Oxford - Worked Examples pp. 270 | 273 | 304 #1-2

p. 270 He^+ (2p+, 2n°, 1e−) → "hydrogen like"

ENERGY LEVEL (n)	ENERGY (eV)
1	-54.4
2	-13.6
3	-6.0
4	-3.4
5	-2.2

* Energies are all ⊖ values P.E. = 0 only when p+ & e− are at infinite separation.
* When e− moves closer to p+ (from infinity), it has lost some energy

n = principal quantum #

(a) Why does ground state for He+ have a higher energy level than that of hydrogen?

H has 1 p+, He has 2p+, so He electron has double the attractive force, so it requires more energy to move it away (to ∞) from p+.

(b) (i) What is the f = ? of the photon emitted by an e− transition from n = 4 → n = 2

$\Delta E = E_f - E_o = -13.6\,eV - {}^{-}3.4\,eV = \boxed{\mp 10.2\,eV}$

convert to J

$+10.2\,eV \times \frac{1.6\times10^{-19}\,J}{eV} = \boxed{1.6\times10^{-18}\,J}$

$\boxed{E = hf}$ or $f = \frac{E}{h} = \frac{1.6\times10^{-18}\,J}{6.63\times10^{-34}\,J.s} = \boxed{2.4\times10^{15}\,Hz}$

(ii) Which region of the EM spectrum does this photon belong?

Ultraviolet.

p. 273

a) Helium was first ID'd from the absorption spectrum of the Sun.

(i) Explain ABSORPTION SPECTRUM: Light is emitted from objects at frequencies that span the rainbow of colors in the visible spectrum. The appearance of dark (absorption) lines corresponds to the exact frequencies being absorbed by certain elements (like hydrogen)

(ii) How can this spectrum be observed? Pass sunlight through a prism or diffraction grating to spread out the colors. Project onto a screen.

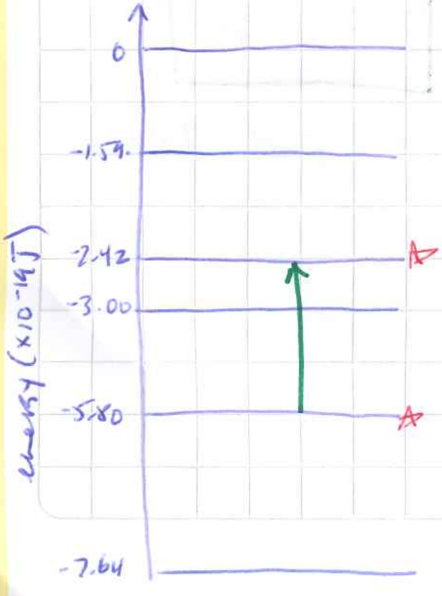
b) One λ in absorption spectrum of He is at 588 nm

(i) Show that E of photon of $\lambda = 588$ nm is 3.38×10^{-19} J

$E = hf \quad c = \lambda f \quad f = \frac{c}{\lambda} \quad E = h \cdot \frac{c}{\lambda} = \frac{(6.63 \times 10^{-34} \text{ J}\cdot\text{s})(3.0 \times 10^{8} \text{ m/s})}{(588 \times 10^{-9} \text{ m})}$

$\boxed{E = 3.38 \times 10^{-19} \text{ J}}$

(ii) Diagram below shows some energy levels of He atom. Use it to explain how absorption at 588 nm happens



Absorption = e^- being raised to higher energy level. Find the difference in energy levels that is $= 3.38 \times 10^{-19}$ J

$\Delta E = E_f - E_o = (-2.42 \times 10^{-19} \text{ J}) - (-5.80 \times 10^{-19} \text{ J})$
$= \boxed{3.38 \times 10^{-19} \text{ J}}$

(iii) Mark this transition on the diagram.

p.304 #1, #2

1. a) Light emitted from gas discharge tube. How can visible line spectrum be obtained?
Radiation emitted by the gas can pass through (collimating) slit on spectrophotometer and then through a prism or diffraction grating and then projected onto a screen.
see chart of 3 λ's in line spectrum for atomic hydrogen.

