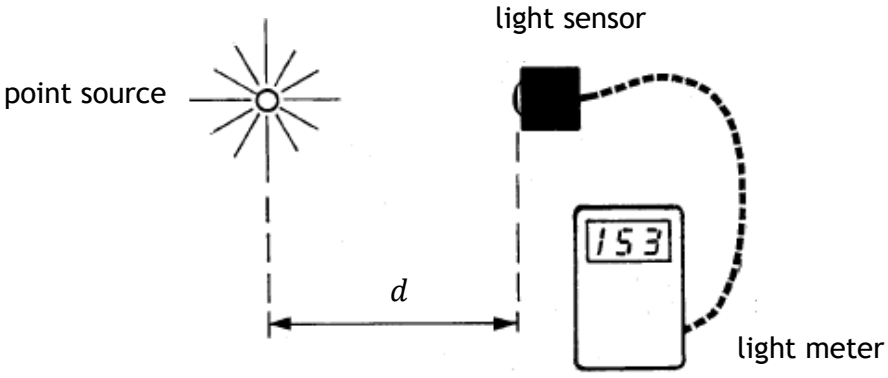
Homework 7 – Spectra

1. A space probe is positioned 3×10^{11} m from the Sun. It needs solar panels with an area of 4 m^2 to absorb sufficient energy from the Sun to keep it functioning properly.

   Calculate the area of solar panels that would be needed to keep the probe functioning correctly if it is to be repositioned at a distance of 6×10^{11} m from the Sun.

   A 1 m^2
   B 2 m^2
   C 4 m^2
   D 8 m^2
   E 16 m^2

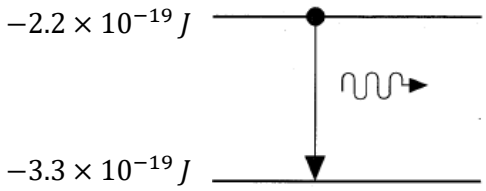
2. An experiment is carried out to investigate the relationship between the irradiance of light I from a point source and the distance d from the point source.
   The experiment is done in a darkened room and a meter connected to a light sensor indicates the irradiance, as shown below.



   Identify the expression which will give an approximately constant value.

   A $I \times d$
   B $I \times d^2$
   C $\frac{I}{d}$
   D $\frac{I}{d^2}$
   E $I \times \sqrt{d}$

3. In a laser, a photon of light is emitted when an electron makes a transition from an excited energy level to a lower energy level as shown.



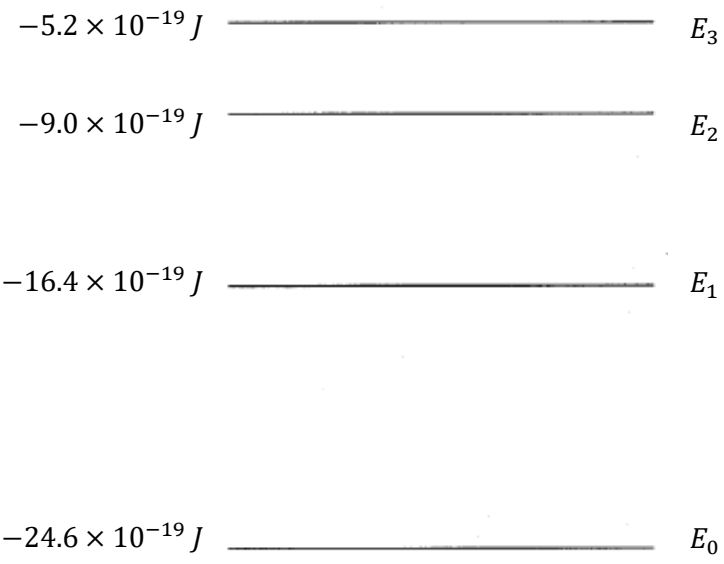
   Identify the expression which would be used to calculate the number of photons in one laser pulse if the energy in each pulse of the laser is 10 J.

