ASSIGNMENT 5 - EMR

NAME: _____ **MARK:** _____/50

1. An industrial process uses a large commercial CO_2 laser for cutting steel plate. The laser has a power of 6.0×10^2 W and produces infra-red radiation of wavelength 10.6 μm.

   a) What is the photon energy at that wavelength?

   [3 marks]

   b) How many photons are released each second?

   [1 mark]

2. Nickel sulfate-6-water ($NiSO_4.6H_2O$) is soluble in water and forms a green solution. Cobalt sulphate-7-water ($CoSO_4.7H_2O$) is also water soluble forming a red solution.

   a) Explain the physics behind how the green colour is produced from the nickel sulfate-6-water.

   [2 marks]

   b) If a solution of nickel sulfate and cobalt sulphate is prepared, what colour would it have? Explain. (No chemical reaction takes place)

   [2 marks]

3. Ceara and Tito repeated the photoelectric effect experiment, by shining a light on a clean metal surface, and measuring the maximum kinetic energy of the photoelectrons. They obtained the following results:

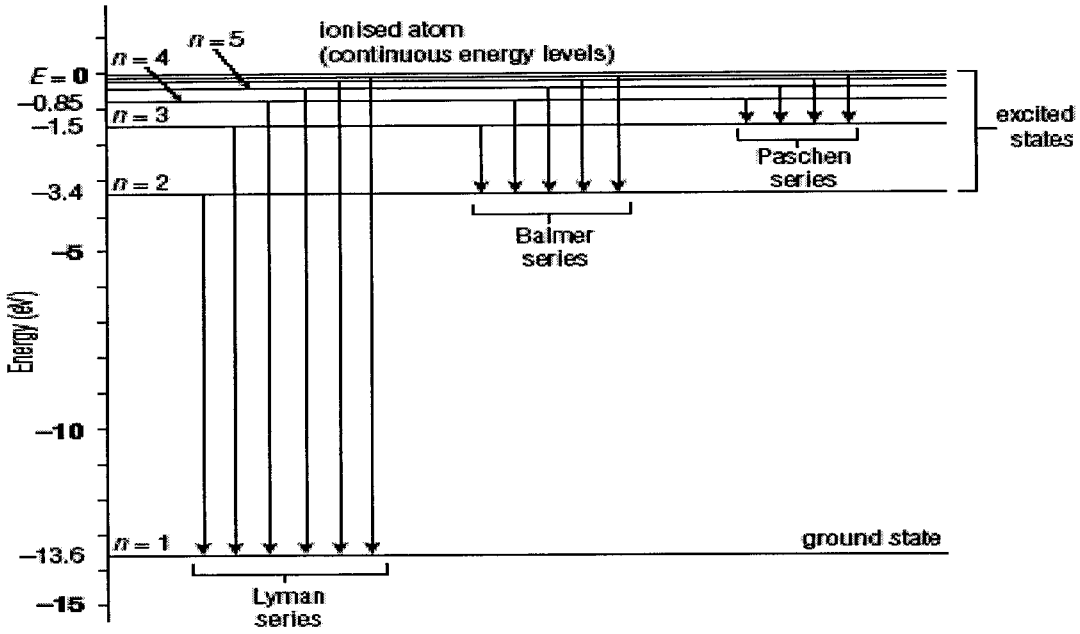
Frequency (10^{14} Hz)	Max Kinetic Energy (eV)
8.24	1.90
7.81	1.61
7.16	1.17
6.45	0.69
5.96	0.35

   a) Plot an appropriate graph of this data on graph paper. [6 marks]

   b) What is the threshold frequency of the metal? [1 mark]

   c) What is the work function of this metal? [2 marks]

4. The diagram below shows the energy levels for a hydrogen atom.



a) The Balmer series of emission lines occurs mainly in the visible spectrum. Would the Lyman series be found in the infra-red or ultra-violet region of the spectrum? Explain your answer. [2 marks]

b) The longest wavelength in the Paschen series would be produced by hydrogen atoms changing from the n=a level to the n=b level.
What are the values for a and b? [2 marks]

c) What is the energy of the photons giving rise to the second longest wavelength of the Balmer series?
[3 marks]

d) A line in the spectrum of hydrogen has a wavelength of 1.88 μm. Is it a member of the Lyman, Balmer or Paschen series? Explain your answer. [4 marks]

5. Electrons fired at the screen of a colour television cause it to emit light of different colours.

a) Explain how the electrons can cause light to be emitted. [3 marks]

b) What determines the different colours of the light? [2 marks]

6. Explain the phenomena called fluorescence and phosphorescence and the differences between them. [3 marks]

7. In a certain X-ray generator, a voltage of 52000 V is used.

a) Explain how a simplified X-ray generator works (a diagram will be necessary). [6 marks]

b) What is the highest energy that the X-rays have in this situation? [1 mark]

c) Sketch a graph showing the intensity of X-rays versus wavelength and label all the relevant features. [4 marks]

d) Determine the minimum wavelength of X-rays that will be observed. [3 marks]

ASSIGNMENT 5 – EMR – SOLUTIONS.

