

الزوجة الثانية



I- ONE Mark for each

1- Which of the following is not a common property of simple harmonic motions?

- (A) periodic motion (B) external elongation force
(C) restoring force (D) exchange of potential and kinetic energy

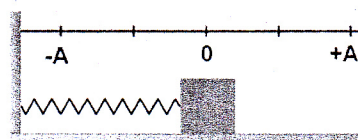
2- A body attached to the lower end of a vertical spring that vibrates up and down. The periodic time depends on which of the following?

- (A) Spring length (B) Vibration amplitude
(C) Spring constant (D) Earth's gravitational acceleration

(The corresponding figure relates to questions 3 and 4)

3- When the mass reaches the point $x = +A$, then the acceleration is?

- (A) maximum positive value (B) maximum negative value
(C) zero (D) minimum negative value



4- What is the point at which the mass reaches the maximum value of kinetic energy?

- (A) Point zero only (B) Point A only (C) Point (-A) only (D) Points A and -A

5- A body of mass 5 kg is suspended in a vertical spring and causes it to elongate by 7 cm. Calculate the spring constant. (Note that $g = 9.8 \text{ m/s}^2$)

- A) 400 N/m B) 500 N/m C) 600 N/m D) 700 N/m

6- What is the maximum kinetic energy of a particle in SHM with mass of 2kg, $\omega = \pi \text{ rad/s}$, $A = 1 \text{ m}$.

- A) 1.57 J B) 6.28 J C) 3.14 J D) 9.87 J

7- A body vibrates according to the equation $x = 5 \cos(16\pi t)$. Find the periodic time.

- A) $1/32 \text{ s}$ B) $1/8 \text{ s}$ C) 8 s D) 16 s

8- In a vibrating mechanical system, such as a spring, there is a restoring force, so what is the corresponding term in an oscillating circuit?

- A) q/L B) q/C C) R/C D) L/C

9- An oscillating circuit whose differential equation is $L \frac{d^2q}{dt^2} + R \frac{dq}{dt} + \frac{1}{C} q = 0$

This oscillation is considered harmonic

- (A) Undamped unforced (B) Undamped forced
(C) Damped unforced (D) Damped forced

10- The relation among the frequency, velocity and wavelength of a wave is

- A) $f = v/\lambda$ B) $f = v\lambda$ C) $f = \lambda$ D) $\lambda = f v$

1	2	3	4	5	6	7	8	9	10

II- Two Marks for each

11- A body of mass 4 kg is suspended by a vertical spring of constant 400 N/m. If the spring moves in a damped medium, calculate the damping coefficient b that makes the body return to the equilibrium position only without completing the vibration.

- A) 80 kg/s B) 85 kg/s C) 90 kg/s D) 95 kg/s

12- A spring is damped by a light oil with damping factor γ of 1.2 s^{-1} . It is found that 10 complete oscillations takes 20s. Determine the ratio of amplitudes of consecutive oscillations.

- A) 4.32 B) 3.32 C) 2.32 D) 1.32

13- A body attached to a spring moves in a damping harmonic motion with a damping constant of 1 s^{-1} . If the energy after two seconds becomes 10 joules, find the initial energy (E_0).

- A) 53.89 J B) 63.89 J C) 73.89 J D) 83.89 J

14- If the summation of forces on a body is given by: $\Sigma F = -kx + F_0 \cos \omega t$, then what is the expression for amplitude of motion?

- A) $A_0 e^{rt/2}$ B) $a \omega_0 / r$ C) $\frac{a}{1 - \omega^2/\omega_0^2}$ D) $\frac{a \omega_0^2}{[(\omega_0^2 - \omega^2)^2 + \omega^2 \gamma^2]^{1/2}}$

15- A car emits a sound of frequency 500 Hz and moves with a speed of 20m/s far away from stopped radar. Find the frequency detected by the radar (the speed of sound in air is 340 m/s)

- A) 472.22 Hz B) 462.22 Hz C) 452.22 Hz D) 452.22 Hz

16- A body of mass 1kg is attached to a spring of constant 100N/m. If the external force is $F = 6 \cos 15t$, Find the amplitude $A(\omega)$ of the displacement.

- A) 3.8 m B) 4.8 m C) 6.8 m D) 6.8 m

III- Four Marks for each

23) Represent by equations and drawing the Gaussian function for the following waves:

- (i) non-traveling wave. (ii) traveling wave by a distance of 2m in the left direction.

24) For forced oscillation (undamped and damped) write only the relation between ω and $A(\omega)$. Then show with drawing values of $A(\omega)$ when ω tends to 0, ω_0 and ∞ .

25) Discuss the physical pendulum to deduce the angular frequency.

26) In Doppler effect, deduce the relation between the emitted and heard frequencies in the case of moving source towards the stopped observer.



The exam is in 5 pages (50 degree)

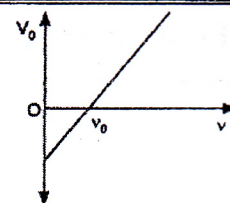
First question: Choose the correct answer:

(25 Marks)

1) The energy of a photon of red light of wavelength 650 nm is			
A. 1.65 eV	B. 2.40 eV	C. 1.90 eV	D. 1.75 eV
2) A furnace has walls of temperature 3000 °C. what the wavelength of maximum intensity emitted when a small door is opened?			
A. 0.99 μm	B. 0.89 μm	C. 0.95 mm	D. 0.99 mm
3) Which of the following electromagnetic radiations has photons with the greatest energy?			
A. blue light	B. X-rays	C. radio waves	D. microwaves
4) The frequency of light beam A is twice that of light beam B. The ratio E_A / E_B of photon energies is:			
A. 1/2	B. 1/4	C. 1	D. 2
5) Of the following which is the best evidence for the wave nature of matter?			
A. the photoelectric effect			
B. the Compton effect			
C. the diffraction of electrons by crystals			
D. the spectral radiancy of cavity radiation			
6) In Compton scattering from stationary electrons the frequency of the emitted light is independent of:			
A. the frequency of the incident light			
B. the speed of the electron			
C. the electron recoil energy			
D. none of the above			
7) The work function for a certain sample is 2.3 eV. The stopping potential for electrons ejected from the sample by 7.0×10^{14} Hz electromagnetic radiation is:			
A. 0.0V	B. 0.60 V	C. 2.4 V	D. 2.90 V
8) Maxwell's equations predict that the speed of light in free space is			

- A. an increasing function of frequency
- B. a decreasing function of frequency
- C. independent of frequency
- D. a function of the distance from the source

9) The stopping potential V_0 for photoelectric emission from a metal surface is plotted along y-axis and frequency ν of incident light along x-axis. A straight line is obtained as shown. Planck's constant is given by



- A. slope of the line
- B. product of the slope of the line and charge on electron
- C. intercept along y-axis divided by charge on the electron
- D. product of the intercept along x-axis and mass of the electron

10) In what way do electromagnetic (em) waves differ from other kinds of waves (e.g., sound waves)?