   A $\frac{10}{5.5\times10^{-19}}$
   B $\frac{10}{(1.1+1.6)\times10^{-19}}$
   C $\frac{10}{3.3\times10^{-19}}$
   D $\frac{10}{2.2\times10^{-19}}$
   E $\frac{10}{1.1\times10^{-19}}$

4. A small lamp is placed 1 m above a desk. At a point on the desk directly below the lamp, the irradiance of light is I. The lamp may be treated as a point source of light.
The lamp is now raised until it is 2 m above the desk.
Identify the expression which would represent the new irradiance at the same point on the desk.

A $\frac{I}{4}$
B $\frac{I}{2\sqrt{2}}$
C $\frac{I}{2}$
D $\frac{I}{\sqrt{2}}$
E $\sqrt{2}\,I$

5. The diagram below shows the energy levels in an atom.



An electron is excited from E_2 to E_3 by absorbing energy.
Calculate the frequency of light being used to excite the electron.

A $1.74 \times 10^{-15}\,Hz$
B $5.73 \times 10^{14}\,Hz$
C $1.69 \times 10^{15}\,Hz$
D $2.14 \times 10^{15}\,Hz$
E $2.92 \times 10^{15}\,Hz$

6. The irradiance of radiation from a point source of light varies
A directly with the distance from the source
B directly with the square of the distance from the source
C directly with the square root of the distance from the source
D inversely with the distance from the source
E inversely with the square of the distance from the source.

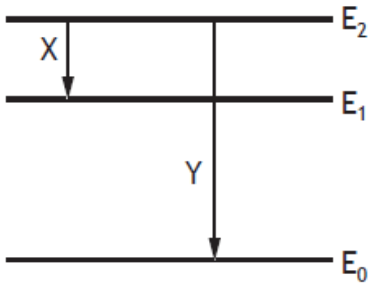
7. In the following passage, three words have been replaced with the letters X, Y and Z.

"The irradiance of light incident on a surface is equal to the X per square metre. The irradiance is Y proportional to the square of the distance from a point source of light, which means that, if the distance from the source is Z, the new irradiance is a quarter of the original value."

Which of the following gives the correct words for X, Y and Z?

	X	Y	Z
A	energy	directly	doubled
B	energy	inversely	doubled
C	power	directly	quartered
D	power	inversely	doubled
E	power	inversely	quadrupled

8. Part of the energy level diagram for a certain atom is shown below.
X and Y represent two possible electron transitions.



A student makes the following statements about transitions X and Y.

I Transition Y produces photons of higher frequency than transition X
II Transition X produces photons of longer wavelength than transition Y
III When an electron is in the energy level E_0, the atom is ionised.

Which of the statements is/are correct?

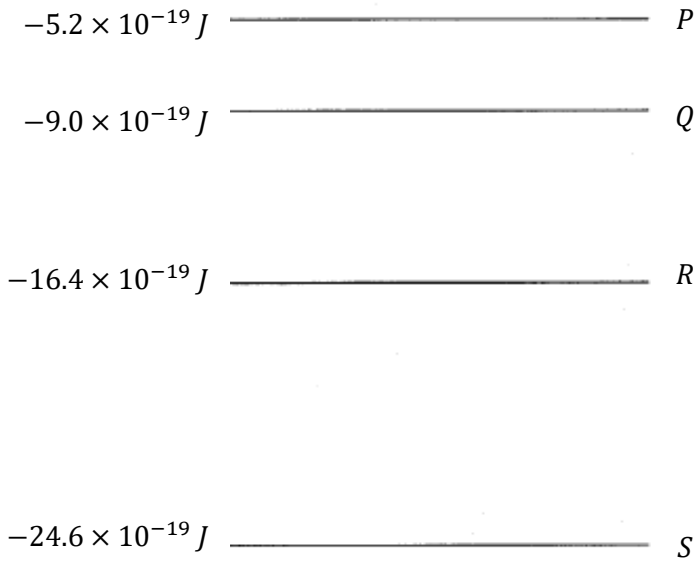
A I only
B I and II only
C I and III only
D II and III only
E I, II and III

9. The irradiance of light from a point source is 20 Wm^{-2} at a distance of 5.0 m from the source.

Calculate the irradiance at a distance of 25 m from the point source.

