Homework I
Introduction to Physical Chemistry

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1 Question 1

(a) 310.95 K

(b) -176.15 °C

(c) 8720 nm

(d) $0.173\text{Å} \times (10^{-10})^3 = 1.73 \times 10^{-31}$ m^3

(e) $\frac{1.76\times10^{-19}\text{ J}}{1.602\times10^{-19}} = 1.10$ eV

(f) 3.1 mols $\times\, 6.022 \times 10^{23} = 1.87 \times 10^{24}$

2 Question 2

(a) Cl(Z=17): $1s^2, 2s^2, 2p^6, 3s^2, 3p^5$

(b) Cu(Z=29): $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^{10}$

(c) Cu^{+2}(Z=29): $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^7$

3 Question 3

(a) $\lambda = 640\text{nm}$

$$v = \frac{c}{\lambda}$$
$$= \frac{3.00 \times 10^{17}}{640}$$
$$= 4.69 \times 10^{14}\text{s}^{-1}$$

(b) Visible light

(c)
$$E = hv$$
$$= 6.626 \times 10^{-34} \times 4.69 \times 10^{14}$$
$$= 3.11 \times 10^{-19} \text{ J}$$

(d)
- A: Constructive
- B: Destructive
- C: Constructive

4 Question 4

(a) Figure 1

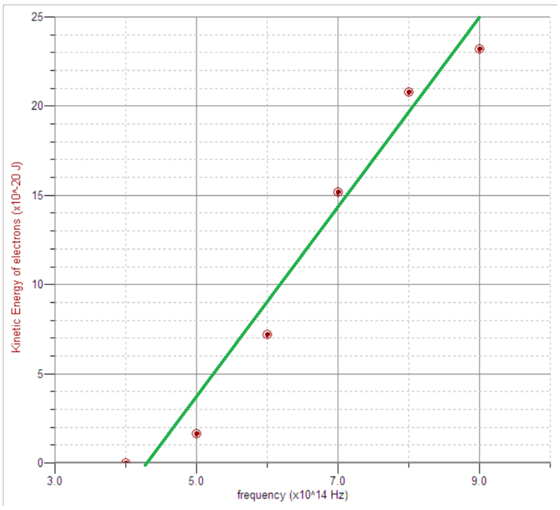

Figure 1: Best-fit line

(b)
$$\begin{aligned} h &= \frac{\Delta KE}{\Delta f} \\ &= \frac{25.0 \times 10^{-20} - 9.0 \times 10^{-20}}{9.0 \times 10^{14} - 6.0 \times 10^{14}} \\ &= 5.33 \times 10^{-34} \text{ Js} \end{aligned}$$

(c) Threshold frequency is *approximately* 4.2×10^{14} Hz

(d) i) The kinetic energy of the emitted electron is *approximately* 14.2×10^{-20} J

ii)
$$\begin{aligned} KE &= \frac{1}{2}mv^2 \\ 14.2 \times 10^{-20} &= \frac{1}{2}(9.1 \times 10^{-31})v^2 \\ v^2 &= 3.12 \times 10^{11} \\ v &= 5.59 \times 10^5 \text{ ms}^{-1} \end{aligned}$$

iii)
$$\begin{aligned} \lambda &= \frac{h}{mv} \\ &= \frac{6.626 \times 10^{-34}}{9.1 \times 10^{-31} \times 5.59 \times 10^5} \\ &= 1.30 \times 10^{-9} \text{ m} \end{aligned}$$

iv)
$$\begin{aligned} E &= eV \\ 14.2 \times 10^{-20} &= (-1.6 \times 10^{-19})V \\ V &= -0.89 \text{ V} \end{aligned}$$

5 Question 5

(a)
$$\begin{aligned} E &= hv \\ &= 6.626 \times 10^{-34} \times 1.52 \times 10^{13} \\ &= 1.01 \times 10^{-20} \text{ J} \end{aligned}$$

(b) Considering at threshold,
$$\begin{aligned} E &= hv_0 \\ 1.03 \times 10^{-20} &= (6.626 \times 10^{-34})v_0 \\ v_0 &= 1.55 \times 10^{13} \text{ Hz} \end{aligned}$$

(c)
$$\begin{aligned} E &= \phi + KE \\ E &= hv + KE \\ 1.01 \times 10^{-20} &= (6.626 \times 10^{-34})(8.95 \times 10^{12}) + KE \\ KE &= 1.01 \times 10^{-20} - 5.93 \times 10^{-21} \\ &= 4.17 \times 10^{-21} \text{ J} \end{aligned}$$

(d)
$$\begin{aligned} KE &= \frac{1}{2}mv^2 \\ 4.17 \times 10^{-21} &= \frac{1}{2}(9.1 \times 10^{-31})v^2 \\ v^2 &= 9.16 \times 10^9 \\ v &= 9.57 \times 10^4 \text{ms}^{-1} \end{aligned}$$

6 Question 6

(a) Consider the maximum wavelength where an electron would be ejected,

$$\begin{aligned}
\lambda &= \frac{hc}{E} \\
&= \frac{(6.626 \times 10^{-34})(3.00 \times 10^{8})}{2.52 \times 1.602 \times 10^{-19}} \\
&= 4.92 \times 10^{-7} \\
&= 492 \text{ nm}
\end{aligned}$$

The incoming wavelength is higher than the threshold wavelength, electrons will be ejected from the metal.

$$\begin{aligned}
E &= \frac{hc}{\lambda} \\
&= \frac{(6.626 \times 10^{-34})(3.0 \times 10^{8})}{550 \times 10^{-9}} \\
&= 3.61 \times 10^{-19}
\end{aligned}$$

$$\begin{aligned}
n &= \frac{10 \times 10^{-3}}{E} \\
&= \frac{10 \times 10^{-3}}{3.61 \times 10^{-19}} \\
&= 2.77 \times 10^{16} \mathrm{s}^{-1}
\end{aligned}$$

(b) The incoming wavelength is lower than the threshold wavelength, no electrons will be ejected from the metal.