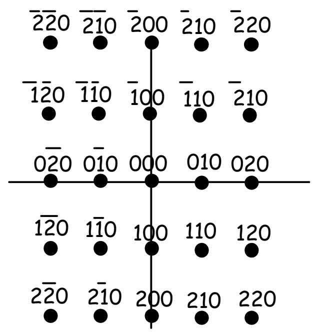
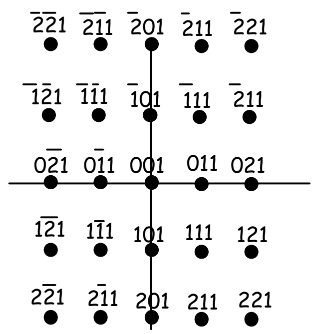
1. Construct, to scale, the *l* = 0, 1, 2 layers of the reciprocal lattice for an orthorhombic crystal for which a = 5, b = 7 Å. Let *h, k* run over the range ± 2. Index each point. Show the unit cell in each layer and mark the unit cell axes.

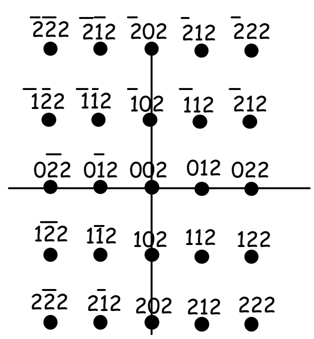
l = 0



l = 1



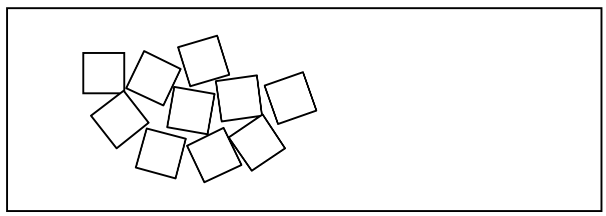
l = 2



2. An almost infinite number of tiny, perfectly cube-shaped grains of salt, about 1 micron in size, are dropped onto a flat glass plate so that they are extremely densely packed. For NaCl, a = 5.64 Å.

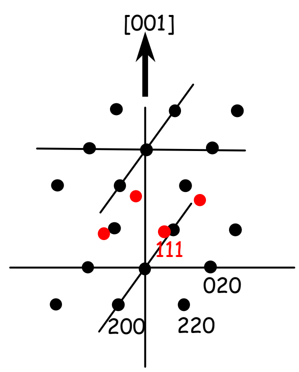
   Construct, to scale, a drawing of the representation of the reciprocal lattice for this specimen, index, and explain.

   When cubes fall onto plate, they will all lie on a cube face. This means that they will have a "preferred orientation", like this:

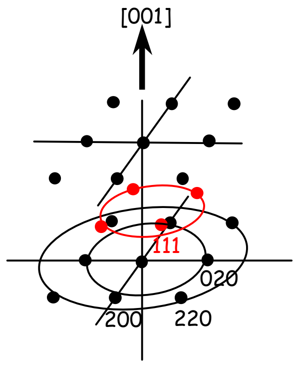


   Note that all cubes have one crystal direction in common, perpendicular to the plate (we might even think of this as a zone).

   The reciprocal lattice for one crystal is (NaCl is F cubic, and certain crystal planes for F don't exist):

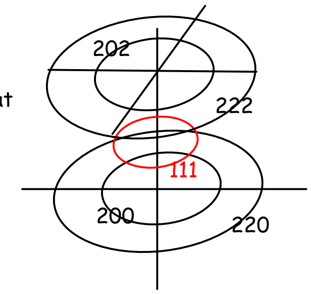


   The representation of the reciprocal lattice for the many crystals is then obtained by rotating the above lattice about [001]:



Answer;

(rings repeat along [001])



3. Calculate the critical voltage necessary to produce characteristic FeK radiation in a conventional laboratory x-ray tube.

   voltage (kV) = $12.4/\lambda_{Kedge}$ (Å) = 12.4/1.74334 = 7.11 kV

4. Calculate the energy for $CrK\alpha$ and $CuK\alpha$ X-radiation. What elements should be used as b-filters for Cr and Cu X-ray tubes?