A 0.032 Wm^{-2}
B 0.80 Wm^{-2}
C 1.2 Wm^{-2}
D 4.0 Wm^{-2}
E 100 Wm^{-2}

10. The diagram below represents the possible energy levels of an atom.

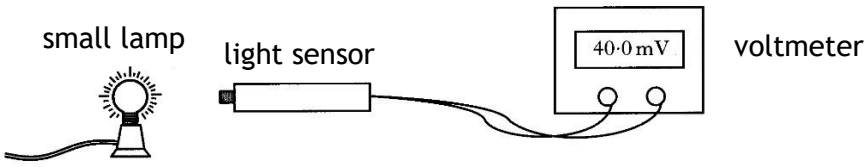


Which of the following statements is/are true?

I There are four emission lines in the spectrum produced as a result of transitions between the energy levels shown.
II The radiation emitted with the shortest wavelength is produced by an electron falling from level P to level S.
III The zero energy level in an energy level diagram is known as the ionisation level.

A I and II only
B I and III only
C II and III only
D III only
E I, II and III

11. The diagram below shows a light sensor connected to a voltmeter.
A small lamp is placed in front of the sensor.



(a) The reading on the voltmeter is 20 mV for each 1·0 mW of power incident on the sensor.
The reading on the voltmeter is 40 mV.
The area of the light sensor is $8{\cdot}0 \times 10^{-5}$ m^2.
Calculate the irradiance of light on the sensor.

(b) The small lamp is replaced by a different source of light.
Using this new source, a student investigates how irradiance varies with distance.
The results are shown.

***Distance*/m**	0·5	0·7	0·9
***Irradiance*/ Wm^{-2}**	1·1	0·8	0·6

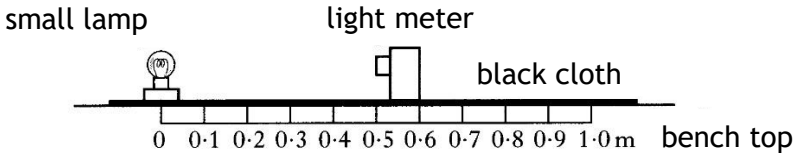
Show, by calculation, whether this new source can be considered to be a point source of light.
You must use **all** the data to justify your answer.

12. A student carries out an experiment to investigate how irradiance on a surface varies with distance from a small lamp.

Irradiance is measured with a light meter.

The distance between the small lamp and the light meter is measured with a metre stick.

The apparatus is set up as shown in a darkened laboratory.



The following results are obtained.

***Distance from source*/m**	0·20	0·30	0·40	0·50
Irradiance/units	675	302	170	108

(a) State what is meant by the term *irradiance*.

(b) Use **all** the data to find the relationship between irradiance *I* and the distance *d* from the source.

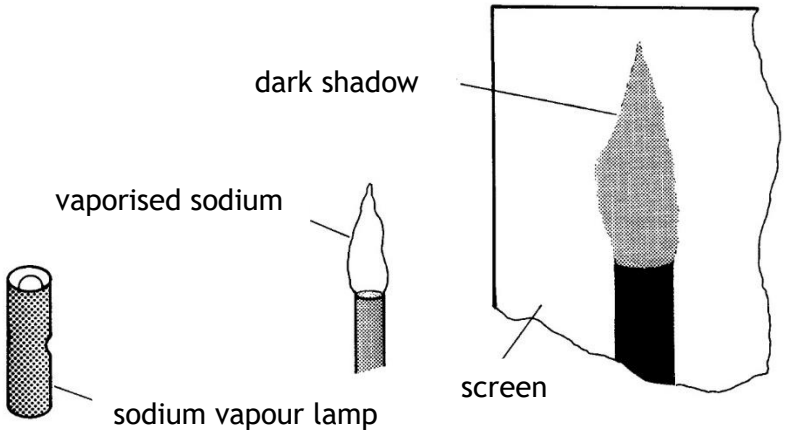
(c) What is the purpose of the black cloth on top of the bench?

