

## Atomic bonding

Ionic: Anions gain electrons, cations lose electrons

Covalent: electrons shared between two atoms

Metallic: electrons shared between many atoms

Van der Waals: temporary or permanent dipole

Interacts with other objects

## Crystal structures

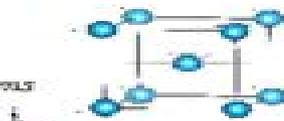
### BODY CENTERED CUBIC

$$4R = \sqrt{a^2 + a^2 + a^2}$$

$$4R = a\sqrt{3}$$

1 center atom, 8 corner atoms

2 atoms per unit cell



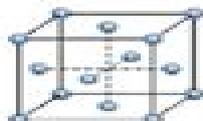
### FACE CENTERED CUBIC

$$4R = \sqrt{a^2 + a^2}$$

$$4R = a\sqrt{2}$$

6 face atoms, 8 corner atoms

4 atoms per unit cell



Volume of a cubic =  $a^3$

$$A = 10^{-10} \text{ m}$$

$$\text{Avogadro No} = 6.022 \times 10^{23} \left( \frac{\text{atoms}}{\text{mol}} \right)$$

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{\# \text{ of atoms} \times \text{atomic mass}}{\text{volume of unit cell} \times \text{Avogadro}}$$

## Miller Indices

crystal	h	k	l
1. Intercepts	1	1	1
2. Reciprocals	1/1	1/1	1/1
3. Reduction	1	1	1
4. Miller indices	(111)		



crystal	h	k	l
1. Intercepts	1/2	1	1
2. Reciprocals	2/1/2	1/1	1/1
3. Reduction	2	1	2
4. Miller indices	(212)		



$$\text{Planar Density} = \frac{\text{atoms per face}}{\text{area of face}}$$

$$\text{Packing Factor} = \frac{\text{volume of atom} \times \text{number of atoms}}{\text{volume of the unit cell}}$$

## Point Defects

$$n_v = n \cdot e^{-\frac{Q_v}{RT}}$$

$$n_v = \# \frac{\text{vacancies}}{\text{cm}^3}, n = \# \frac{\text{atoms}}{\text{cm}^3}$$

$Q_v$  = energy for 1 mol of vacancies,  $T$  = Temp

$$R = \text{Gas constant} = 1.987 \frac{\text{cal}}{\text{mol} \cdot \text{K}} = 8.314 \frac{\text{joules}}{\text{mol} \cdot \text{K}}$$

## Diffusion

$$D = D_0 \cdot e^{-\frac{Q_d}{RT}}$$

$D_0$  = constant based on material

$Q_d$  = energy for 1 mol of vacancies,  $T$  = Temp

$$R = \text{Gas constant} = 1.987 \frac{\text{cal}}{\text{mol} \cdot \text{K}} = 8.314 \frac{\text{joules}}{\text{mol} \cdot \text{K}}$$

$$J = -D \cdot \frac{dc}{dx}, x = \text{thickness}, J = \text{Flux} \text{ - Fick's 1st law}$$

$c$  = Compositions in atomic percent

## Mechanical Properties

$$\text{Engineering stress } (S) = \frac{F}{A_0}$$

$$\text{Engineering Strain } (e) = \frac{\Delta l}{l}$$

$$\text{Young Modulus } (E) = \frac{S}{e}$$

$F$  = Force,  $A_0$  = Area

$\Delta l$  = Change in length,  $l$  = Original length

$$K_f \text{ or } K_{IC} = f \cdot \sqrt{\pi a}$$

$\sigma$  = Exposed stress,  $a$  = flaw size

$f$  = geometry factor for the specimen and flaw

$K_{IC}$  = fracture toughness

$K_{IC}$  = plain strain fracture toughness

$$\pm \sigma = 5.09 \cdot \frac{FL}{d^3}$$

$F$  = Applied Load,  $L$  = Length of shaft

$d$  = diameter of shaft

$$1 - K(V) = \exp \left[ - \left( \frac{\sigma}{\sigma_0} \right)^m \right]$$

$m$  = Weibull Modulus,  $\sigma_0$  = Flexural Strength

$F$  = Failure,  $\sigma_0$  = Initial Flexural Strength

$$\text{Poissons Ratio } (\nu) = \frac{-\epsilon_{lateral}}{\epsilon_{longitudinal}}$$

$$\text{Modulus of resilience } (E_r) = \frac{1}{2} (\text{yield strength}) (\text{strain @ yielding})$$

$$\text{Ductility \% Elongation} = \frac{l_f - l_0}{l_0} \cdot 100\%$$

$$\text{Ductility \% Reduction in area} = \frac{A_0 - A_f}{A_0} \cdot 100\%$$

$$\text{True Stress} = \frac{F}{A_f}$$

$$\text{True Strain} = \ln \left( \frac{l}{l_0} \right)$$

$$\sigma_t = K \epsilon_t^n$$

$n$  = strain coefficient,  $K$  = Constant

$\epsilon_t$  = True strain,  $\sigma_t$  = True Stress

$$\sigma_m = 2\sigma_0 \left( \frac{a}{r_0} \right)^{\frac{1}{2}}$$

$\sigma_m$  = Stress @ Crack tip,  $\sigma_0$  = Applied stress

$a$  = Crack Length,  $r_0$  = radius of curvature

$$\sigma_c = \left( \frac{2E\gamma_s}{\pi a} \right)^{\frac{1}{2}}$$

$\sigma_c$  = Critical Stress,  $E$  = elastic modulus

$\gamma_s$  = specific surface energy

$a$  = one half length of internal crack

## Solidification and Nucleation

# Material Science Final Exam Key

**Mike Jess**



**Material Science Final Exam Key:**

Material Science Final Exam Key: Bestsellers in 2023 The year 2023 has witnessed a noteworthy surge in literary brilliance, with numerous compelling novels enthralling the hearts of readers worldwide. Lets delve into the realm of top-selling books, exploring the captivating narratives that have charmed audiences this year. Material Science Final Exam Key : Colleen Hoover's "It Ends with Us" This heartfelt tale of love, loss, and resilience has captivated readers with its raw and emotional exploration of domestic abuse. Hoover masterfully weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can prevail. Uncover the Best : Taylor Jenkins Reids "The Seven Husbands of Evelyn Hugo" This captivating historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reids compelling storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Discover the Magic : Delia Owens "Where the Crawdads Sing" This mesmerizing coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens crafts a tale of resilience, survival, and the transformative power of nature, entrancing readers with its evocative prose and mesmerizing setting. These bestselling novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of captivating stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is a brilliant and thrilling novel that will keep you guessing until the very end. The novel is a cautionary tale about the dangers of obsession and the power of evil.

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