6. (10 points)

A diver descends from a salvage ship to the ocean floor at a depth of 35 m below the surface. The density of ocean water is 1.025×10^3 kg/m^3.

(a) Calculate the gauge pressure on the diver on the ocean floor.

(b) Calculate the absolute pressure on the diver on the ocean floor.

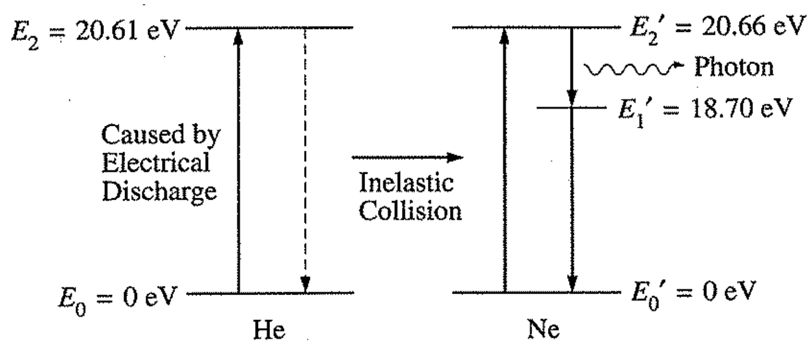
The diver finds a rectangular aluminum plate having dimensions 1.0 m × 2.0 m × 0.03 m. A hoisting cable is lowered from the ship and the diver connects it to the plate. The density of aluminum is 2.7×10^3 kg/m^3. Ignore the effects of viscosity.

(c) Calculate the tension in the cable if it lifts the plate upward at a slow, constant velocity.

(d) Will the tension in the hoisting cable increase, decrease, or remain the same if the plate accelerates upward at 0.05 m/s^2?

____ increase ____ decrease ____ remain the same

Explain your reasoning.



7. (10 points)

Energy-level diagrams for atoms that comprise a helium-neon laser are given above. As indicated on the left, the helium atom is excited by an electrical discharge and an electron jumps from energy level E_0 to energy level E_2. The helium atom (atomic mass 4) then collides inelastically with a neon atom (atomic mass 20), and the helium atom falls to the ground state, giving the neon atom enough energy to raise an electron from E_0' to E_2'. The laser emits light when an electron in the neon atom falls from energy level E_2' to energy level E_1'.

(a) Calculate the minimum speed the helium atom must have in order to raise the neon electron from E_0' to E_2'.

(b) Calculate the DeBroglie wavelength of the helium atom when it has the speed determined in (a).

(c) The excited neon electron then falls from E_2' to E_1' and emits a photon of laser light. Calculate the wavelength of this light.

(d) This laser light is now used to repair a detached retina in a patient's eye. The laser puts out pulses of length 20×10^{-3} s that average 0.50 W output per pulse. How many photons does each pulse contain?

END OF EXAMINATION

2003 APB #7

a) $\frac{1}{2}M_{He}V_{He}^2 = \underbrace{\frac{1}{2}M_{He}V_{He}'^2}_{0} + \underbrace{\frac{1}{2}M_{Ne}V_{Ne}'^2}_{0} + (E_2' - E_2)$

cons. of E

$$M_{He}V_{He} = M_{He}V_{He}' + M_{Ne}V_{Ne}'$$

$$V_{He} = \frac{M_{He}V_{He}' + M_{Ne}V_{Ne}'}{M_{He}}$$

$$\frac{1}{2}M_{He}\left(\frac{\cancel{M_{He}V_{He}'} + M_{Ne}V_{Ne}'}{M_{He}}\right)^2 = \cancel{\frac{1}{2}M_{He}V_{He}'^2} + \frac{1}{2}M_{Ne}V_{Ne}'^2 + \underbrace{(E_2' - E_2)}_{0.05\,eV}$$

$V_{He}' = 0$

$$\frac{1}{2}\frac{M_{He}M_{Ne}^2V_{Ne}'^2}{M_{He}^2} = \frac{1}{2}M_{Ne}V_{Ne}'^2 + 0.05\,eV$$

$M_{He} = (4\,u)\left(\frac{1.66\times10^{-27}\,kg}{1\,u}\right) = 6.64\times10^{-27}\,kg$

$M_{Ne} = (20\,u)\left(\frac{1.66\times10^{-27}\,kg}{1\,u}\right) = 3.32\times10^{-26}\,kg$

