Year 13 Science: Modern physics: photons, energy levels and the nucleus

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Find the energy in joules of a 450 nm photon. Use $h = 6.63 \times 10^{-34}$ J s and $c = 3.00 \times 10^{8}$ m s^{-1}.

2. Give that energy in electronvolts.

3. Those photons fall on a metal with a work function of 2.10 eV. Find the electrons' maximum kinetic energy in eV.

4. An electron in hydrogen falls from n = 4 to n = 2. Find the photon energy in eV.

5. The deuterium nucleus has a mass defect of 0.002388 u. Find its binding energy in MeV, using 1 u = 931.5 MeV.

Fix the mistake

6. Correct this statement: "Brighter light gives the photoelectrons more kinetic energy."

7. Correct this statement: "$E_k = 6.63 \times 10^{-19} - 2.28 = 6.63 \times 10^{-19}$ J."

8. Correct this statement: "The electron drops from n = 3 to n = 2, so the photon has 13.6 ÷ 3 – 13.6 ÷ 2 eV."

9. Correct this statement: "Fission releases energy because the nucleus has extra energy stored in it."

Answer key (for parents and tutors)

1. Find the energy in joules of a 450 nm photon. Use $h = 6.63 \times 10^{-34}$ J s and $c = 3.00 \times 10^{8}$ m s^{-1}.
   $E = hc \div \lambda = 1.989 \times 10^{-25} \div 450 \times 10^{-9} = 4.42 \times 10^{-19}$ J.
2. Give that energy in electronvolts.
   $4.42 \times 10^{-19} \div 1.60 \times 10^{-19} = 2.76$ eV.
3. Those photons fall on a metal with a work function of 2.10 eV. Find the electrons' maximum kinetic energy in eV.
   Ek(max) = 2.76 − 2.10 = 0.66 eV.
4. An electron in hydrogen falls from n = 4 to n = 2. Find the photon energy in eV.
   $E_4 = -13.6 \div 16 = -0.85$ eV, $E_2 = -3.40$ eV, so $\Delta E = -0.85 - (-3.40) = 2.55$ eV (a blue-green line at 486 nm).
5. The deuterium nucleus has a mass defect of 0.002388 u. Find its binding energy in MeV, using 1 u = 931.5 MeV.
   $E = 0.002388 \times 931.5 = 2.22$ MeV.
6. Correct this statement: "Brighter light gives the photoelectrons more kinetic energy."
   Brightness changes the number of photons; each electron's maximum energy depends only on frequency, $Ek = hf - \varphi$.
7. Correct this statement: "$Ek = 6.63 \times 10^{-19} - 2.28 = 6.63 \times 10^{-19}$ J."
   Put both in the same unit first: 2.28 eV = 3.65×10^{-19} J, then subtract.
8. Correct this statement: "The electron drops from n = 3 to n = 2, so the photon has $13.6 \div 3 - 13.6 \div 2$ eV."
   Levels go as $1/n^2$: $E_3 - E_2 = -13.6/9 - (-13.6/4) = 1.89$ eV.
9. Correct this statement: "Fission releases energy because the nucleus has extra energy stored in it."
   The products have greater binding energy per nucleon, so less total mass; the missing mass becomes energy.