Question 1. *Half Life*

A first order reaction has an activation energy (E_A) of 140 kJ/mol and a pre-exponential factor (A) of $8 \cdot 10^{12} s^{-1}$. At what temperature will that reaction have a half-life ($t_{1/2}$) of 45 days? Express your answer in Kelvin (K).

Solution 1.

Question 2.   *Resist*

A current of 8.714 milliamps (10^{-3} A) is measured flowing through a tungsten wire of diameter 0.2 mm and 8 cm long when 1.4 mV is applied. What is the resistivity of tungsten? Express your answer in ohm-m.

Solution 2.

Recall the definition of resistivity:

$$p = R \cdot A \cdot l^{-1}$$

See by Ohm's law that

$$R = \frac{V}{I};$$

thus from the given information,

$$
\begin{aligned}
p &= \frac{1.4 \cdot 10^{-3}}{8.714 \cdot 10^{-3}} \cdot \frac{(1/2(0.2 \cdot 10^-3))^2 \cdot \pi}{8 \cdot 10^-2} \\
&= 6.309 \cdot 10^{-8} \, \Omega\mathrm{m}^{-1}
\end{aligned}
$$

Question 3. *A Carrier of a Different Size than the Typical Aircraft Carrier*

Determine the amount (in grams) of arsenic required to be substitutionally incorporated into a mole of silicon in order to achieve a carrier density of $7x10^{17}/cm^3$. Assume intrinsic carriers are negligible.

Solution 3.

Question 4. *You Discovered a New Element*

An unknown element is known to be a simple cubic and have a molar volume of 22.22 cm3.

Calculate the atomic density (atoms/cm2) in the (011) plane of this material.

What is the distance to the second nearest neighbor? (in cm)

Solution 4.

Question 5. *Silver Bells*

What is the minimum voltage required to produce two K_α peaks from an X-ray generator that has a silver-copper alloy anode? (express your answer in eV)

Solution 5.

Question 6. *Characteristic Wavelengths*

You are operating an X-ray tube with a cobalt (Co) target by applying an acceleration potential of 53 kVolt. Calculate the values of two characteristic wavelngths, $\lambda_{K\alpha}$ and λ_{SWL}. Express your answers in meters.

Solution 6.

Question 7. *Is Big Al Really Big?*

Which of the following (of each pair) have GREATER Young's modulus? Pair 1:

- Al [100]
- Al [111]

Pair 2:

- Al [111]
- Cu [111]

Pair 3:

- Pb [100]
- Al [100]

Solution 7.

Pair 2:

Question 8. *Push! Can we Fit It?!*

Determine the radius of the largest atoms that can be accommodated in the interstices of BCC iron (Fe) without stress. Express your answer in meters. (Hint: the center of the largest site is at 1/2, 1/4, 0; draw a unit cell-it helps)

Solution 8.

Question 9. *How Many Ways Can Salt Slip?*
Slip in NaCl-structure ioinic crystals occurs most commonly on {110} planes and in <110> directions. How many slip systems are there?

Solution 9.

Question 10.   *All Hail King pyRex*

Soda-lime glass has a typical composition of:

A: $0.15Na_2O$ - $0.10CaO$ - $0.75SiO_2$

Soda-lime glass is used for containers and floatglass (window glass). Borosilicate glass is used for products such as PyrexTM. The composition of borosilicate glass is typically:

B: $0.05Na_2O$ - $0.025CaO$ - $0.125B_2O_3$ - $0.80SiO_2$

Calulate the number of oxygens per network forming ion in each glass:

Solution 10.

Question 11. *Nitro-licious Glass*

It has been observed that up to 3% nitrogen can be dissolved in silicate based glasses.

How do you expect the viscosity of the glass melt to change with nitrogen addition?

How do you expect the glass working temperature to change with nitrogen addition?

Assume you cool the glass at the same rate from the melt. How do you expect the free volume to change with nitrogen addition?

Respond to all with increase/decrease.

Solution 11.