29 Worksheet (A2)

Data needed to answer questions can be found in the Data, formulae and relationships sheet.

1 What is a photon? [1]

2 γ-rays from a radioactive material have higher frequency than visible light.
Explain why this means that γ-rays are more harmful. [2]

3 State one piece of evidence that electromagnetic radiation has:

a wave-like properties [1]

b particle-like properties. [1]

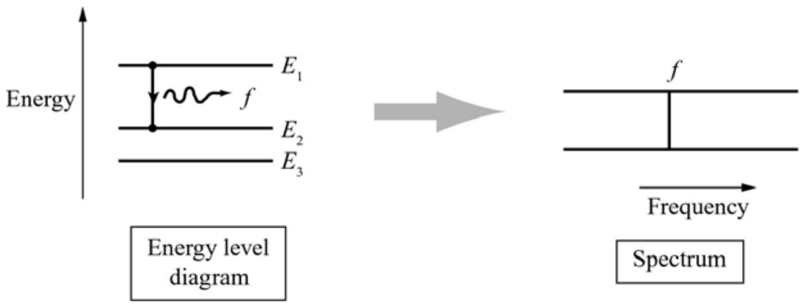
4 A light-emitting diode emits red light of wavelength 6.4×10^{-7} m. Calculate:

a the frequency of the red light [2]

b the energy of a photon of red light. [3]

5 Using the terms **photons** and **work function**, describe why electrons are emitted from the surface of a zinc plate when it is illuminated by ultraviolet radiation but not when it is illuminated by visible light. [3]

6 The figure below shows an electron making a transition between two energy levels and the bright spectral emission line observed.



a Explain why electromagnetic radiation is emitted when an electron jumps from energy level E_1 to energy level E_2. [2]

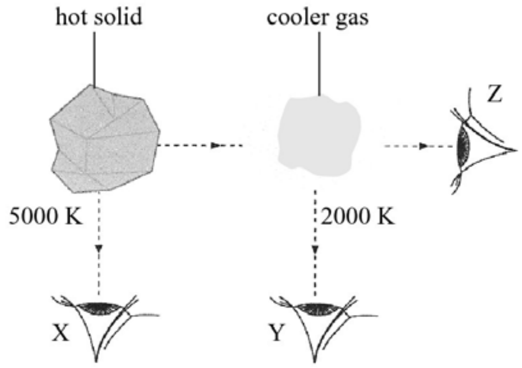
b Derive an expression for the frequency f of the radiation emitted. [2]

c State and explain the position of the spectral line when an electron makes a transition between energy levels E_1 and E_3. [2]

7 An electron in an atom can occupy four energy levels. With the help of an energy level diagram, determine the maximum number of spectral emission lines from this atom. [2]

8 Lithium atoms emit red light of wavelength 670 nm. Calculate the difference between the energy levels responsible for this red light. [3]

9 The diagram below shows a hot solid, at a temperature of 5000 K, emitting a continuous spectrum.



State the type of spectrum observed from:

a position X [1]

b position Y [1]

c position Z. [1]

10 What experimental evidence is there that suggests that electrons behave as waves? [1]

11 The **electronvolt** is a convenient unit of energy for particles and photons. Define the electronvolt. [1]

12 An electron is accelerated through a potential difference of 6.0 V. According to a student, this electron has kinetic energy greater than the energy of a photon of ultraviolet radiation of wavelength 2.5×10^{-7} m. With the aid of calculations, explain whether or not the student is correct. [5]

13 a Define **threshold frequency** for a metal. [1]

b The work function of caesium is 1.9 eV. Calculate the threshold frequency. [3]

14 A particular filament lamp of rating 60 W emits 5.0% of this power as visible light. The average wavelength of visible light is 550 nm. Calculate:

a the average energy of a single photon of visible light [3]

b the number of photons of visible light emitted per second from the lamp. [3]

15 A plate of zinc is illuminated by electromagnetic radiation of wavelength 2.1×10^{-7} m. The work function of zinc is 4.3 eV. Calculate the maximum kinetic energy of a photoelectron. [4]

16 Neutrons travelling through matter get diffracted just as electrons do when travelling through graphite. In order to show diffraction effects, the neutrons need to have a de Broglie wavelength that is comparable to the spacing between the atoms. Calculate the speed of a neutron that has a de Broglie wavelength of 2.0×10^{-11} m. [3]

