# 22.106 Neutron Interactions and Applications
# Problem Set 5

**Due SES #19**

**Question 1**

The theory of thermal neutron inelastic scattering involves at least three key concepts: Born approximation, the Fermi pseudopotential and the dynamic structure factor.

a) Define each concept mathematically and physically, focusing on the approximations involved (how well justified?) or the information it conveys (how significant?)
b) Explain in the case of the Born approximation and Fermi pseudopotential why they are essential in developing an expression for the double differential cross section.
c) Explain the significance of the dynamic structure factor in experimental and theoretical studies in thermal neutron inelastic scattering.

**Question 2**

Define coherent and incoherent scattering.

**Question 3**

Calculate the coherent and incoherent scattering cross-sections of a neutron with hydrogen if the scattering lengths are:

$a_+ = 5.3$ fm $\qquad$ $a_- = -24.0$ fm

**Question 4**

Demonstrate that (notes 1, page 7)

$$\left[\nabla + k\right]e^{ikz} = 0$$

**Question 5**

Discuss the behavior of $\sigma_s(\theta,\varphi)$ for the low energy approximation (kd << 1) and for the high energy approximation (kd >> 1). (notes 2, page 6)

$$\sigma_s(\theta,\varphi) = \frac{1}{2} a^2 \left[1 + \cos(kd \sin\theta \cos\varphi)\right]$$

**Question 6**

Suggested homework on page 14 of Neutron InteractionMIT2.pdf

**Question 7**

A silicon crystal has Bragg edges at 0.008 eV and 0.012 eV, what information can be obtained from these measurements? Explain the concept of Bragg scattering.

**Question 8**

Derive the following relation due to chemical binding effects

$$a_{bound} = \frac{A+1}{A} a_{free}$$

and show how it impacts the scattering cross-section.

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Spring 2010