1.) (a) $\lambda = 10.6\,\mu m = 1.06 \times 10^{-5}\,m$ (1)

$c = f\lambda$

$f = \frac{c}{\lambda} = 2.83 \times 10^{13}\,Hz$ (1)

$E_1 = hf = 1.88 \times 10^{-20}\,J.$ (1)

(b) $P = 600\,W = 600\,J\,s^{-1}$

$N = \frac{E_{TOTAL}}{E_1} = \frac{600\,J}{1.88 \times 10^{-20}\,J} = 3.2 \times 10^{22}\,PHOTONS\,s^{-1}.$ (1)

2.) (a) – ABSORPTION SPECTRA

– ALL COLOURS (RED, ORANGE, YELLOW, BLUE, VIOLET) EXCEPT GREEN ABSORBED – SO MAINLY GREEN TRANSMITTED.

(b) DARK – BLACK/BROWN

– $CoSO_4$ ABSORBS ALL BUT RED, $NiSO_4$ ALL BUT GREEN, HENCE ALL COLOURS ARE ABSORBED.

3.) (a) PLOT – AXES LABELLED – LINE OF BEST FIT

– APPROPRIATE SCALES – X-INTERCEPT

(1 MARK EACH) – POINTS PLOTTED – Y-INTERCEPT SHOWN

(b) FROM GRAPH $\sim 5.5 \times 10^{14}\,Hz$ (1)

(c) FROM GRAPH – Y-INTERCEPT IS $\sim -3.65\,eV$ (1)

HENCE $W = +3.65\,eV.$ (1)

4.) (a) – UV (1)

– PHOTONS HAVE MORE ENERGY, HENCE HIGHER f. (1)

(OR CALCULATIONS OK)

(b) $a = 4$ 2 MARKS (1 MARK IF REVERSED)

$b = 3$

(c) 2^{ND} LONGEST λ IS 2^{ND} SMALLEST ΔE

HENCE $n = 4$ TO $n = 2$ (1)

$\Delta E = -0.85 - (-3.4)$ (1)

$= +2.55\ eV.$ (1)

(d) $\lambda = 1.88 \times 10^{-6}\ m$ (1)

$f = \frac{c}{\lambda} = 1.60 \times 10^{14}\ Hz$ (1)

$E = hf = 1.06 \times 10^{-19}\ J$ OR $0.66\ eV$ (1)

HENCE PASCHEN (FROM DIAGRAM) (1)

5.) (a) – ELECTRONS 'COLLIDE' WITH PHOSPHOR MATERIALS ON SCREEN

– PHOSPHOR ELECTRONS GAIN ENERGY (EXCITED)

– THESE ELECTRONS EMIT PHOTONS (LIGHT) WHEN RETURNING TO GROUND STATE.

(b) – THE ΔE OF ELECTRON ENERGY LEVELS

– THESE DEPEND ON THE TYPE OF MATERIALS (PHOSPHORS)

6.) – FLUORESCENCE & P ARISE FROM EXCITATION OF ELECTRONS TO VARIOUS UPPER ENERGY LEVELS, WHICH QUICKLY DECAY TO A PARTICULAR UPPER ENERGY LEVEL

– THEN A PHOTON IS EMITTED WHEN RETURNING TO GROUND STATE (WHICH IS LESS ENERGY THAN INITIAL EXCITATION ENERGY)

– DIFFERENCE IS THAT F IS ALMOST IMMEDIATE (MICROSECONDS), WHILE P OCCURS OVER A LONGER TIME PERIOD.

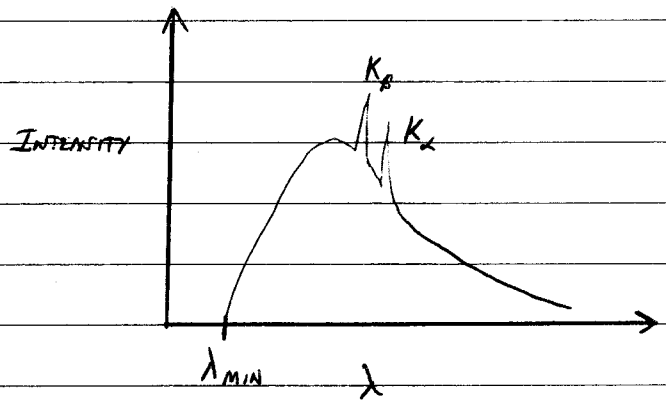
7.) (a) - DIAGRAM SHOWING (UP TO 3 MARKS FOR DIAGRAM)
- LOW VOLTAGE FILAMENT CATHODE
- HIGH VOLTAGE BTWN ELECTRODES
- METAL ANODE

- OPERATION (UP TO 3 MARKS)
- 'HOT' ELECTRONS ACCELERATED FROM FILAMENT TO ANODE BY HIGH V.
- ELECTRONS SLOW DOWN WHEN REPELLED BY ELECTRONS IN METAL ANODE
- ENERGY LOSS IS BY EMISSION OF A PHOTON (X-RAY)

(b) $E = 52000 \times 1.6 \times 10^{-19}$
$= 8.3 \times 10^{-15}$ J (1)

OR $E = 52000$ eV.

(c)



1 - FOR GRAPH
1 - FOR LABELLED AXES
1 - λ_{MIN}
1 - 'SPIKES'

(d) λ_{MIN} CORRESPONDS TO E_{MAX} (1)

$E_{MAX} = 52000$ eV
$= 8.3 \times 10^{-15}$ J (1)

$\lambda_{MIN} = \frac{hc}{E_{MAX}} = 2.4 \times 10^{-11}$ m. (1)