Ex

A1

$$\lambda = \frac{h}{p} \quad , \quad E = \frac{p^2}{2m}$$

e^-: $$E = \frac{h^2}{2m\lambda^2} = 37{,}6\ \text{eV}$$

n: $$E = 0{,}02\ \text{eV}$$

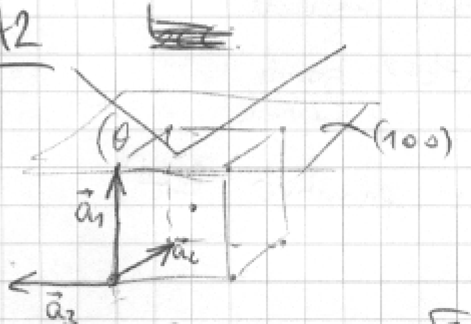
Photon: $$E = h\nu = \frac{hc}{\lambda} = 6{,}2\ \text{keV}$$

$$\frac{3}{2}kT = \frac{1}{2}mv^2 = E$$

$$\rightarrow T = \frac{2E}{3k} = \cancel{7{,}74}\,291\ \text{kK} \quad (e^-)$$

$$155\ \text{K} \quad (n)$$

A2



(100): $$n\lambda = 2a\sin\theta$$

$$\sin\theta = \frac{n\lambda}{2a}$$

$$\rightarrow \theta = \arcsin\left(\frac{n\lambda}{2a}\right) = 17{,}09°$$

(110): $a \rightarrow \frac{\sqrt{2}a}{2} \Rightarrow \cancel{\theta = \arcsin\left(\frac{3\lambda}{\sqrt{2}a}\right) = 11{,}99°}$

$$\theta = \arcsin\left(\frac{\lambda}{\sqrt{2}a}\right) = \cancel{11{,}99°}\ 24{,}6°$$

(111): $a \rightarrow \frac{\sqrt{3}a}{3} \rightarrow \theta = \cancel{19{,}84°}\ 30{,}6°$

(200): $a \rightarrow \frac{a}{2} \rightarrow \theta = 36{,}0°$

(210): $\vec{n} = \frac{1}{\sqrt{5}}\begin{pmatrix}2\\1\\0\end{pmatrix} \Rightarrow a \rightarrow \frac{1}{2}\vec{a}_1 \cdot \frac{1}{\sqrt{5}}\begin{pmatrix}2\\1\\0\end{pmatrix} = \frac{a}{\sqrt{5}} \Rightarrow \theta = 41{,}1°$

(211): $\vec{n} = \frac{1}{\sqrt{6}}\begin{pmatrix}2\\1\\1\end{pmatrix} \Rightarrow a \rightarrow \frac{1}{2}\vec{a}_1 \cdot \frac{1}{\sqrt{6}}\begin{pmatrix}2\\1\\1\end{pmatrix} = \frac{a}{\sqrt{6}} \Rightarrow \theta = 46{,}0°$

Al: $$\lambda = 2d\sin\alpha \rightarrow d = \frac{\lambda}{2\sin\alpha} = 2{,}34\ \text{Å}$$

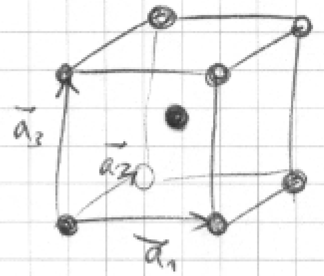
A3

a) $$\langle E_{kin}\rangle = \frac{1}{2}k_BT \overset{\text{Virialsatz}}{=} \langle E_{pot}\rangle = \frac{m\omega^2\langle u^2\rangle}{2} \rightarrow \langle u^2\rangle = \frac{k_BT}{m\omega^2}$$

b) Intensität fällt mit steigender Temperatur schnell ab.

A4

a)



● Cl : f_{Cl}

○ Cs : f_{Cs}

Basis: $\vec{r}_{Cs} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$, $\vec{r}_{Cl} = \begin{pmatrix} 1/2 \\ 1/2 \\ 1/2 \end{pmatrix}$

$$S_{hkl} = \sum_{\alpha=1}^{2} f_\alpha \, e^{-2\pi i (h u_\alpha + k v_\alpha + l w_\alpha)}$$

$$= f_{Cs} \, e^0 + f_{Cl} \, e^{-i\pi(h+k+l)}$$

$$= f_{Cs} + f_{Cl} \underbrace{e^{-i\pi(h+k+l)}}_{= \begin{cases} 1 & \text{für } h+k+l \text{ gerade} \\ -1 & h+k+l \text{ ungerade} \end{cases}} = \begin{cases} f_{Cs} + f_{Cl}, & h+k+l \text{ gerade} \\ f_{Cs} - f_{Cl}, & h+k+l \text{ ungerade} \end{cases}$$

bcc: $f_1 = f_2 = f$ $\quad S_{hkl} = \begin{cases} 2f \cdot \cancel{(1+e^{-i\pi(h+k+l)})} & h+k+l \text{ gerade} \\ 0 & \text{ungerade} \end{cases}$

da $\vec{r}_1 = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$ (1-Atom-Basis in primitiver EZ)

$\vec{r}_2 = \begin{pmatrix} 1/2 \\ 1/2 \\ 1/2 \end{pmatrix}$

b) Cs^+ und I^- haben gleiche Valenzelektronen

$\Rightarrow$ gleiches Streuverhalten $\Rightarrow S_{hkl} = \begin{cases} 2f, & h+k+l \text{ gerade} \\ 0 & h+k+l \text{ ungerade} \end{cases}$ $\quad (100) \rightarrow S_{hkl} = 0$

A5

$d = 57{,}3$ mm $\qquad$ $\cancel{\ldots}\ \lambda = 2\delta \sin\vartheta$

$a_1 = 43{,}4$ mm $\qquad \varphi_1 = \frac{a_1}{d} = 2\vartheta_1 \Rightarrow \vartheta_1 = \frac{a_1}{2d}$

$a_2 = 50{,}6$ mm $\qquad \vartheta_2 = \frac{a_2}{2d}$

$a_3 = 74{,}41$ mm

$a_4 = 90{,}21$ mm $\qquad \rightarrow \delta_i = \frac{\lambda}{2\sin\left(\frac{a_i}{2d}\right)}$

$a_5 = 95{,}21$ mm $\qquad$ Netzebenenabstand

$\lambda = 0{,}154$ nm

a	43,4	50,6	74,41	90,21	95,21
δ / 10^{-12} m	208,3	180,2	127,4	108,7	104,3
(hkl)	(111)	(200)	(220)	(311)	(222)

z.B. Li ($a = 3{,}51$ Å)

$\longrightarrow$ bcc-Gitter

Gitterkonst: $361 \cdot 10^{-12}$ m

$= 3{,}61$ Å