Name: ____________________ /50

# Yr 12 Physics EMR Test 2017

**Instructions**

1. Answer all questions in the spaces provided.
2. Give all numerical answers to three significant figures, except when you are required to estimate values where two significant figures will be appropriate.
3. Show all working – marks may be awarded for logical working even when an incorrect final answer is arrived at.
4. If you require extra working space, there are blank pages at the back of test – ensure you clearly label where your answers are.

50 marks for the questions, up to 2 marks may be deducted for incorrect units and / or significant figures

**QUESTION ONE** **(5 marks)**

Around the beginning of the 20th Century, new revelations in Physics saw light take on a dual nature.

a) Describe the nature of light's duality. (1 mark)

It behaves as a wave in some situations and as a particle in others.

b) Use two famous experiments or physical effects to explain how this dual nature of light. (4 marks)

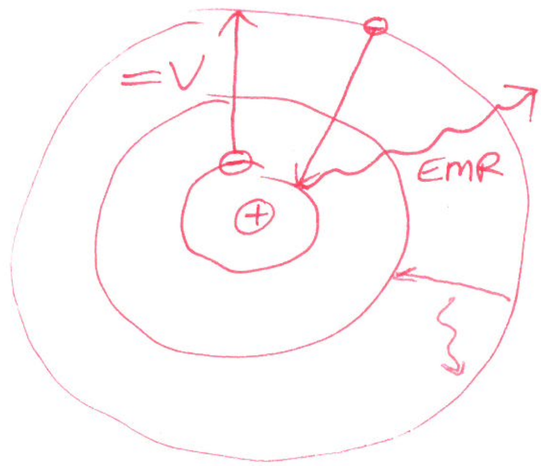
(i) YDSDE : • Light from a coherent source is directed through two narrow, parallel slits. (1)
• This produces an interference pattern which is phenomenon exhibited by waves.

ii) PHOTO-ELECTRIC EFFECT (or COMPTON EFFECT)
• A wave model of light predicts that greater light intensity should produce more energetic photo-electrons, and that there should be a time delay ~~which~~ where energy builds up.
• Neither of these expected observations occurs – light behaves as discreet particles with energy correlating to freq.

**QUESTION TWO** ~~(3~~ 4 **marks)**

The street lamps lining the Mitchell freeway have bulbs containing sodium vapour and emit have a distinct yellow / orange colour when the vapour is exposed to a high voltage. Explain, with the aid of simple diagrams, how this light is produced.

- The high voltage causes electrons to jump to higher energy levels.
- ~~Wh~~ The electrons return to lower levels, losing energy.
- This energy is emitted as a photon (of the characteristic yellow/orange colour).




**QUESTION THREE** **(3 marks)**

Determine the De Broglie wavelength of a 156g cricket ball, with a diameter of 7.05cm, travelling at 158km/h.

$$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{(0.156\times43.88...)}$$

$$v = \frac{158}{3.6} \qquad = \frac{6.63\times10^{-34}}{6.8466...}$$

$$= 43.88... \qquad = 9.68\times10^{-35}\ \text{m}$$

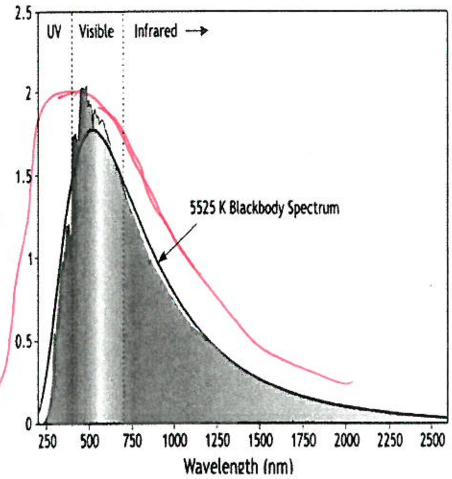
$E_K = hf - W = Vq$

## QUESTION FOUR (4 marks)

The diagram on the right shows the spectrum emitted by the sun.