- | | |
|--------------------------------------|------------------------------------|
| A. em waves have only one wavelength | B. em waves have zero amplitude |
| C. em waves have only one frequency | D. em waves can travel in a vacuum |

11) Which of the following sentences are correct for black body

- (1) The black body is a hypothetical body
- (2) The black body is a real body
- (3) The black body is used as a standard of perfection against which the radiation characteristics of other bodies are compared

- | | |
|--------------------------|---------------------------------------|
| A. sentences (1) and (2) | B. sentences (1) and (3) |
| C. sentences (2) and (3) | D. all the sentences (1), (2) and (3) |

12) The shortest wavelength present in the radiation from an X-ray machine whose accelerating potential is 5×10^4 V.

- | | | | |
|--------------|--------------|--------------|--------------|
| A. 0.0248 nm | B. 0.0125 nm | C. 0.0356 nm | D. 0.0592 nm |
|--------------|--------------|--------------|--------------|

13) Light of frequency 1.9 times the threshold frequency is incident on a photosensitive material. If the frequency is halved and intensity is doubled, the photocurrent becomes

- | | | | |
|---------------|------------|-----------|---------|
| A. quadrupled | B. doubled | C. halved | D. zero |
|---------------|------------|-----------|---------|

14) Pair production occurs only when the energy of the photon is at least equal to

- | | | | |
|-------------|------------|-------------|-------------|
| A. 1.02 KeV | B. 1.02 eV | C. 1.02 MeV | D. 0.51 MeV |
|-------------|------------|-------------|-------------|

15) Compton shift depends on which of the following?

- | | |
|-----------------------|-----------------------------------|
| A. incident radiation | B. nature of scattering substance |
|-----------------------|-----------------------------------|

C. at all wavelengths

D. none of the above

24) A surface which diffusely reflects and emits the same amount of energy which it receives by radiation, is known as

A. a perfect surface

B. a perfect blue surface

C. a perfect radiating surface

D. none of the above

25) For the hydrogen atom, which series describes electron transitions to the $n=1$ orbit "the lowest energy electron orbit"? Is it the:

A. Lyman series

B. Balmer series

C. Paschen series

D. Pfund series

Second question: Circle T for the true statement and F for the false one:
(25 Marks)

26) X-ray is the reverse phenomenon of photoelectric emission.

27) Compton shift $\Delta\lambda$ depends on the type of scattering material.

28) According to Max Planck, oscillator can emit radiation by dropped to any lowest energy state where the amount of energy emitted is $\Delta E = nhf$.

29) In Compton scattering, scattered photon has smaller wavelength than the incident one.

30) No time lag between the illumination of the metal and the emission of the photoelectrons.

31) The probability of pair production increases only by decreasing the photon energy.

32) In blackbody radiation, as the temperature increases, the maximum of the curve shifts toward higher frequencies.

33) In photoelectric effect, the maximum kinetic energy of photoelectrons depends on the intensity of incident electromagnetic waves.

34) Heisenberg's uncertainty principle says "It impossible to measure simultaneously the position and the momentum of a particle".

35) In blackbody radiation, as the temperature increases, the maximum of the curve

C. angle of scattering		D. amplitude of frequency	
16) The kinetic energy of an electron is 5 eV. Calculate the de-Broglie wavelength associated with it			
A. 5.47 Å	B. 10.9 Å	C. 2.7 Å	D. None of these
17) The minimum energy required to remove an electron is called			
A. stopping potential		B. kinetic energy	
C. work function		D. none of these	
18) X rays of wavelength 10.0 pm are scattered from a target the maximum wavelength present in the scattered x rays is			
A. 12.42 pm	B. 14.9 pm	C. 10.0 pm	D. 4.9 pm
19) As a radiator, the black body emits the maximum possible thermal radiation			
A. at a constant single wavelength			
B. at the maximum wavelength			
C. at all wavelengths			
D. none of the above			
20) For an X-ray tube operating at a peak voltage of 70 kV. What is the maximum energy of the emitted photons?			
A. 1.1×10^{-14} J		B. 4.4×10^{23} J	
C. 1.1×10^{-19} J		D. 4.4×10^{26} J	
21) Energy released by a radiating surface is not continuous but is in the form of successive and separate packets of energy called			
A. photons	B. protons	C. electrons	D. neutrons
22) The threshold wavelength of photoelectric emission of a metal is 4000 Å. Then the minimum energy required to eject photoelectron is			
A. 4.96 e V	B. 3.1 e V	C. 49.6 e V	D. 31 e V
23) As a radiator, the black body emits the maximum possible thermal radiation			
A. at a constant single wavelength			
B. at the maximum wavelength			

shifts toward higher frequencies.
36) In photoelectric effect, the maximum kinetic energy of photoelectrons depends on the intensity of incident electromagnetic waves.
37) The minimum wavelength $\lambda_{\min}$ of X-rays depend on the kind of the metal target.
38) Visible Light rays cannot show Compton effect.
39) According to De Broglie, the larger of momentum of particle, the larger its wavelength.
40) Wien's law can fit the blackbody radiation curve in the shorter wavelength region.
41) The red line in Balmer series is produced as electron transition from $n = 3$ to $n=2$.
42) According to Thomson's atomic model, α -particles will scatter from thin gold foil through very large scattering angles.
43) Bohr considered that nucleus has a finite mass M and the electron and nucleus rotate about their center of mass.
44) De Broglie wavelength depends on momentum and on the size of the particle.
45) The Rutherford model failed to explain the hydrogen atom's spectrum.
46) In photoelectric, the maximum kinetic energy of photoelectrons depends on the intensity of incident EM waves.
47) Thermal radiation wave is electromagnetic wave.
48) Rutherford's model destroyed by the electromagnetic theory.
49) Photoelectron emission from a given metal does not take place unless the frequency of incident light is equal or greater than a certain minimum frequency f_0 .
50) The emissivity for the blackbody depends on the material that make the blackbody.