   Cr: energy (keV) = 12.4//λ (Å) = 12.4/2.29092 = 5.41 keV
   Cu: energy (keV) = 12.4//λ (Å) = 12.4/1.541838 = 8.04 keV

5. Calculate the mass attenuation coefficient for the compound SiO_2 for $CuK\alpha$ radiation.

   $(\text{wt. fraction})_{Si} = 28/60 = 0.467$, $(\text{wt. fraction})_{O} = 0.523$

   $\mu_{Si} = 60.6$ $\mu_{O} = 11.5$

   $\mu_{SiO_2} = (\text{wt. fraction})_{Si} \times \mu_{Si} + (\text{wt. fraction})_{O} \times \mu_{O}$

   $\mu_{SiO_2} = 0.467 \times 60.6 + 11.5 \times 0.523 = 34.3\ cm^2/gm$

6. Calculate μ (= $\frac{\mu^*}{\rho}$ = mass attenuation coefficient; μ^* = linear attenuation coefficient) for air for $CrK\alpha$ radiation. Plot the transmission factor $\frac{I}{I_o} = e^{-\mu\rho x}$ for path lengths of 0-20 cm. Assume that air is 80 % nitrogen and 20 % oxygen by weight, with a density of $1.29 \times 10^{-3} \frac{gm}{cm^3}$.

$$\mu_{air} = 0.8 \times 23.9 + 0.2 \times 36.6$$

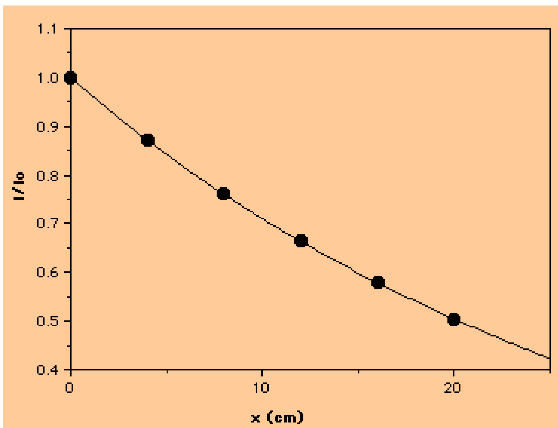
$$\mu_{air} = 26.44 \text{ cm}^2/\text{gm}$$

$$\mu^*_{air} = 26.44 \times 1.29 \times 10^{-3}$$

$$\mu^*_{air} = 0.0341 \text{ cm}^{-1}$$

$$I/I_o = e^{-\mu^* x} = e^{-0.0341x}$$

x (cm)	I/I_o
0	1.0
4	0.872
8	0.761
12	0.664
16	0.579
20	0.505



Wavelengths (in Angstroms) of Some Characteristic Emission and Absorption Edges*

Element	Z	$K\alpha$ (weighted average)†	$K\alpha_2$ Strong	$K\alpha_1$ Very strong	$K\beta_1$ Weak	K edge	$L\alpha$ Ver stro
Na	11		11.909	11.909	11.617		
Mg	12		9.8889	9.8889	9.558	9.5117	
Al	13		8.33916	8.33669	7.981	7.9511	
Si	14		7.12773	7.12528	6.7681	6.7446	
P	15		6.1549	6.1549	5.8038	5.7866	
S	16		5.37471	5.37196	5.03169	5.0182	
Cl	17		4.73050	4.72760	4.4031	4.3969	
A	18		4.19456	4.19162	....	3.8707	
K	19		3.74462	3.74122	3.4538	3.43645	
Ca	20		3.36159	3.35825	3.0896	3.07016	
Sc	21		3.03452	3.03114	2.7795	2.7573	
Ti	22		2.75207	2.74841	2.51381	2.49730	
V	23		2.50729	2.50348	2.28434	2.26902	
Cr	24	2.29092	2.29351	2.28962	2.08480	2.07012	
Mn	25		2.10568	2.10175	1.91015	1.89636	
Fe	26	1.93728	1.93991	1.93597	1.75653	1.74334	
Co	27	1.79021	1.79278	1.78892	1.62075	1.60811	
Ni	28		1.66169	1.65784	1.50010	1.48802	
Cu	29	1.54178	1.54433	1.54051	1.39217	1.38043	13.357
Zn	30		1.43894	1.43511	1.29522	1.28329	12.282
Ga	31		1.34394	1.34003	1.20784	1.19567	11.313
Ge	32		1.25797	1.25401	1.12889	1.11652	10.456
As	33		1.17981	1.17581	1.05726	1.04497	9.671
Se	34		1.10875	1.10471	0.99212	0.97977	8.990
Br	35		1.04376	1.03969	0.93273	0.91994	8.375
Kr	36		0.9841	0.9801	0.87845	0.86546	
Rb	37		0.92963	0.92551	0.82863	0.81549	7.318
Sr	38		0.87938	0.875214	0.78288	0.76969	6.862
Y	39		0.83300	0.82879	0.74068	0.72762	6.448
Zr	40		0.79010	0.78588	0.701695	0.68877	6.070
Nb	41		0.75040	0.74615	0.66572	0.65291	5.724
Mo	42	0.71069	0.713543	0.70926	0.632253	0.61977	5.406
Tc	43		0.6793	0.6749	0.6014	0.5891	
Ru	44		0.64736	0.64304	0.57246	0.56047	4.845
Rh	45	0.61470	0.617610	0.613245	0.54559	0.53378	4.597
Pd	46		0.589801	0.585415	0.52052	0.50915	4.367
Ag	47		0.563775	0.559363	0.49701	0.48582	4.154