63 \times 10^{-18} J$

$E = hf = \frac{hc}{\lambda}$

$\therefore \lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34} \times 3 \times 10^{8})}{1.63 \times 10^{-18}} = 1.22 \times 10^{-7} m$

c) A dark line in the absorption spectrum of helium occurs at a wavelength of 471 nm. Between which two energy levels does a transition occur when this absorption line is formed?

(3 marks)

$\lambda = 471 \times 10^{-9} m$

$E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34} \times 3 \times 10^{8})}{471 \times 10^{-9}} = 4.22 \times 10^{-19} J$

$\div 1.6 \times 10^{-19}$

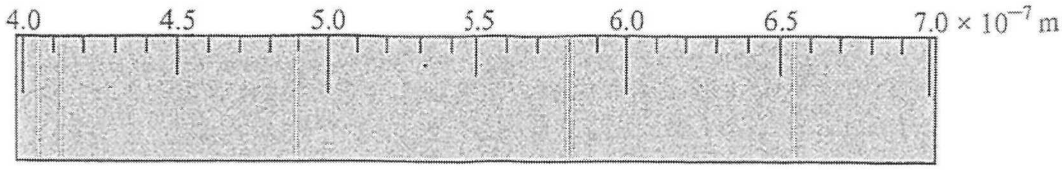
$= 2.64 eV$

transition from $n = 3 \rightarrow n = 4$.

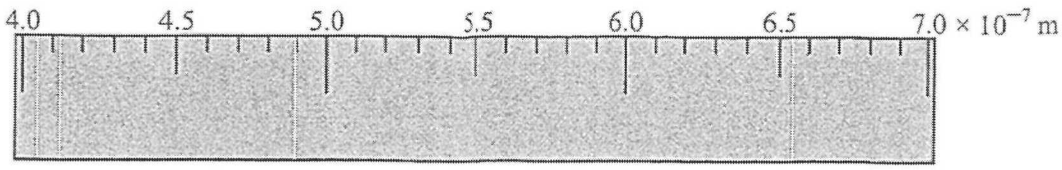
Question 8

The diagrams below show the bright line emission spectra for hydrogen gas, helium gas, sodium gas as an unknown gas mixture.

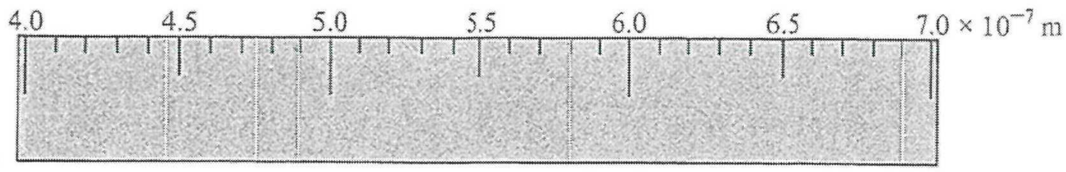
Unknown Gas Mixture Spectrum



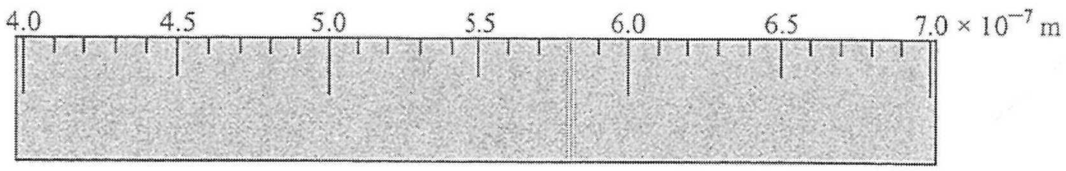
Hydrogen Gas Spectrum



Helium Gas Spectrum



Sodium Gas Spectrum



a) According to the spectra above, the gas mixture probably contains

A – hydrogen, helium and sodium gases
B – hydrogen and sodium gases only
C – hydrogen and helium gases only
D – helium and sodium gases only

B

(2 marks)

b) Briefly explain the reasons for your answer. **(3 marks)**

- Emission spectra of both are shown.

∴ Unknown gas is emitting light through electron transitions common to Sodium and those common to hydrogen.

- Helium emmission spectrum is not shown in the unknown gas.

Question 7

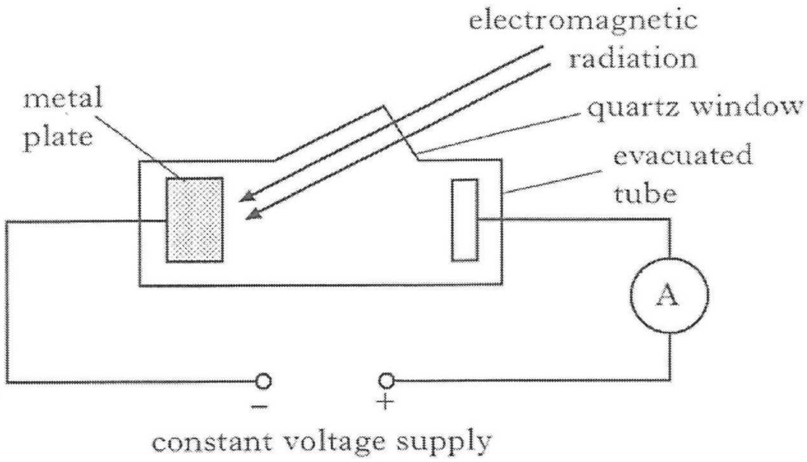
Tara and Bronte are having an argument over the nature of light. Tara claims that light is a wave, whereas Bronte insists light behaves as a particle. Who is correct? Explain your answer.

(6 marks)

- Both and neither
- Light has properties of both a wave and a particle.
- Wave properties include:
  - Young's double-slit shows diffraction of light
  - polarisation of light proves wave properties.
  - Interference ✓
- Particle properties include:
  - photoelectric effect and threshold frequency
  - Bohr theory / Atomic theory – absorption and emission of ~~various~~ particular wavelengths.

Question 9

A metal plate emits electrons when certain wavelengths of electromagnetic radiation are incident on it.



When light of wavelength 605 nm is incident on the metal plate, electrons are just released from the surface of the metal. The corresponding amount of energy is called the **work function** of the metal.

a) Determine the size of the work function for the metal. Give the answer in units of **electron volts.** **(3 marks)**

$E = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34} \times 3\times10^{8})}{605\times10^{-9}} = 3.29\times10^{-19}$ J

$\div 1.6\times10^{-19}$

$= 2.05$ eV

$\lambda = 605\times10^{-9}$ m

b) Will light of frequency 3.50 x 10^{14} Hz be able to release electrons from the surface of this metal? **(2 marks)**

$E = hf = 6.63\times10^{-34} \times 3.5\times10^{14} = 2.32\times10^{-19} < 3.29\times10^{-19}$

$\therefore$ No.

c) The brightness (intensity) of the light used in b) is **increased.** Will this make any difference to your answer in b)? Explain. **(2 marks)**

No.

Without achieving the threshold frequency, corresponding to 2.05 eV, electrons will not be released.

Increasing the brightness will have no effect.

Question 10

Describe two methods of producing electromagnetic radiation.

(4 marks)

· Oscillating electrons.

· Oscillating electrons at a particular frequency will produce electromagnetic radiation at that frequency, through creation of oscillating electric and magnetic fields.

· Heating a h.p. gas / solid.

· Sufficiently heating a h.p. gas/solid will excite electrons to higher energy levels. As these electrons fall back down, electromagnetic radiation of particular frequencies will be released/produced.

END OF TEST