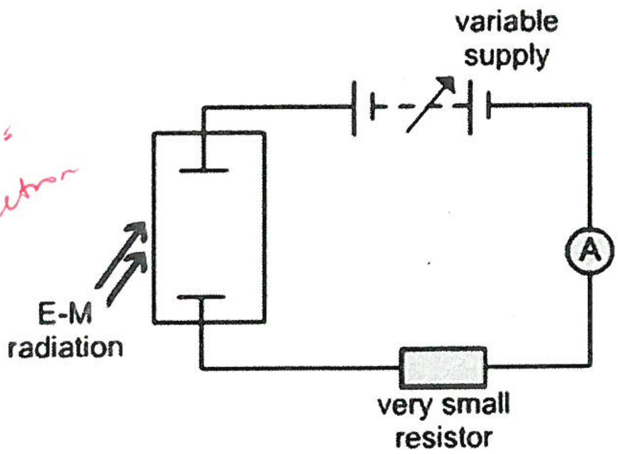
~~Explain why the spectra emitted by blackbodies always have this same general shape.~~

Explain how and why the spectrum from a star burning at 8000K would be different.




- 8000K brighter peak be higher
- Explained by greater amount of energy being radiated by hotter body
- 8000K bluer, emit more U.V spectrum
- Explained by greater temp, more energetic electron transitions

## QUESTION FIVE (8 marks)




The diagram on the left shows the apparatus used to determine the threshold frequency of various metals. The metal shentonium required a stopping voltage of 1.76V when light of wavelength 245nm was directed onto it.

Stopping voltage = max $E_k$ of electron
$E_k = hf - W = Vq$
$W = hf - Vq$

Determine:

a) The frequency of this light (1 mark)

$f = \frac{c}{\lambda} = \frac{3.0 \times 10^8}{2.45 \times 10^{-7}} = 1.22 \times 10^{15}$ Hz

~~$5.29 \times 10^{-19}$~~ $5.30 \times 10^{-19}$ J (3.31 eV)

b) The work function of shentonium (2 marks)

$E_{photon} = hf - hf_0 = hf - W = qV_{STOPPING}$

$\therefore W = hf - qV = \frac{hc}{\lambda} - qV$

$= (8.11 \times 10^{-19}) - (2.816 \times 10^{-19}) = \left(\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{2.45 \times 10^{-7}}\right) - (1.6 \times 10^{-19} \times 1.76)$

c) The threshold frequency of shentonium (2 marks)

$W = hf_0$

$\therefore f_0 = \frac{W}{h} = \frac{5.29.. \times 10^{-19}}{6.63 \times 10^{-34}}$

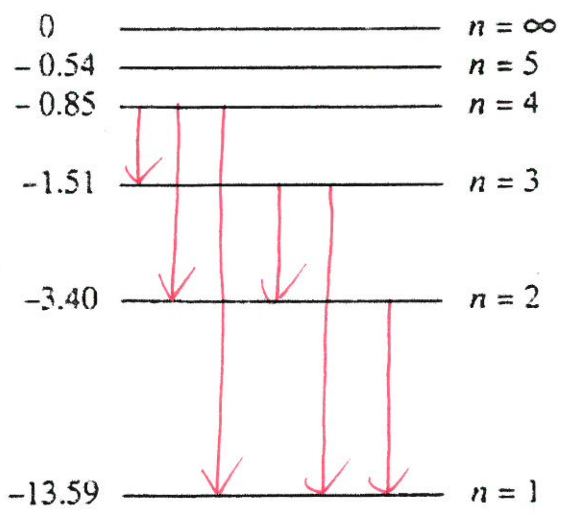
$= 7.98 \times 10^{14}$ Hz.

d) Increasing the brightness of the 245nm light does not increase the stopping voltage. Explain. (3 marks)

Stopping voltage ≈ max $E_k$ of $e^-$.

- The KE of photo-electrons is a function of frequency, not brightness/intensity.
- The opposing (stopping) energy is given by $E_{stopping} = qV$. for each photo-electron.
- Increasing brightness only increases the number of photo-electrons (ie current) but not their energy.