Electron charge e	$1.6 \times 10^{-19} \text{ C}$	Plank's constant h	$6.626 \times 10^{-34} \text{ Joul.sec}$
Electron mass m_e	$9.1 \times 10^{-31} \text{ kg}$	Light velocity c	$3 \times 10^8 \text{ m.sec}^{-1}$
Proton mass m_p	$1.672 \times 10^{-27} \text{ kg}$	Coulomb constant k	$9 \times 10^9 \text{ J.m.C}^{-2}$
Bohr radius a_0	$0.529 \times 10^{-10} \text{ m}$	Mass of a hydrogen atom	$1.672 \times 10^{-27} \text{ kg}$
1 eV	$1.602 \times 10^{-19} \text{ J}$	Ionization energy of the hydrogen atom E_0	13.6 eV

**Physical Chemistry Examination for Second Year Students
(Industry Group) (C-208)**

Answer Five Only from the following:

(50 Marks)

- 1) Derive the relation between the free energy change and the equilibrium constant for any gaseous reaction.
- 2) Derive and discuss the relation between the enthalpy change of a reaction and its temperature.
- 3) If the heat of combustion of methane is equal to -191.77 Kcal. and the heat of formation for carbon dioxide and water are -94.05 and -57.80 Kcal respectively. Calculate the heat of formation for methane.
- 4) Compare graphically and mathematically between the amount of work performed in the following processes that accompanied by volume change from V_1 to V_2 .
 - a) Isothermal and reversible process.
 - b) Constant pressure and reversible process.
 - c) Isothermal and irreversible process.
- 5) Consider the following reaction ($\text{Zn} + \text{Cu}^{++} \rightleftharpoons \text{Zn}^{++} + \text{Cu}$) that proceed in a cell contains 1M of solutions from each Cu^{++} ions and possess a voltage of 1.1 Volt. Calculate the corresponding free energy change and equilibrium constant for the above reaction.
- 6) Derive the following relations:
 - a) Equilibrium constant and temperature and its correlation with Le Chatelier's principle.
 - b) The relation between the emf of an electrochemical cell and the concentration of its cations constituents.
- 7) For the reaction $\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO}$ the enthalpy change of formation of NO is 21 Kcal/mol. And the absolute entropy of NO , N_2 and O_2 are 50.34 , 45 , 77 and 49.01 Kcal/mol K. Respectively. Calculate ΔG and K for the reaction.

Good Luck

Prof.Dr.Rabei.Gabr



Q1 (13)	Q2 (18)	Q3 (19)	Total (50 marks)

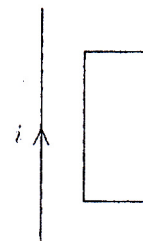
الاختبار مكون من 6 صفحات

Q1: Circle the correct answer for the following questions: (13 Marks)

- What is induction in electricity?
 - The process of generating magnetic field by passing current in a conductor.
 - The process of generating current in a conductor by placing it in a changing magnetic field.
 - The process of heating a conductor by passing current in it.
 - The process of increasing the resistance of a conductor by heating it.

- A long straight wire is in the plane of a rectangular conducting loop. The straight wire carries an increasing current in the direction shown. The current in the rectangle is:

- clockwise
- counterclockwise
- clockwise in the left side and counterclockwise in the right side
- counterclockwise in the left side and clockwise in the right side



- Which of the following is correct for 1 Henry (H): [Wb: Weber; A: Ampere; V: Volt; s: second; C: Coulomb; N: Newton; J: Joule]

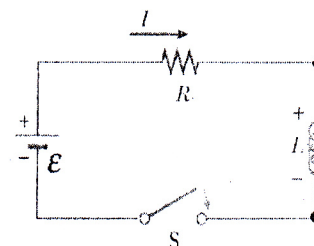
- $H = \text{Wb/A} = \text{V.s/A} = \text{J/A}^2$
- $H = \text{Wb/V} = \text{A.s/V} = \text{N/A}^2$
- $H = \text{A/Wb} = \text{A/V.s} = \text{A}^2/\text{J}$
- $H = \text{V/A} = \text{Wb.s/C} = \text{V/A}^2$

- Eddy currents are induced in bulk pieces of metal

- moving through an electric field.
- at rest in an electric field.
- moving through a magnetic field.
- at rest in a magnetic field.

- For the given RL circuit, the switch S is closed (at $t=0$), the time constant τ for this circuit represents the:

- time required for the current to reach its maximum value.
- time required for the current to reach 63.2% of its maximum value.
- time required for the current to reach 36.8% of its maximum value.
- the life time of the battery.



6. Which of the following increases the magnetic energy density in the interior of a very long solenoid?
- increasing the number of turns per unit length on the solenoid
 - increasing the cross-sectional area of the solenoid
 - increasing only the length of the solenoid while keeping the number of turns per unit length fixed
 - decreasing the current in the solenoid

7. Wireless charging in cordless devices uses the of solenoids as part of its battery-charging system.

- mutual induction
- self-induction
- resonance
- eddy currents

8. Which of the following statements might be true for a resistor connected to a sinusoidal AC source?

- $P_{av} = 0$ and $i_{av} = 0$
- $P_{av} = 0$ and $i_{av} > 0$
- $P_{av} > 0$ and $i_{av} = 0$
- $P_{av} > 0$ and $i_{av} > 0$

9. If the input to an RLC series circuit is $V = V_m \sin \omega t$, then the current in the circuit is

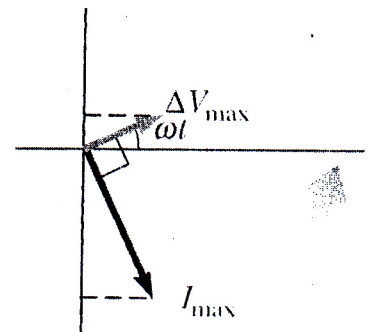
- | | |
|---|---|
| a. $\frac{V_m \cos \omega t}{R}$ | b. $\frac{V_m \sin \omega t}{\sqrt{R^2 + \omega^2 L^2}}$ |
| c. $\frac{V_m \sin \omega t}{\sqrt{R^2 + (\omega L + 1/\omega C)^2}}$ | d. $\frac{V_m \cos(\omega t - \phi)}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}}$ |

10. The impedance of a series RLC circuit at resonance is:

- larger than R
- less than R
- equal to R
- impossible to determine

11, 12. According to the phasor diagram in the figure, the current the voltage by 90° which is the case for circuit.