17 A yellow light-emitting diode (LED) is connected to a d.c. power supply. The output voltage from the supply is slowly increased from zero until the LED just starts to glow. The yellow light from the LED has a wavelength of about 5.8×10^{-7} m. Estimate the potential difference across the LED when it just starts to glow. [4]

18 **a** In an electron-diffraction experiment, electrons are accelerated through a p.d. V.
Show that the de Broglie wavelength λ of an electron is given by:

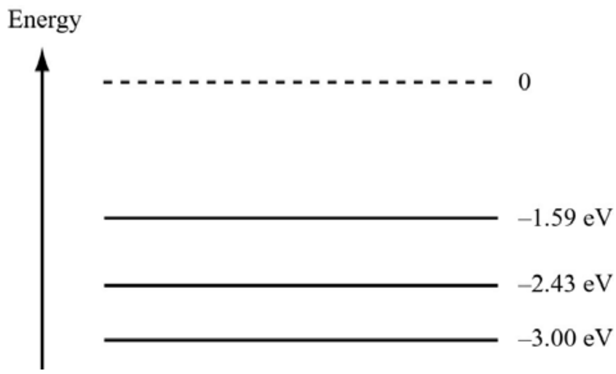
$$\lambda = \frac{h}{\sqrt{2m_e Ve}}$$

where m_e is the mass of the electron and e is the elementary charge. [3]

b Calculate the accelerating p.d. V that gives an electron a de Broglie wavelength of 4.0×10^{-11} m. [3]

19 In an experiment on the photoelectric effect, a metal is illuminated by visible light of different wavelengths. A photoelectron has a maximum kinetic energy of 0.9 eV when red light of wavelength 640 nm is used. With blue light of wavelength 420 nm, the maximum kinetic energy of the photoelectron is 1.9 eV. Use this information to calculate an experimental value for the Planck constant h. [5]

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



a Explain the significance of the energy levels being negative. [1]

b When a helium atom is not excited, the electrons have an energy of −3.00 eV. This is known as the **stable state** of the electrons. Calculate the minimum energy, in joules, required to free an electron at this energy level. Explain your answer. [3]

c The helium atom absorbs a photon of energy 1.41 eV.

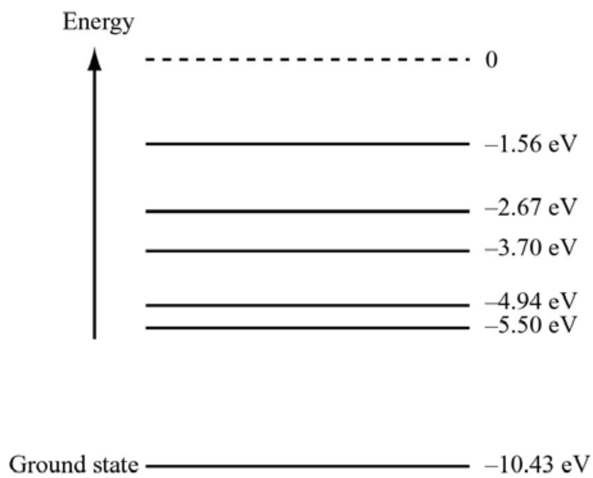
i State the transition made by an electron. [2]

ii Calculate the wavelength of the radiation absorbed by the helium atom. [3]

21 The figure below shows the energy level diagram for an atom of mercury.

a Explain what is meant by the **ground state**. [1]

b Calculate the shortest wavelength emitted by the atom. Explain your answer. [4]



22 For the hydrogen atom, the energy level E_n in joules is given by the equation

$$E_n = -\frac{2.18\times10^{-18}}{n^2}$$

where n is an integer, known as the principal quantum number.

a Calculate the energy level of the ground state ($n = 1$) and the energy level of the first excited state ($n = 2$). [2]

b Determine the wavelength of radiation emitted when an electron makes a transition from the first excited state to the ground state. In which region of the electromagnetic spectrum would you find a spectral line with this wavelength? [4]

c In which region of the electromagnetic spectrum would you find the spectral line corresponding to an electron transition between energy levels with principal quantum numbers of 6 and 7? Justify your answer. [4]

Total: $\frac{\quad\quad}{90}$ Score: %