Quantum Physics

Review Worksheet Answers

1. B
2. A
3. C
4. B
5. B
6. A

7. (a) any particle has wave-like properties / other appropriate statement;

where wavelength = $\frac{h}{p}$ with h and p identified;

Can be back credited from (b).

(b) use of $E = \frac{p^2}{2m}$; **OR** $\frac{1}{2}mv^2 = qV$ **or** $v = \sqrt{\left(\frac{2qV}{m}\right)}$;

$5.0 \times 10^3 \times 1.6 \times 10^{-19} \times 2 \times 9.1 \times 10^{-31} = p^2$ $v = \sqrt{\left(\frac{2 \times 1.6 \times 10^{-19} \times 5.0 \times 10^3}{9.11 \times 10^{-31}}\right)}$

$p = 3.8 \times 10^{-23}$; $= 4.1(9) \times 10^7$ m s^{-1};

$\lambda = \frac{(6.3 \times 10^{-34})}{(3.82 \times 10^{-23})}$; $\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 4.19 \times 10^7}$;

$= 1.7(4) \times 10^{-11}$ m; $= 1.7(4) \times 10^{-11}$ m;

Award incorrect calculation of p or v but then clear and correct evaluation of λ ***[2 max]****.*

8. (a) all particles have a wavelength associated with them / *OWTTE*;

the de Broglie hypothesis gives the associated wavelength as $\lambda = \frac{h}{p}$;

where h is the Planck constant and p is the momentum of the particle;

If answers just quote the formula from the data book then award ***[1]*** *for showing at least they recognize which formula relates to the hypothesis.*

(b) (i) KE = $Ve = 850 \times 1.6 \times 10^{-19}$ J $= 1.4 \times 10^{-16}$ J;

(ii) use $E = \frac{p^2}{2m}$ to get $p = \sqrt{2mE}$;

substitute $p = \sqrt{2 \times 9.1 \times 10^{-31} \times 1.4 \times 10^{-16}} = 1.6 \times 10^{-23}$ N s;

(iii) $\lambda = \frac{h}{p}$;

substitute $\lambda = \frac{6.6 \times 10^{-34}}{1.6 \times 10^{-23}} = 4.1 \times 10^{-11}$ m;

9. (a) the angular momentum must be an integral number of $\frac{h}{2\pi}$ where h is the Planck constant / orbit can fit an integral number of wavelengths associated with the electron;

If quoted mathematically, then terms must be defined.

(b) *Look for these general points.*
whilst in a stable orbit the electron does not emit radiation;
when it makes a transition to a lower energy orbit it emits a photon whose frequency is determined by the difference in energy of the orbits;
transitions between orbits will give rise to the wavelengths in the line spectrum; 3

(c) $E = \frac{hc}{\lambda} = \frac{k}{n^2}$;

$= k\left(\frac{1}{4} - \frac{1}{9}\right) = 0.139\ k$;

$k = \frac{hc}{0.14\lambda} = \frac{6.63\times10^{-34}\times3\times10^{8}}{362\times10^{-9}\times0.139} = 3.95\times10^{-18}$ J;

recognize that k is the ionization energy;

Allow use of 2 significant figures.

(d) *Look for some of these points.*
the electron has wave properties;
the "electron wave" in the atom has to fit boundary conditions;
only certain wavelengths are allowed / standing waves by boundary conditions;
the wavelength of the electron determines its energy; 2 max

To award ***[2]*** *boundary conditions must be mentioned.*

10. (a) negative;
the electrons emitted from P have a certain maximum energy;
they will be repelled by plate Q / *OWTTE*;
if the maximum KE is less than the energy required for an electron to move between P and Q / less than the pd per unit charge it will not reach Q;

(b) light consists of photons each of energy; $E = hf$;
where h is the Planck constant and f is the frequency (of the light);
the greater the frequency (of the incident light) the greater the energy of the emitted electrons / electrons now have sufficient energy to overcome the potential barrier / *OWTTE*;

(c) the energy of each photon is increased;
therefore for same intensity there are less photons;

(d) $h = \frac{E_{K_{max}} + \phi}{f}$;

$= \frac{(8.0+4.4)\times1.6\times10^{-19}}{3.0\times10^{15}}$;

$= 6.6\times10^{-34}$ J s;

Must show working for full credit.