- leads, capacitive
- leads, inductive
- lags behind, capacitive
- lags behind, inductive



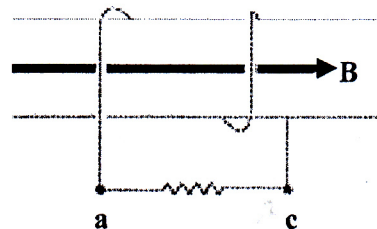
13. Both of ωL and $1/\omega C$ have the unit of [ω : the angular frequency, L : self inductance in Henri, C : capacitance in Farad]

- resistance (Ohm)
- energy (Joule)
- voltage (Volt)
- current (Ampere)

Q2: Circle the correct answer in the following, and show your calculations. (18 Marks)

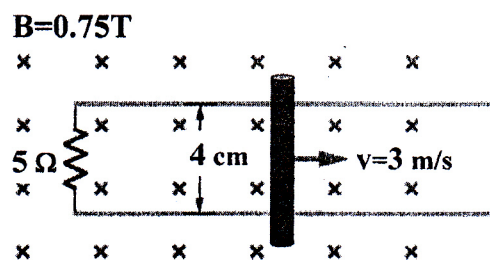
1. (3 marks) As shown in the figure, a 2-turns coil has a cross-sectional area of 0.2 m^2 is exposed to a magnetic field (parallel to the axis of the coil) given by $B = (4 + 3t^2) \text{ T}$, where t is in s. What is the induced emf between the terminals a and c, at $t = 3 \text{ s}$?

- a) -7.2 V
- b) $+7.2 \text{ V}$
- c) -4.8 V
- d) $+4.8 \text{ V}$



2. (4 marks) As shown in the figure, a rod moves to the right on zero-resistance rails. What is the value and direction of the current through the 5Ω resistor?

- a) 0.018 A , clockwise
- b) 0.018 A , counterclockwise
- c) 0.09 A , clockwise
- d) 0.09 A , counterclockwise



3. (3 marks) An AC power supply is connected in series with a $100\sqrt{3} \Omega$ resistor, an 80 mH inductor, and a $50 \mu\text{F}$ capacitor. What is the resonance frequency in Hz?

- a) 50 Hz
- b) 80 Hz
- c) 1 Hz
- d) 25 Hz

4. (3 marks) A 2 nF capacitor with an initial charge of $5.10 \mu\text{C}$ is discharged through a $1.30 \text{ k}\Omega$ resistor. What charge remains on the capacitor after $8 \mu\text{s}$ after the resistor is connected across the terminals of the capacitor?

- a) $5.10 \mu\text{C}$
- b) $110.2 \mu\text{C}$
- c) 0.0 C
- d) $0.235 \mu\text{C}$

5. (5 marks) The voltage $8\sin(400t)$ is applied to a series RLC circuit, with $R = 200 \Omega$, $L = 0.1 \text{ H}$, and $C = 1 \mu\text{F}$. What are the impedance Z of the circuit and the phase angle ϕ ?

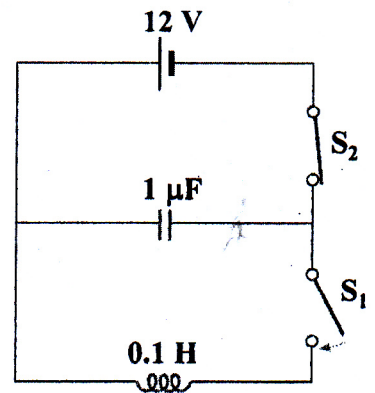
- a) 566Ω , $+87^\circ$
- b) 200Ω , -37°
- c) 2470Ω , -85.4°
- d) 2540Ω , -88.8°

Q3. Answer the following problems:

(19 Marks)

I. In the Figure, the capacitor is initially charged when switch S_1 is open and S_2 is closed for long time. Switch S_2 is then opened and switch S_1 is then closed. What are:?

(a) (2 marks) the frequency of oscillation of the LC circuit,



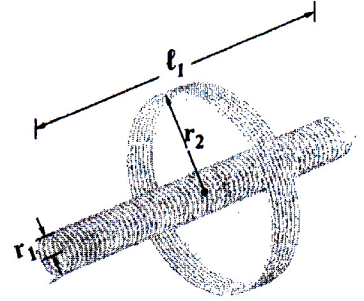
(b) (2 marks) the maximum charge that appears on the capacitor,

(c) (2 marks) the maximum current in the circuit,

(d) (2 marks) the total energy the circuit possesses at $t = 3\ \text{s}$?

II. The given figure shows a long solenoid of length ℓ_1 , radius r_1 , and N_1 turns; surrounded at its center with a short coil of radius r_2 , and N_2 turns. If $N_1=1000$ turns, $r_1=2$ cm, $\ell_1=50$ cm, $N_2=10$ turns, $r_2=15$ cm and the current in the long solenoid is changing at a rate of 100 A/s:

(a) (3 marks) Calculate the mutual inductance M of the two coils?



(b) (3 marks) Calculate the induced emf in the surrounding coil (coil 2)?

$$[\mu_0=4\pi\times 10^{-7} \text{ T.m/A}]$$

III. An AC generator consists of 200 turns of wire loop, each of area 300 cm^2 . The loop rotates in a 30 mT magnetic field.

(a) (3 marks) At what frequency should the loop rotate to have a maximum value of the induced emf equal to 8 V?

(b) (2 marks) What is the maximum induced current when the output terminals are connected to a low-resistance conductor of $12\ \Omega$? (End of the exam).

Q1 (13)	Q2 (18)	Q3 (19)	Total (50 marks)

الإجمالي ماركات من 6 ماركات

2.1. Circle the correct answer for the following questions: (13 Marks)

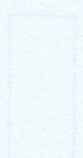
1. What is induction in electricity?

Best of luck.

- The process of generating magnetic field by passing current in a conductor.
- The process of generating current in a conductor by placing it in a changing magnetic field.
- The process of heating a conductor by passing current in it.
- The process of increasing the resistance of a conductor by heating it.