$(0.05\,eV)\left(\frac{1.6\times10^{-19}\,J}{1\,eV}\right) = 8\times10^{-21}\,J$

$$\frac{1}{2} M_{He}\left(\frac{M_{Ne}^2 V_{Ne}'^2}{M_{He}^2}\right) = \frac{1}{2} M_{Ne} V_{Ne}'^2 + (E_2' - E_2)$$

$$\frac{1}{2}(6.64\times10^{-27})\left(\frac{(3.32\times10^{-26})^2 (V_{Ne}')^2}{(6.64\times10^{-27})^2}\right) = \frac{1}{2}(3.32\times10^{-26}) V_{Ne}'^2 + (8\times10^{-21} J)$$

$$8.3\times10^{-26}(V_{Ne}')^2 = 1.66\times10^{-26} V_{Ne}'^2 + (8\times10^{-21})$$

$$-(\quad)$$

$$6.64\times10^{-26} V_{Ne}'^2 = 8\times10^{-21}$$

$$V_{Ne}'^2 = 120{,}481.92$$

$$V_{Ne}' = 347.1\ m/s$$

$$(6.64\times10^{-27}\ kg) V_{He} = (3.32\times10^{-26}\ kg)(347.1)$$

$$\boxed{1735.5 = V_{He}}$$

$$V_{He}' = 0$$

(B) from "A" $v_{He} = 1735.5\,\frac{m}{s}$

de Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

$$\lambda = \frac{6.63\times10^{-34}\,J\cdot s}{(6.64\times10^{-27}\,kg)(1735.5\,\frac{m}{s})} =$$

(C) $E_{photon} = hf$

$E_2' - E_1' = hf$

$20.66eV - 18.7eV = (4.14\times10^{-15}\,eV\cdot s)f$

$= f$

$c = \lambda f$

$3\times10^{8}\,\frac{m}{s} = \lambda(\quad)$

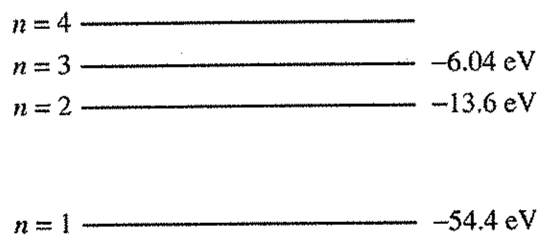
$= \lambda$

(D) $E_{photon} = E_2' - E_1' = 20.66eV\ 18.7eV =$

$P = \frac{W}{t}$ $\quad W = \Delta E$ $\quad P = \frac{\Delta E}{t} \longrightarrow P\cdot t = \Delta E$

$(0.5W)(20\times10^{-3}s) = \text{total } E$

$$\frac{\text{Total } E}{E \text{ of } 1 \text{ photon}} = \#\text{photons}$$



Note: Energy levels not drawn to scale.

7. (10 points)

The diagram above shows the lowest four discrete energy levels of an atom. An electron in the $n = 4$ state makes a transition to the $n = 2$ state, emitting a photon of wavelength 121.9 nm.

(a) Calculate the energy level of the $n = 4$ state.

(b) Calculate the momentum of the photon.

The photon is then incident on a silver surface in a photoelectric experiment, and the surface emits an electron with maximum possible kinetic energy. The work function of silver is 4.7 eV.

(c) Calculate the kinetic energy, in eV, of the emitted electron.

(d) Determine the stopping potential for the emitted electron.

END OF EXAM

2005 AP B

#7 (a) $n=4 \longrightarrow n=2$

$X\ eV \longrightarrow -13.6eV$

$\lambda = 121.9\times10^{-9}\,m$

$E = hf$

$= \text{need } f$

$c = \lambda f$

$3\times10^8 \frac{m}{s} = (121.9\times10^{-9}\,m) f$

$2.46\times10^{15}\,Hz = f$

I like this b/c the problem is in eV.

$E = (4.14\times10^{-15}\,eV\cdot s)(2.46\times10^{15}\,Hz)$

$E = 10.18eV$

or

$1.63\times10^{-18}\,J = (6.63\times10^{-34}\,J\cdot s)(2.46\times10^{15}\,Hz)$

(b) $\vec{p} = \frac{hf}{c}$ (from $E = hf = pc$)

$$\vec{p} = \frac{(4.14\times10^{-15}\,eV\cdot s)(2.46\times10^{15}\,Hz)}{3\times10^8\,m/s} = \boxed{3.4\times10^{-8}\,\frac{eV\cdot s}{m}}$$

OR

$$p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}\,J\cdot s}{121.9\times10^{-9}\,m} = \boxed{5.44\times10^{-27}\,\frac{J\cdot s}{m}}$$

(c) $\phi = 4.7\,eV$

$KE = hf - \phi$

$= \underline{10}.18\,eV - 4.7\,eV$

$\boxed{= 5.48\,eV}$

(d) $KE = qV$ $\longrightarrow$ from Electricity

$V = \frac{kq}{r} \rightarrow E = \frac{kq}{r}(q_2)$ or Vq

$$V = \frac{(5.48\,eV)\left(\frac{1.6\times10^{-19}J}{1eV}\right)}{\underbrace{1.6\times10^{-19}J}_{\text{charge of 1 electron}}} = \boxed{5.48\,eV}$$

(I don't expect you to get pt. (d))