**QUESTION SIX** **(10 marks)**




The diagram on the left shows the electron energy states around an atom. The numbers down the left hand side show energy quantities in eV.

a) If an electron jumps up from the groundstate to the n=4 level, show on the diagram all the possible transitions it can make when returning to the ground state.

(2 marks)

(6 possible photons)

5 shown – 1 mark

4 or less – 0 marks.

transition from (a)

b) Determine the energy, frequency and wavelength that the most energetic ~~photon that could be emitted~~ would have, and which part of the EMR spectrum it would belong to. (4 marks)

n = 4 to n = 1 $E = 13.59 - 0.85 = 12.74 \text{ eV}$

$= 2.04 \times 10^{-18} \text{ J}$

$f = E/h = \frac{2.04 \times 10^{-18}}{6.63 \times 10^{-34}} = 3.07 \times 10^{15} \text{ Hz.}$

$\lambda = c/f = \frac{3.0 \times 10^{8}}{3.07 \times 10^{15}} = 9.77 \times 10^{-8} \text{ m}$

$= 97.7 \text{ nm}$

UV range.

c) If the light from a very hot blackbody (like the sun, for example) was shone through a cold sample of this ~~which consist~~ monatomic gas, a particular spectrum would be observed.

(i) Describe its appearance. (1 mark)

Full spectrum with a few black lines on it.

(ii) Explain how this spectrum is created. (3 marks)

- The gas atom's nucleus has regions where electrons may be found (called shells), depending on the electron energy
- As blackbody ~~ratir~~ radiation is shone through the gas, wavelengths whose energies correspond to the energy required to cause electrons to jump up will be absorbed.
- The resulting spectrum emanating from the gas will not contain the ~~ai~~ wavelengths absorbed.

**QUESTION SEVEN** **(8 marks)**

If a metal is **vaporised** and heated it will emit a spectrum that **looks different** to the spectrum emitted by a hot **solid** sample of the same metal when viewed through a spectroscope.

a) Describe the appearance of the typical types of spectrum these hot objects emit. (2 marks)

V – black background with one or more coloured lines. (Line emission spectrum).

S – ~~Complete~~ (ie blackbody) spectrum ~~[illegible]~~ Continuous

b) Explain how these spectra are produced, being sure to explain why they appear different. (6 marks)

V :
- In the gas the particles are spread out.
- By energising (heating) the gas, electrons move to higher / more energetic states.
- As the electrons transition back down towards the ground state, they emit distinct photons.

S
- In the solid there is a large amount of overlapping of electron shells.
- As the solid is heated the electrons move away from their nuclei.
- When they return to the groundstate the transitions possible allow the continuous spectrum (ie ~~possible~~ every λ) to be emitted.

**QUESTION EIGHT** **(4 marks)**

A laser used for astronomy nights has a power of 5.00mW and emits light of wavelength 532 nm. Determine the number of photons emitted per second by this laser.

$$\text{No. photons sec} = \frac{\text{Total energy / sec}}{\text{energy / photon}} \quad 1$$

$$E_{photon} = hf = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{5.32 \times 10^{-7}} \quad 1$$

$$= 3.7387\ldots \times 10^{-19} \text{ J}$$

$$\text{No. photons sec} = \frac{5.00 \times 10^{-3}}{3.7387\ldots \times 10^{-19}} \quad 1$$

$$= 1.34 \times 10^{16} \text{ photons / sec} \quad 1$$

**QUESTION NINE** **(5 marks)**

Steve was conducting an investigation into the effect of shining UV light onto various materials. He found that when he illuminated some materials, such as a piece of gypsum, it glowed brightly, but stopped glowing when the UV light source was removed. He also found that materials, such as a watch dial, glowed but not as brightly and continued to glow for some time after the UV light source was removed. Name and explain the two phenomena Steve was investigating.

- Fluorescence (only when irradiated) and phosphorescence (delayed).
- Both processes are similar in that UV photons are absorbed by and excite ground state electrons.
- The electrons then jump down through a triplet of energy substates. which do not emit EMR
- The fluorescent materials then emit visible photons as the electron transitions immediately to the ground state.
- The phosphorescent materials also emit visible photons, but with a longer time delay.