2. A long straight wire is in the plane of a rectangular conducting loop. The straight wire carries an increasing current in the direction shown. The current in the rectangle is

- clockwise
- counterclockwise
- clockwise in the left side and counterclockwise in the right side
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3. Which of the following is correct for 1 Henry (H)? (Wb: Weber; A: Ampere; V: Volt; s: second; C: Coulomb; N: Newton; J: Joule)

- $H = Wb \cdot A = V \cdot A = J \cdot A^2$
- $H = Wb \cdot V = A \cdot V = N \cdot A^2$
- $H = A \cdot Wb = A \cdot V \cdot s = A^2 \cdot J$
- $H = V \cdot A = Wb \cdot s \cdot C = V \cdot A^2$

4. Eddy currents are induced in bulk pieces of metal

- moving through an electric field.
- at rest in an electric field.
- moving through a magnetic field.
- at rest in a magnetic field.

5. For the given RL circuit, the switch S is closed (at $t=0$), the time constant τ for this circuit represents the:

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Assiut University
Faculty of Science
Department of Physics



Term: 2nd 2022 - 2023
Date: May 27th, 2023
Time: 3 hours

Course Title: Modern Physics - Code: P215 – Final Exam (50 %)

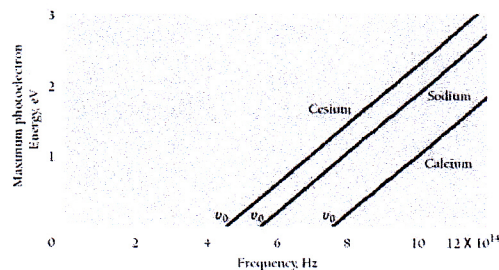
Teaching Staff: Prof. Dr. Salah A. Makhoul

Constants & Conversion of units

<i>Electron mass: $m = 9.11 \times 10^{-31} \text{ kg}$ & Proton mass: $m = 1.673 \times 10^{-27} \text{ kg}$</i>
<i>Electron charge: $e = 1.6 \times 10^{-19} \text{ C}$</i>
<i>Planck's constant: $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$ and $\hbar = 1.054 \times 10^{-34} \text{ J}\cdot\text{s}$</i>
<i>Avogadro's number: $N_A = 6.02 \times 10^{23} \text{ atom/mole}$</i>
<i>Speed of light: $c = 3 \times 10^8 \text{ m/s}$</i>
<i>Boltzmann's constant: $k_B = 1.38 \times 10^{-23} \text{ J/K}$</i>
<i>Compton wavelength: $\lambda_c = 2.426 \text{ pm}$</i>
<i>Rydberg Constant $R = 1.097 \times 10^7 \text{ m}^{-1}$</i>
<i>For hydrogen atom: Bohr radius $a_0 = 5.292 \times 10^{-11} \text{ m}$ & $E_{ion} = 13.6 \text{ eV}$</i>
<i>$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N m}^2$</i>
<i>$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$</i>
<i>$1 \text{ \AA} = 10^{-10} \text{ m}$ & $1 \text{ nm} = 10^{-9} \text{ m}$</i>

Part One) Choose the correct option for the following questions (1 Mark each) (26 Marks)

- As the temperature of black body is decreased the frequency corresponding to maximum intensity
 - shifts towards shorter wavelength
 - shifts towards higher frequency
 - remain the same
 - shifts towards lower frequency
- Which of the following processes is impossible under all circumstances?
 - photon $\rightarrow$ electron + positron
 - electron + positron $\rightarrow$ photons
 - electron $\rightarrow$ electron + photon
 - photon + electron $\rightarrow$ photon + electron
 - photon + electron $\rightarrow$ electron
 - All of the above are possible.
- Which one of these processes involves a decrease in the kinetic energy of an electron?
 - bremsstrahlung
 - photoelectric effect
 - Compton scattering
 - pair production
- What is the de Broglie wavelength of an electron with a kinetic energy of 12.8 eV?
 - 96.9 nm
 - 0.34 nm
 - 16.8 nm
 - 0.66 nm
- Electrons of maximum kinetic energy $(KE)_1$ are released when X rays of wavelength λ_1 are incident on the surface of a metal. If the light source is replaced by another that emits photons at the same rate but of longer wavelength λ_2 , how is the resulting maximum kinetic energy $(KE)_2$ related to $(KE)_1$?
 - $(KE)_2 = (KE)_1$
 - $(KE)_2 > (KE)_1$
 - $(KE)_2 < (KE)_1$
- Photons of wavelength λ are Compton scattered from electrons, and the scattered photons of wavelength λ' are observed at an angle of 90° relative to the direction of the incident photons. If the detector of the scattered photons is moved to an angle that is smaller than 90° , the wavelength of the scattered photons will:
 - increase
 - decrease
 - remain the same
 - increase at some angles between 0 and 90° and decrease at other angles
- The graph shows maximum kinetic energy of emitted electrons against frequency (f) of incident light for several different metals. The plank constant is determined by:
 - the x-intercept.
 - the y-intercept.
 - the slope.



- Which of the following is essential for laser action to occur between two energy levels of an atom?
 - the lower level is metastable
 - the upper level is metastable
 - the lower level is the ground state
 - the lasing material is a gas
- Which of the following does NOT provide evidence for the wave nature of matter?
 - the photoelectric effect
 - neutron diffraction
 - the Heisenberg relationships
 - electron diffraction

10. In an electron microscope, we use energetic particles because of
- Penetrating power is zero
 - Kinetic energy is very small
 - Wavelength is very short
 - Wavelength is very long
11. If a particle moves with speed of light (c) its acceleration becomes:
- double of that of a same particle moving with $v = 0.5 c$
 - half of that of a same object moving with $v = 0.5 c$
 - infinite
 - zero
12. Assume the Heisenberg uncertainty principle can take the form $\Delta E \cdot \Delta t \geq \hbar$. How accurate can the position of an electron be made if its speed is 5×10^6 m/s and if the uncertainty in its energy is 10 eV?
- 7.7×10^{-18} m
 - 1.3×10^{-23} m
 - 6.2×10^{-15} m
 - 3.3×10^{-10} m
13. An electron of mass m_e and a proton of mass m_p are accelerated by the same potential difference V , the ratio of the de-Broglie wavelength associated with the electron to that associated with the proton is:
- 1
 - $\frac{m_p}{m_e}$
 - $\frac{m_e}{m_p}$
 - $\sqrt{\frac{m_p}{m_e}}$
14. The probability that a particle exists in a given small region of space is proportional to:
- the square of the frequency of its wave function
 - the square of its momentum
 - the square of the wavelength of its wave function
 - the square of the magnitude of its wave function
15. If the kinetic energy of a non-relativistic free electron doubles, the wavelength of its wave function changes by the factor:
- $1/\sqrt{2}$
 - 2
 - 1/2
 - $\sqrt{2}$
16. In terms of a_0 , where $a_0 = 0.0529$ nm, the radii of the allowed orbits in the Bohr model of the hydrogen atom are given by $r_n =$
- $\frac{1}{n^2} a_0$
 - $\frac{a_0}{n}$
 - $n a_0$
 - $n^2 a_0$
17. In the Bohr model of the hydrogen atom, the speed of the electron is:
- much smaller than the speed of light, so that nonrelativistic equations can safely be used.
 - large enough that the difference between the relativistic and nonrelativistic equations is important.
 - very close to the speed of light, so that the extreme relativistic approximation $E = pc$ should be used
18. In Rutherford scattering we ignore the effect of the electrons because:
- electrons do not exert any force on alpha particles.
 - electrons are uniformly distributed throughout the atom.
 - the electrons are in such rapid motion that the alpha particles do not collide with them.
 - the mass of an electron is much smaller than the mass of an alpha particle.

