Homework #8

① Al: $900\ \mathrm{J/kg\,K} \times .027\ \mathrm{kg/mol} = 24.3\ \mathrm{J/mol\,K}$

Cu: $386\ \mathrm{J/kg\,K} \times .0635\ \mathrm{kg/mol} = 24.5\ \mathrm{J/mol\,K}$

Ag: $235\ \mathrm{J/kg\,K} \times .108\ \mathrm{kg/mol} = 25.4\ \mathrm{J/mol\,K}$

Au: $128\ \mathrm{J/kg\,K} \times .197\ \mathrm{kg/mol} = 25.2\ \mathrm{J/mol\,K}$

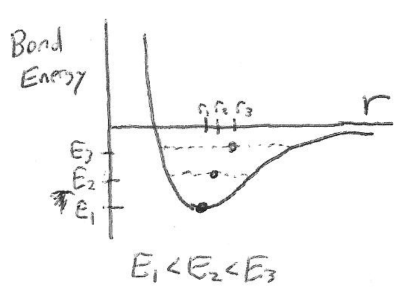
$3R = 3(8.314) = 24.9\ \mathrm{J/mol\,K}$

② C_p is larger because the added heat has to do work on the piston as well as heat up the material.

③ $\frac{\Delta L}{L_0} = \alpha \Delta T$ Units of α = $1/K$ or $1/°C$

$\frac{\Delta V}{V_0} = \alpha_v \Delta T$ Units of α_v = $1/K$ or $1/°C$

④



As a crystal is heated, the energy in the crystal increases. This energy causes the atoms to vibrate. The distance it can vibrate is shown by the walls of the well in the Potential Energy curve. The material expands because the walls of the well are assymetric so the mean distance r, is larger for increasing T's.

⑤ Water: Ice has a larger volume than liquid water. Ice does not have a very close packed structure, so as it melts the molecules aren't forced into the ice structure and are able to get much closer to one another.

Other examples: Silicon, Rubber, Diamond

(You should have been able to get 1 of these, you don't need Wikipedia to tell you about ZrW_2O_8)

⑥ $l_i = 1\,m$

$l_f = 1.005\,m$

$\Delta T = 80°C$

$$\frac{\Delta l}{l_i} = \alpha \Delta T$$

$$\frac{0.005\,m}{1\,m} = \alpha (80°C)$$

$$\boxed{\alpha = 6.3\times10^{-5}\ 1/°C}$$

⑦ $T_i = 25°C$

$d_w = 15.025\,nm$ $\quad$ $\alpha_w = 4.5\times10^{-6}\ 1/°C$

$d_{st} = 15\,nm$ $\quad$ $\alpha_{st} = 12\times10^{-6}\ 1/°C$

$$\frac{\Delta l}{l_i} = \alpha \Delta T$$

Assume the materials expand isotropically.

$$l_f = l_i(\alpha(T_f - T_i) + 1)$$

$$l_{f,st} = l_{f,w}$$

$$15\,nm\,(12\times10^{-6}\ 1/°C\,(T_f - 25°C) + 1) = 15.025\,nm\,(4.5\times10^{-6}\ 1/°C\,(T_f - 25°C) + 1)$$

$$\boxed{T_f = 247.445°C}$$

8 2 pts

a) Thermal conduction occurs through:

1) e^- motion
2) phonon propagation

Better electrical conductors => e^- can move more easily
=> e^- can carry heat (diffuse) more easily.

b) Phonon conduction depends on

1) Crystal quality (uniform in 3-D, defect free)
2) Bond strength

Diamond has higher crystal quality (3D structure instead of layered rings) and much stronger bonds => much better phonon based thermal conduction

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9 2 pts

Glass is a poor electrical conductor → poor e^- thermal conduction
Glass has an open, amorphous structure → poor phonon thermal conduction

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Magnetic properties

1 4 pts

$B = \mu_0 (H + M)$ in SI units

($B = H + 4\pi M$ in cgs units)

also: $M = \chi_m H$ (SI)

$\therefore B = (1 + \chi_m)\mu_0 H$

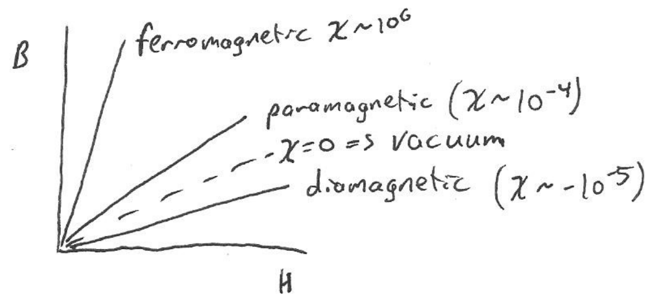
SI

w/ $\mu_0 = 1.26 \times 10^{-6}$ H/m

$H \Rightarrow [A/m]$ $B \Rightarrow [T] = \frac{Wb}{m^2}$

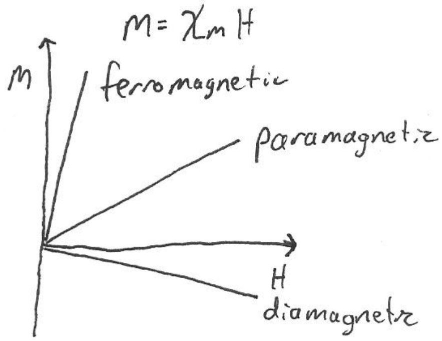
$M \Rightarrow [A/m]$

2 4 pts

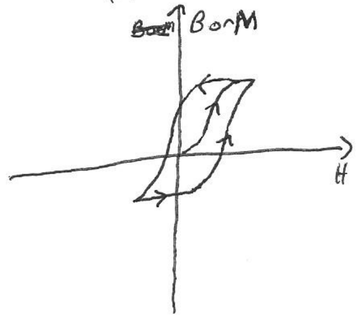


$$B = \underbrace{(1+\chi)\mu_0}_{\text{slope}} H$$

$$M = \underbrace{\chi_m}_{\text{slope}} H$$



Remember: as H is cycled → hystersis for ferro- & ferrimagnetic



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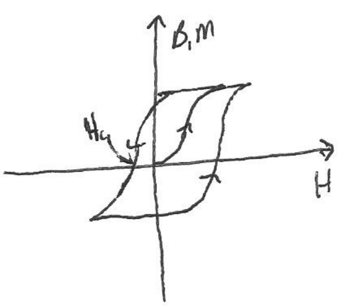
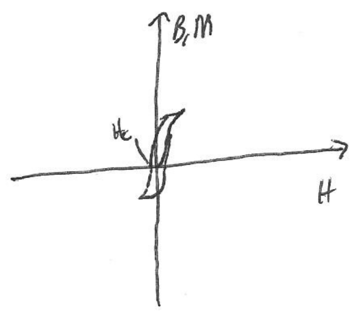
3 4 pts

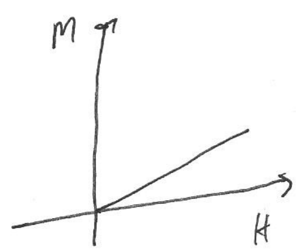
Hard:
large H_c (coercive field)



Soft:
small H_c



above T_c
⇒ paramagnetic



(should be symmetric about the origin)

4   2 pts

Ferromagnets: magnet moments are aligned with the applied magnetic field

ex ↑↑↑↑   ↑H

Ferrimagnets: magnetic moments on different sublattices are opposed but unequal, dominant moment is aligned w/the field

ex ↑↓↑↓   ↑H