(1) A 6 nm (diameter) spherical nanoparticle shows a relatively large coercivity at room temperature. What is the necessary effective magnetic anisotropy constant for this spherical nanoparticle to be thermally stable for ten years at room temperature? Assume the required thermal stability factor is 60. Boltzmann constant is $1.38\text{x}10^{-16}$erg K^{-1}. There are limited material candidates that could provide such high magnetic anisotropy. List one type of such magnetic materials. (1.0 point)

(2) Granular type heat assisted magnetic recording medium, consisting of multiple tiny magnetic nanoparticles with thin nonmagnetic grain boundaries, uses such a magnetic material. The state-of-art magnetic writer using the high saturation magnetization material FeCo still couldn't provide a magnetic switching field to record information on such a medium. Assume you are allowed to use a localized heating source (e.g. a focused laser beam) to heat up the medium. Explain the physical principle of one design how to reduce the coercivity of the recording medium, and thus allow recording information. (0.8 point)

(3) Plot and explain the trend of the coercivity vs. the diameter of such a magnetic nanoparticle from 2 nm up to 200 nm. (0.7 point)

(4) Engineers in the recording industry are trying to use this material to manufacture bit patterned media. Bit patterned media consists of physically isolated and well-ordered magnetic bits (dots) with different dimensions. Somehow, its large uniaxial magnetic anisotropy was largely degraded down to $1 \text{ x } 10^5$ erg/cm^3 through an etching process (e.g. ion milling). Assume the patterned bit is in ultrathin disk shape (50 nm in diameter and 3 nm in thickness). Plot a possible domain configuration for such a ultrathin magnetic disk bit. Assume there is no stress and this material still possesses its large saturation magnetization after patterning. Provide the justification for your choice. (0.5 point)

(5) Engineers in the memory industry are trying to use this material to manufacture the current-perpendicular-to-plane (CPP) giant magnetoresistance (GMR) arrays for future magnetic random access memory. Explain the working principle of a tri-layer structured CPP GMR using a simplified two-spin channel model. (0.6 point);

(6) Engineers at the memory industry later found that this material has too high anisotropy, and thus coercivity, to function as a switchable free layer of CPP GMR. One suggested solution is to use a composite free layer structure, e.g. two exchange-coupled magnetic layers. Explain how this idea works. (0.4)