13. A sodium vapour lamp emits bright yellow light when electrons make transitions from one energy level to another within the sodium atom.

(a) State whether electrons are moving to a higher or lower energy level when the light is emitted.

(b) Using information provided in the data sheet, calculate the energy difference between these two electron energy levels in the sodium atom.

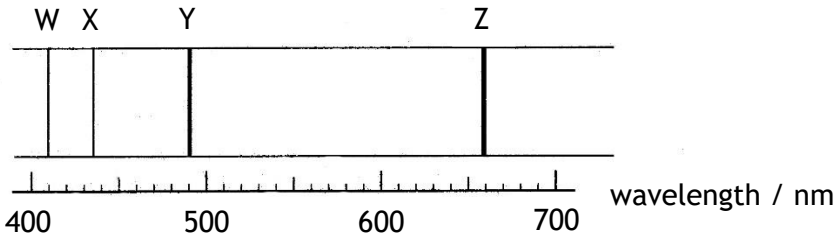
(c) A Bunsen flame containing vaporised sodium is placed between a sodium vapour lamp and a screen as shown.



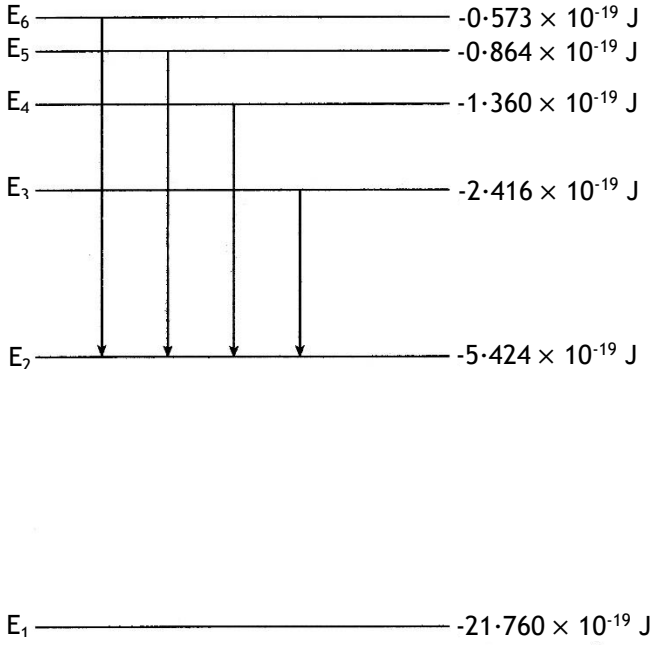
(i) Explain why a dark shadow of the flame is seen on the screen.

(ii) The sodium vapour lamp is replaced with a cadmium vapour lamp.
Explain why there is now no dark shadow of the flame on the screen.

14. The line emission spectrum of hydrogen has four lines in the visible spectrum as shown in the following diagram.



These four lines are caused by electron transitions in a hydrogen atom from high energy levels to a low energy level E_2 as shown below.



(a) From the information above, state which spectral line - W, X, Y or Z - is produced by an electron transition from E_3 to E_2.

(b) Explain why lines Y and Z in the line emission spectrum are brighter than the other two lines.

(c) Infrared radiation of frequency $7{\cdot}48 \times 10^{13}$ Hz is emitted from a hydrogen atom.
(i) Calculate the energy of one photon of this radiation.
(ii) Show by calculation which electron transition produces this radiation.