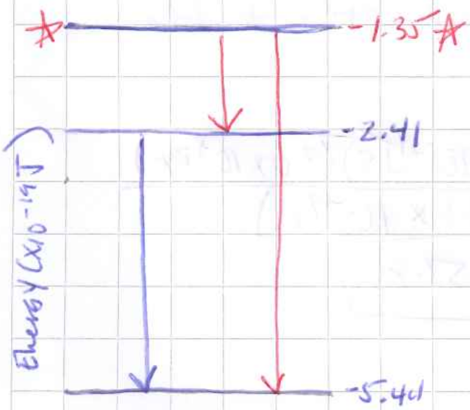
λ ($\times 10^{-9}$ m)	Photon E ($\times 10^{-19}$ J)
1880	1.06
656	3.03
486	4.09

b) Deduce that the photon energy for 486×10^{-9} m is 4.09×10^{-19} J

$E = hf \quad f = \frac{c}{\lambda} \quad$ So $\quad E = h \cdot \frac{c}{\lambda}$

$$E = \frac{(6.63 \times 10^{-34}\,J \cdot s)(3.0 \times 10^{8}\,m/s)}{(486 \times 10^{-9}\,m)} = \boxed{4.09 \times 10^{-19}\,J}$$

c)(i) On the diagram, construct the other energy level needed to produce the energy changes shown in the above table



$\Delta E = E_f - E_0$

For $\lambda = 1880 \quad \Delta E = 1.06 \times 10^{-19}$ J

so $1.06 = 2.41 - x$

$x = 1.35$

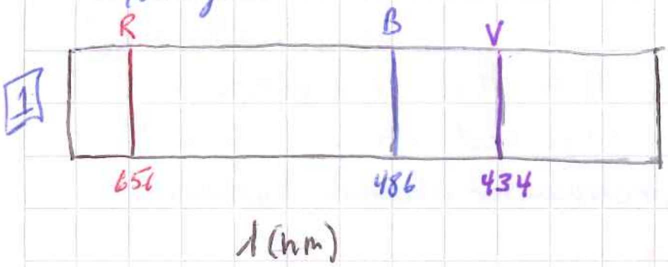
For $\lambda = 486 \quad \Delta E = 4.09$

so $4.09 = 5.44 - x$

$x = 1.35$

(ii) Arrows drawn

(3) Diagram 1 shows part of emission line spectrum of atomic hydrogen.



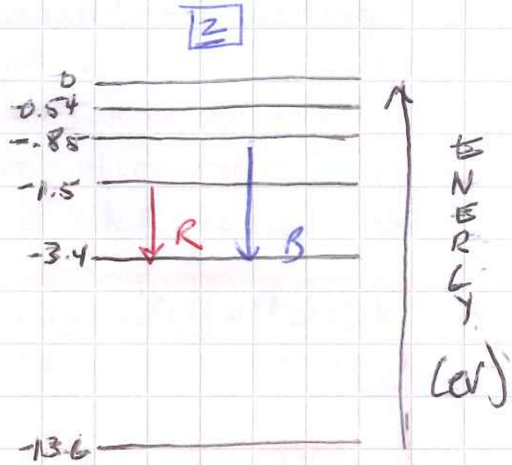


Diagram 2 shows some of the principal energy levels for atomic hydrogen.

a) Show that the energy of a photon of red light ($\lambda = 656$ nm) $= 1.9$ eV

$$E = hf \quad f = \frac{c}{\lambda} \quad \text{So } E = h \cdot \frac{c}{\lambda} = \frac{(6.63 \times 10^{-34} J\,s)(3.0 \times 10^{8} m/s)}{(656 \times 10^{-9} m)}$$

$$E = 3.03 \times 10^{-19} J \times \frac{1 eV}{1.6 \times 10^{-19} J} = 1.89 eV = \boxed{1.9 eV}$$

b) Draw arrows to represent:

(i) the e^- transition that gives rise to the red line (R)

(ii) a possible e^- transition that gives rise to the blue line (B)

$$\text{Blue (486 nm)} \quad E = h \cdot \frac{c}{\lambda} = \frac{(6.63 \times 10^{-34} J\,s)(3.0 \times 10^{8} m/s)}{(486 \times 10^{-9} m)}$$

$$E = 4.09 \times 10^{-19} J \times \frac{1 eV}{1.6 \times 10^{-19} J} \quad \boxed{= 2.56 eV}$$