Hmk # 5 Solutions

1).

a). ultraviolet

b). $E = \frac{hc}{\lambda}$

$$E_{IR} = \frac{(6.6\times10^{-34}\,J\cdot s)(3.0\times10^{8}\,m/s)}{2.0\times10^{-6}\,m} = \boxed{9.9\times10^{-20}\,J = 0.62\,eV}$$

$$E_{UV} = \frac{(6.6\times10^{-34}\,J\cdot s)(3.0\times10^{8}\,m/s)}{7.0\times10^{-8}\,m} = \boxed{2.8\times10^{-18}\,J = 18\,eV}$$

c). each laser is 200 W. $W \rightarrow \frac{[J]}{[s]}$

\# of photons = n :

$$n_{IR} = \frac{200\,W}{9.9\times10^{-20}\,J} = \boxed{2.0\times10^{21}\ \text{photons/sec}}$$

$$n_{UV} = \frac{200\,W}{2.8\times10^{-18}\,J} = \boxed{7.1\times10^{19}\ \text{photons/sec.}}$$

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2). $$E = \frac{hc}{\lambda} = \frac{(6.6\times10^{-34}\,J\cdot s)(3.0\times10^{8}\,m/s)}{0.70\times10^{-6}\,m} = \boxed{2.8\times10^{-19}\,J = 1.8\,eV}$$

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3). a). $E = 3.1\,eV = 3.1\,eV\cdot(1.6\times10^{-19}\,J/eV) = 4.9\times10^{-19}\,J$

$$4.9\times10^{-19}\,J = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{4.9\times10^{-19}\,J} = \frac{(6.6\times10^{-34}\,J\cdot s)(3.0\times10^{8}\,m/s)}{4.9\times10^{-19}\,J}$$

$f = \frac{c}{\lambda}$

$$\boxed{\lambda = 4.0\times10^{-7}\,m = 400\,nm} \quad \boxed{f = 7.5\times10^{14}\,Hz}$$

4). $f_0 = 1.04 \times 10^{15}\ Hz$

$hf = \phi + k \quad , \quad k = 0$

$\phi = hf_0 = (6.6 \times 10^{-34}\ J\cdot s)(1.04 \times 10^{15}\ Hz)$

$= 6.9 \times 10^{-19}\ J = 4.3\ eV$

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5). $hf = \phi + k \quad , \quad \phi = 2.16\ eV = 3.5 \times 10^{-19}\ J$

a). $hf = \frac{hc}{\lambda} \rightarrow$ To find the kinetic energy K_{max}

$K_{max} = hf - \phi = -\phi + \frac{hc}{\lambda}$

$= -3.5 \times 10^{-19}\ J + \frac{(6.6 \times 10^{-34}\ J\cdot s)(3.0 \times 10^{8}\ m/s)}{413 \times 10^{-9}\ m}$

$\boxed{K_{max} = 1.34 \times 10^{-19}\ J}$

b). The Threshold wave length is the lagest value of λ that can eject an electron from the rubidium surface.

That is when $K = 0$.

$hf_0 = \phi \rightarrow \frac{hc}{\lambda_0} = \phi \rightarrow \lambda_0 = \frac{hc}{\phi} = \frac{(6.6 \times 10^{-34}\ J\cdot s)(3.0 \times 10^{8}\ m/s)}{(2.16\ eV)(1.6 \times 10^{-19}\ J/eV)}$

$\boxed{\lambda_0 = 5.7 \times 10^{-7}\ m = 570\ nm}$

6). So once the wave length of UV light falls below 288nm electrons are emitted. That means that 288nm is the threshold wave length just like the previous problem.

a). $hf = \phi + k$, $k = 0$ at threshold

$hf_0 = \phi \rightarrow \frac{hc}{\lambda_0} = \phi$ so

$$\boxed{\phi = \frac{(6.6\times10^{-34}\,J\cdot s)(3.0\times10^{8}\,m/s)}{288\times10^{-9}\,m} = 6.9\times10^{-19}\,J = 4.3\,eV}$$

b). again,

$hf = \phi + k_{max} \rightarrow k_{max} = hf - \phi$

$$k_{max} = \frac{hc}{\lambda} - \phi = \frac{(6.6\times10^{-34}\,J\cdot s)(3.0\times10^{8}\,m/s)}{140\times10^{-9}\,m} - 6.9\times10^{-19}\,J$$

$$\boxed{k_{max} = 7.3\times10^{-19}\,J = 4.5\,eV}$$

7). The mean kinetic energy of an ideal gas is,

$$U = \frac{3}{2} kT \quad , \quad k = 1.38 \times 10^{-23} J/k \quad \text{(Boltzman's constant).}$$

part 1

$$T = \frac{\frac{2}{3} U}{k} = \frac{2/3 \, (3.2 \times 10^{-20} J)}{(1.38 \times 10^{-23} J/k)} = 1545 \, K$$

part 2

The smoke particles are in thermal equilibrium w/ the Ideal gas so,

$$U_{gas} = U_{smoke} = 3.2 \times 10^{-20} J$$

$$U_{smoke} = \frac{1}{2} m_{smoke} \cdot V_{rms}^2 = 3.2 \times 10^{-20} J$$

$$V_{rms}^2 = \frac{2 \cdot (3.2 \times 10^{-20} J)}{m_{smoke}} \rightarrow V_{rms} = \sqrt{\frac{2 \cdot (3.2 \times 10^{-20} J)}{(1.38 \times 10^{-17} kg)}}$$

$$\boxed{V_{rms} = 6.8 \times 10^{-2} \, m/s}$$

8).

1^{st} law of themodynamics,

$\boxed{\Delta U = Q + W}$, if the system dos work then W is negative

part 1

and the system take in heat so Q is positive.

so

$$\Delta U = Q - W = 550J - 840J$$

$$\boxed{= -290 J}$$

part 2

$$\Delta S = \frac{\Delta Q}{T} = \frac{550J}{(20+273)k} = \boxed{1.9 \, J/k}$$

since T is constant, meaning that thi process is isothermal then it is reversible.