19. The quantity mc^2 represents:

- a) the kinetic energy of a particle moving at speed c .
- b) the energy of a particle of mass m at rest.
- c) the total relativistic energy of a particle of mass m moving at speed c .
- d) the maximum possible energy of a moving particle of mass m .

20. An astronaut traveling with a speed $v = 0.8c$ holds a rod of length 1.0 meter in his hand. If he measures its length, he will obtain a value of

- a) $0.8m$
- b) $0.6m$
- c) $1.0m$
- d) $1.25m$

21. What is the quantum number n of a particle of mass m confined to a one-dimensional box of length L when its momentum is $4h/L$?

- a) 2
- b) 4
- c) 8
- d) 16

22. Because of which property of the crystals, x-rays can be diffracted from the crystals:

- a) random arrangement of atoms
- b) color of the crystal
- c) periodic array of atoms
- d) none of these

23. If two observers are in relative motion (one moves relative to the other) with constant relative velocity, in which of the following measurements would they obtain identical values?

- a) The velocity of an electron.
- b) The speed of a light beam.
- c) The ticking rate of a clock.
- d) The volume of a box.

24. A certain particle at rest has a lifetime of $2.52 \mu\text{s}$. What must be the speed of the particle for its lifetime to be observed to be $8.34 \mu\text{s}$?

- a) $0.953c$
- b) $0.302c$
- c) $0.913c$
- d) $0.985c$

25. What is the momentum of a proton that has a kinetic energy of 750 MeV?

- a) $750 \text{ MeV}/c$
- b) $1186 \text{ MeV}/c$
- c) $1404 \text{ MeV}/c$
- d) $1688 \text{ MeV}/c$

26. Two particles each of mass m are each moving at a speed of $0.707c$ directly toward one another. After the head-on collision, all that remains is a new particle of mass M at rest. What is the approximate mass M of this new particle?

- a) $2.25m$
- b) $1.0m$
- c) $2.0m$
- d) $2.8m$

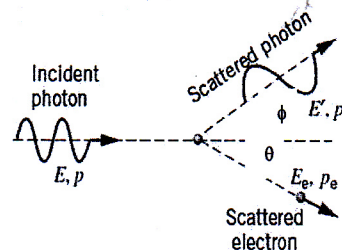
27. A spaceship leaves Earth and maintains a constant force by means of a nuclear engine. As the speed of the spaceship increases, an observer on Earth finds that relative to her the magnitude of the spaceship's acceleration is:

- a) 0.
- b) decreasing.
- c) constant.
- d) increasing.

Part Two: Answer Four (4) only of the following questions**(24 Marks)****Q1)****(6 Marks)**

X-ray photons of wavelength $\lambda = 0.0248$ nm are incident on a target and the Compton-scattered photons are observed at $\phi = 90^\circ$. Find:

- the wavelength (λ') of the scattered photons in nm units.
- the momentum (p) of the incident photons.
- the momentum (p') of the scattered photons.
- the kinetic energy (E_e) in eV units of the scattered electrons.
- the momentum magnitude (p_e) and direction (θ°) of the scattered electrons.



Q2)**(6 Marks)**

1. Consider a first electron with a kinetic energy $(KE)_1 = 1 \text{ eV}$ and a second electron with a kinetic energy $(KE)_2 = 100 \text{ MeV}$.

a) Calculate the rest energy of the electron (E_0) in MeV, and decide which electron can be treated as a classical particle and which one can be treated as a relativistic particle? Why?

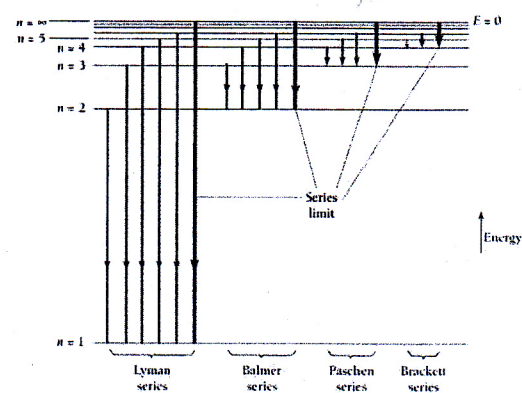
b) Accordingly, calculate the momentum p_1 and p_2 and de-Broglie wavelength λ_1 and λ_2 of each electron?

2. An uncharged π -meson has a rest energy of 135 MeV and a lifetime (Δt) of $8.3 \times 10^{-17} \text{ s}$. Find the energy uncertainty (ΔE) of this π -meson, expressed in MeV units?

Q3)

(6 Marks)

Referring to the figure below, showing the spectral series of Hydrogen. Computer the energies ($\Delta E_1, \Delta E_2, \Delta E_3$) in eV and wavelengths ($\lambda_1, \lambda_2, \lambda_3$) in nm of the first 3 transitions of the Balmer series?



Q4)**(6 Marks)**

The proper lifetime (t_0) of a certain particle is 100.0 ns.

- a) How long does it live in the laboratory (t) if it moves at $v = 0.96 c$?
- b) How far does it travel in the laboratory during that time?
- c) What is the distance traveled in the laboratory according to an observer moving with the particle?

