Prob 1

(a) \( P(\Omega_c) = C \) \quad 0 \leq \theta_c \leq \pi/2 \quad \int d\Omega_c P(\Omega_c) = 1 \quad 2\pi C \int \sin \theta_c \cos \theta_c d\theta_c = 1 \Rightarrow C = \frac{1}{2\pi}

(b) \( G(\theta_c) d\theta_c = \int_{\theta_c}^{\pi} d\theta' \sin \theta' d\theta' \quad P(\Omega_c) = \sin \theta_c d\theta_c \quad G(\theta) = \sin \theta_c \sin \theta'

\( F(E \to E') dE' = G(\theta) d\theta_c \quad F(E \to E') = G(\theta_c) \left| \frac{d\theta_c}{dE'} \right| \\
\text{with} \quad E' = \frac{E}{2} \left[ (1+\alpha) + (1-\alpha) \cos \theta_c \right] \quad \theta_c = \pi/2, \quad E' = \frac{E(1+\alpha)}{2}

\( F(E \to E') = \frac{2}{E(1-\alpha)} \quad \frac{E}{2} \leq E' \leq E \quad \text{otherwise}

\( E \)

\[ \begin{array}{c}
\alpha E \\
E/2 \\
(1+\alpha)E/2 \\
E
\end{array} \]

present: \( \quad \text{sph symmetry:} \quad \overline{\text{---}} \)

(c) Range: \( \text{present range} = E - \frac{E}{2}(1+\alpha) = \frac{E(1-\alpha)}{2} \)

\( \text{sph symmetry range} = E - \alpha E = E(1-\alpha) \)

When angular range is restricted, expect the energy range to be also restricted. Reduction is a factor of \( \frac{1}{2} \) in the present case.
Problem 2

(a) Peak A: elastic scattering of thermal neutron $E' \approx E$
dominant process is Bragg diffraction in a crystal

Peak B: (lattice) inelastic scattering, $E' < E$ (downscattering
by exciting lattice vibration - phonon emission)

Intensity variation with $T$ and $\theta$ —

peak A will vary with $\theta$ (Bragg condition, $n = 2d \sin \theta$) but
not with $T$

peak B will not vary much with $T$ or $\theta$, although the phonon
absorption (upscattering by de-excitation lattice vibration) will
be sensitive to $T$ (intensity will increase with increasing $T$)

(b) Peak A: elastic photon scattering (both are Compton

B: inelastic photon scattering, scattering while the
elastic Compton $\rightarrow$ Thomson scattering

$\alpha = E/n^2 \to 0$ Compton $\rightarrow$ Thomson (Thomson dominates)

$\alpha \gg 1$ Compton dominates

position of peak B will vary with $\theta$ according

$E = \frac{\omega}{1 + \alpha(1 - \cos \theta)}$

$E' = \frac{\omega'}{1 + \alpha(1 - \cos \theta)}$

$\omega' = \frac{\omega}{1 + \alpha(1 - \cos \theta)}$
**Prob 3**

(a) $\beta^+$ does not undergo $\beta^+$ decay (given), so $\beta^+$ must come from pair production by the two $\gamma$s indicated in the diagram (provided $E > 1.02$ MeV (2$m_e^2$)).

Note, another process "internal pair conversion" also can occur - one person in the class mentioned this.

(b) Each point energies

\[ E(\gamma_1) = 14.14 - 1.38 = 12.76 \quad T_{\text{max}}(\beta^+) = 2.76 - 1.02 = 1.74 \text{MeV} \]

\[ E(\gamma_2) = 1.38 \]

(c) Decay modes:

- $\beta^-$: $4^+ \to 4^+$ allowed, $E$ and $G-T$
- $\gamma_1$: $4^+ \to 2^+$ $E\gamma_2$
- $\gamma_2$: $2^+ \to 0^+$ $E\gamma_2$ unique

**Prob 4**

(a) $K/N$

(b) $\delta N/E$ (K-N)

(c) $\sigma = \sigma_c - \sigma_{\text{sc}}$, $\sigma_c = \int d\Omega \frac{d\sigma}{d\Omega}$, $\sigma_{\text{sc}} = \int d\omega \frac{d\sigma}{d\omega}$

\[ \approx 1-2x \]

\[ \approx 1-3x \]

This means there will be a peak in $\sigma$. 

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(d) Both selection rules are governed by conservation of angular-momentum (orbital & spin) and parity.

\[ \gamma - \text{decay} \quad I_f = I_i + 1 \gamma \]

\[ \pi_f = (-1)^{L_f} \pi_i \]

\[ L_f = 0, 1, \ldots \]

\[ S_f = 0 \text{ or } 1 \]

\[ \pi_i = \pi_x \pi_y \]

\[ L_i = 1, 2, \ldots \]

\[ \pi_x = (-1)^{L_x} \]

\[ \pi_y = (-1)^{L_y} \]

E transition.

angular momentum and parity affect are expressed differently.

(e) Singh

 resonance

interference (destructive \( T_n < T_n^* \))

\( n + X^A \rightarrow (X^A)^* \rightarrow n + X^A \)

CN

at resonance \( T_i = T_i^* \) \( (T_n = T_n^*) \)

CN is at energy \( E^* \) (one of its resonance levels)

\( Q = 0 \) (elastic scattering)