3.091 Final Exam

Problem 1

(a): Define some variables:

$\partial X = 0.00444$ m

$\partial C = 5.55$ kg/m^3

$A = 6.66$ m^2

$D = 2.22 \cdot 10^{-10}$

$m = 0.0111$ kg; then recall Fick's first law, which states that

$$\text{flux} = -D \frac{\partial c}{\partial x} = \frac{m}{A \cdot t}$$

$$-2.22 \cdot 10^{-10} \cdot \frac{5.55}{0.00444} = \frac{0.0111}{6.66 \cdot t}$$

implies

$t = 6006$ s

(b): A lower dislocation density implies lower diffusivity, thus increase.

Problem 2

Recall

$$D = D_0 \exp\left(\frac{-E_A}{8.314 \cdot (T)}\right) = 6.11 \cdot 10^{-11} \ m^2/s$$

Then, since

$$\frac{C_{x,t} - C_s}{C_0 - C_s} = \operatorname{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$$

Then

$$0.3 = \operatorname{erf}\left(\frac{0.7 \cdot 10^{-3}}{2\sqrt{6.11 \cdot 10^{-11} \cdot t}}\right)$$

implies

$$t = 2.696 \cdot 10^{4} \ s$$

Problem 3

See that

$$K_{sp} = [Cu^{+2}][CrO_4^{-2}] = x^2 \Rightarrow x = \sqrt{K_{sp}} = 3.086 \cdot 10^{-5} \text{ mol/L}$$

Then, since we have the solubility,

$$3.065 \cdot 10^{-5} \text{ mol/L} \cdot \frac{179.5 \text{ g}}{\text{mol}} \cdot 0.05 \text{ L} \cdot \frac{1000 \text{ mg}}{\text{g}} = 0.275 \text{ mg}$$

Problem 4

(a): Highly soluble – both components are non polar

(b): Almost insoluble – mismatch in polar/nonpolar nature, and mismatch in hydrogen bonding.

Problem 5

(a): 6

(b): Yes

(c): 530 Kelvin

(d): 3 kbar

Problem 6

(a): Cons.

(b): Cons.

(c): Cons

(d): Cons

(e): Cons

(f): Cons

(g): BCC Ti-rich
BCC V-rich

(h): BCC Ti-rich
BCC V-rich
Close packed Ti-rich

(i): $\frac{19-3}{80-3} = 0.2078$

Problem 7

(1) Cons

(2) Cons

(3) Cons

(4) Cons

(5) Decr

(6) Cons

(7) Incr

(8) Cons

(9) Cons

(10) Decr

(11) Incr

(12) Con

(13) 0

(14) On 1596

Problem 8

(a): 0 and 120 ~~degrees~~, and 360 degrees.

(b): 180 and 300 degree.

(c): 240 degrees.

Problem 7

(a): $1.469 \cdot 10^5$

(b): 0

Problem 10

(a): e

(b): $2.835 \cdot 10^5$ g/mol

Problem 11

(a): PBMA
PPMA
PEMA
PMMA

(b): glass transition temperature

(c): glass transition temperature

(d): 11

(e): 11

(f): (1) D
(2) A

Problem 12a

(A): 10.6 nm

Problem 13

(a): Hydrophobic regions are disrupted

Problem 14

(a): $+2$

(b): -1

(c): 0

(d): 10

~~(e)~~:

Problem 15

(a): 6.78

(b): +1

(c): −2

(d): 0

(e): 3.09

Problem 16

(A): 4.87

Problem 17

(a): e

Problem 18

(a): (111)

(b): (100), (110), and (111)

Problem 19

First find energy per bond:

$$w_{Au-Au} = \frac{3.64 \cdot 10^5 \cdot 2}{12 \cdot 6.02 \cdot 10^{23}} = 1.007 \cdot 10^{-19}$$

and volume of cell:

$$V = \frac{100.2 \cdot 4}{6.02 \cdot 10^{23}} = 6.78 \cdot 10^{-23}$$

and thus

$$a = V^{1/3} = 4.07 \cdot 10^{-8}.$$

Then

$$\gamma_{110} = \frac{10 \cdot 1.007 \cdot 10^{-19}}{2 \cdot \sqrt{2}(4.07 \cdot 10^{-8})^2} = 2.143 \cdot 10^{-4}\ J/cm^2$$

Problem 20

(a): we see the deBroglie velocity

$$v = \frac{h}{\lambda \cdot m_p} = 7.694 \cdot 10^4 \ m/s;$$

(b): Write

$$qV = \frac{1}{2} m v^2 \Rightarrow (1.602 \cdot 10^{-19}) V = \frac{1}{2}(1.67 \cdot 10^{-27})(7.694 \cdot 10^4)^2$$

Implies

$$V = 30.9 \text{ Volts.}$$

Problem 21

(a): AVEE carbon $= (1.72)\cdot(2/4) + (1.09)(2/4) = 1.405$ MJ/mol

(b): AVEE Fluorine ~~carbon~~ $= (3.88)(2/7) + (1.68)(5/7) = 2.308$ MJ/mol

Problem 22

(a): See that

$$\frac{5.49 \cdot 10^6}{9.86 \cdot 10^8} = \left(\exp\left(-\left(\frac{\Delta H}{8.314}\right)\left(\frac{1}{5000} - \frac{1}{10000}\right)\right)\right)$$

implies

$\Delta H = 431557 \text{ J/mol};$

Thus since

$$5.49 \cdot 10^6 = A \exp\left(\frac{-\Delta H}{8.314 \cdot 7500}\right)$$

Then

$$K_{T=7500} = A \exp\left(\frac{-\Delta H}{8.314 \cdot 7500}\right) = 1.748 \cdot 10^8 \text{ L} \cdot \text{mol}^{-1} \cdot \text{s}^{-1}$$

(b): 1.5

Problem 23

(a): Let us find the critical wavelength:

$$\lambda_c = \frac{hc}{E_g} = 1.13 \cdot 10^{-6} \text{ m};$$

no, since the photon does not have small enough wavelength.

(b): Refer to (a).

Problem 24

See that

$$\frac{0.0008}{0.0001} = \exp\left(\frac{-\Delta H_v}{1.38 \cdot 10^{-23}} \cdot \left(\frac{1}{923} - \frac{1}{688}\right)\right)$$

implies

$$\Delta H_v = 8.194 \cdot 10^{-20}$$