Q5)**(6 Marks)**

An electron and a proton are each accelerated starting from rest through a potential difference of 10.0 million volts and thus each acquires a kinetic energy KE of 10 MeV. Use the relativistic equations to find:

- a) the total energy E_1 (in MeV) and the momentum p_1 (in MeV/c) of the electron.
- b) the total energy E_2 (in MeV) and the momentum p_2 (in MeV/c) of the proton.
- c) Find the momenta p_1 (in MeV/c) of the electron and p_2 (in MeV/c) of the proton using the classical formulas, and comment on the results you obtained?

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Term: 2nd 2022 - 2023Date: May 27th, 2023

Time: 3 hours

Course Title: Modern Physics - Code: P215 - Final Exam (50.%)

Teaching Staff: Prof. Dr. Salah A. Makhoul

Constants & Conversion of unitsElectron mass: $m = 9.11 \times 10^{-31} \text{ kg}$ & Proton mass: $m = 1.673 \times 10^{-27} \text{ kg}$ Electron charge: $e = 1.6 \times 10^{-19} \text{ C}$ Planck's constant: $h = 6.626 \times 10^{-34} \text{ Js}$ and $\hbar = 1.054 \times 10^{-34} \text{ Js}$ Avogadro's number: $N_A = 6.02 \times 10^{23} \text{ atoms/mole}$ Speed of light: $c = 3 \times 10^8 \text{ m/s}$ Boltzmann's constant: $k_B = 1.38 \times 10^{-23} \text{ JK}$ Common wavelength: $\lambda_c = 2.426 \text{ pm}$ Rydberg Constant $R = 1.097 \times 10^7 \text{ m}^{-1}$ For hydrogen atom: Bohr radius $a_0 = 5.292 \times 10^{-11} \text{ m}$ & $E_{\text{ion}} = 13.6 \text{ eV}$ $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$ $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$ $1 \text{ \AA} = 10^{-10} \text{ m}$ & $1 \text{ nm} = 10^{-9} \text{ m}$



Answer all the following questions.

Question (I):

(30 Marks)

In the following multiple-choice questions, please circle the correct answer(s). You must write down the steps to get the correct answer.

1. The atomic packing factor for BCC is:

- a. 68% b. 74% c. 63% d. 28%

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2. Calculate the radius of a vanadium atom, given that V has a BCC crystal structure, a density of 5.96 g/cm³, and an atomic weight of 50.9 g/mol ($N_A = 6.022 \times 10^{23}$ atoms/mol).

- a. 0.124 nm b. 0.132 nm c. 0.148 nm d. 0.156 nm

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3. Rhodium has an atomic radius of 0.1345 nm, a density of 12.41 g/cm³ and an atomic weight is 102.91 g/mol, its crystal structure should be:

- a. SC b. FCC c. BCC d. HCP

.....
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4. Zinc has an HCP crystal structure, a c/a ratio of 1.856, and a density of 7.13 g/cm³. Compute the atomic radius for Zn:

- a. 0.133 nm b. 0.142 nm c. 0.153 nm d. 0.167 nm

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5. The atomic radius for tungsten (W) is 0.137 nm, W has a BCC crystal structure, therefore, the linear density for the [111] direction is:

- a. 2.46 nm⁻¹ b. 1.42 nm⁻¹ c. 2.23 nm⁻¹ d. 3.65 nm⁻¹

.....
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6. The atomic radius for nickel (Ni) is 0.125 nm, Ni has an FCC crystal structure, therefore, the planar density for the (111) plane is:

- a. 16.00 nm⁻² b. 18.48 nm⁻² c. 19.20 nm⁻² d. 20.56 nm⁻²

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7. Molybdenum (Mo) has a BCC crystal structure and an atomic radius of 0.1363 nm. the interplanar spacing d_{111} equals:
- a. 0.1817 nm b. 0.1432 nm c. 0.1527 nm d. 0.1707 nm
8. Determine the expected diffraction angle (2θ) for the first-order reflection from the (113) set of planes for FCC platinum (Pt) when monochromatic radiation of wavelength 0.1542 nm is used:
- a. 81.38° b. 76.31° c. 38.85° d. 17.88°
9. For which set of crystallographic planes will a first-order diffraction peak occur at a diffraction angle (2θ) of 46.21° for BCC iron when monochromatic radiation having a wavelength of 0.0711 nm is used?
- a. (011) b. (310) c. (200) d. (330)
10. Calculate the number of vacancies per cubic meter in iron at 850°C . The energy for vacancy formation is 1.08 eV/atom. Furthermore, the density and atomic weight for Fe are 7.65 g/cm^3 and 55.85 g/mol , respectively, ($K_B\ 8.62 \times 10^{-5}\text{ eV/atom K}$):
- a. $1.18 \times 10^{24}\text{ m}^{-3}$ b. $1.18 \times 10^{-24}\text{ m}^{-3}$ c. $2.75 \times 10^{22}\text{ m}^{-3}$ d. $3.40 \times 10^{28}\text{ m}^{-3}$
11. The concentration of carbon in an iron-carbon alloy is 0.15 wt%. What is the concentration in kilograms of carbon per cubic meter of alloy? (densities for carbon and iron are 2.25 and 7.87 g/cm^3)
- a. 11.80 kg/m^3 b. 9.72 kg/m^3 c. 7.33 kg/m^3 d. 2.48 kg/m^3
12. Gold (196.97 g/mol) forms a substitutional solid solution with silver. Compute the number of gold atoms per cubic centimeter for a silver-gold alloy that contains 10 wt% Au and 90 wt% Ag. The densities of pure gold and silver are 19.32 and 10.49 g/cm^3 , respectively.
- a. 7.36×10^{21} b. 5.66×10^{21} c. 3.36×10^{21} d. 1.44×10^{21}

13. Iron (Fe) and vanadium (V) both have the BCC crystal structure and V forms a substitutional solid solution in Fe for concentrations up to approximately 20 wt% V at room temperature. Determine the concentration in weight percent of V that must be added to Fe to yield a unit cell edge length of 0.289 nm. (Hint: $\rho_V = 6.11 \text{ g/cm}^3$, $\rho_{Fe} = 7.86 \text{ g/cm}^3$, $A_V = 50.94 \text{ g/mol}$, $A_{Fe} = 55.85 \text{ g/mol}$).

- a. 8 wt% b. 17 wt% c. 26 wt% d. 92 wt%

14. Determine the indices for the direction shown in the cubic unit cell shown in **Figure (a)**:

- a. $[0\bar{1}\bar{1}]$ b. $[\bar{2}10]$ c. $[112]$ d. $[11\bar{2}]$

15. Determine the Miller indices for plane A shown in the following unit cell (**Figure (b)**):

- a. $(0\bar{1}\bar{1})$ b. $(3\bar{2}4)$ c. (221) d. $(0\bar{2}\bar{1})$

Figure (a)

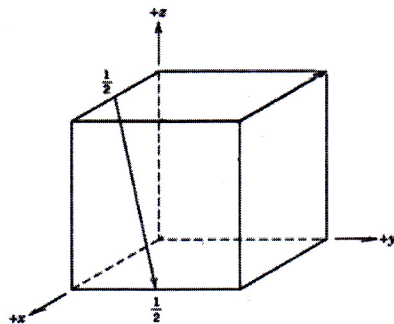
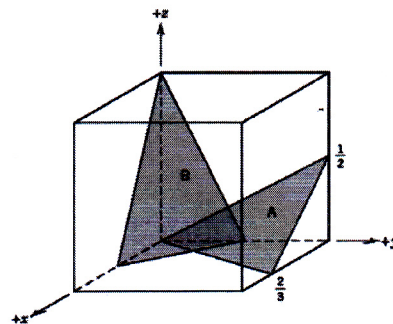


Figure (b)



Question (II): Put (✓) or (×) in a below Table for all the following sentences:(9 Marks)

1. The structure of a material usually relates to the arrangement of its internal components.
2. Structural elements that may be viewed with the naked eye are termed "microscopic".
3. Ceramics are compounds between polymers and nonmetallic elements; they are most frequently oxides, nitrides, and carbides.
4. A composite is composed of two (or more) individual materials, which come from the categories: metals, ceramics, and polymers.
5. The cubic system has the greatest degree of symmetry, but the orthorhombic system has the least symmetry.

6. The primitive unit cell contains the same kind of atoms, while the Bravais lattice contains only one lattice point.
7. The coordination number is the number of nearest-neighbor or touching atoms.
8. The coordination number for FCC and HCP structure is 12.
9. The atomic packing factor (APF) for the HCP structure is 0.74.
10. Substances in which measured properties are independent of the direction of measurement are isotropic.
11. Frenkel defect is equivalent to a missing atom that leaves its original site and migrates to the surface of the crystal.
12. A screw dislocation is formed by shear stress that is applied to produce the distortion.
13. Planar defects include external surfaces, grain boundaries, twin boundaries, precipitates, stacking faults, and phase boundaries.
14. Grain size and shape are only two features of what is termed the microstructure.
15. For many alloy systems and at some specific temperature, there is a maximum concentration of solute atoms that may dissolve in the solvent to form a solid solution; this is called a solubility limit.
16. A stable state or microstructure may persist indefinitely, experiencing only extremely slight and almost imperceptible changes as time progresses.
17. The binary isomorphous phase diagram presents the complete liquid and solid solubility of the two components.
18. Point defects are thermodynamically stable defects.

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sign																		

Question (III): Answer the following problems:

1. In Figure, cite the phases that are present and the phase compositions for 90 wt% Zn-10 wt% Cu at 400°C. Determine the relative amounts (in terms of mass fractions) of the phases for the alloys. (3 Marks)

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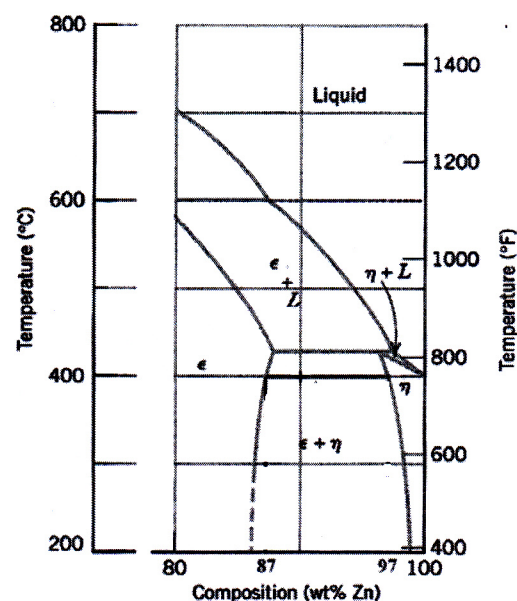
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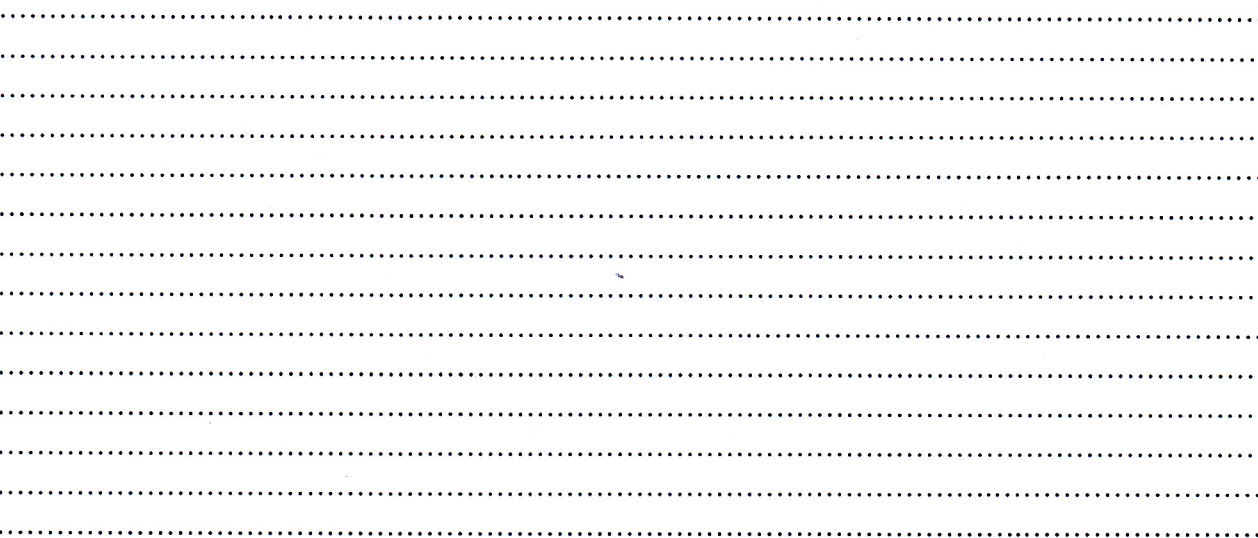
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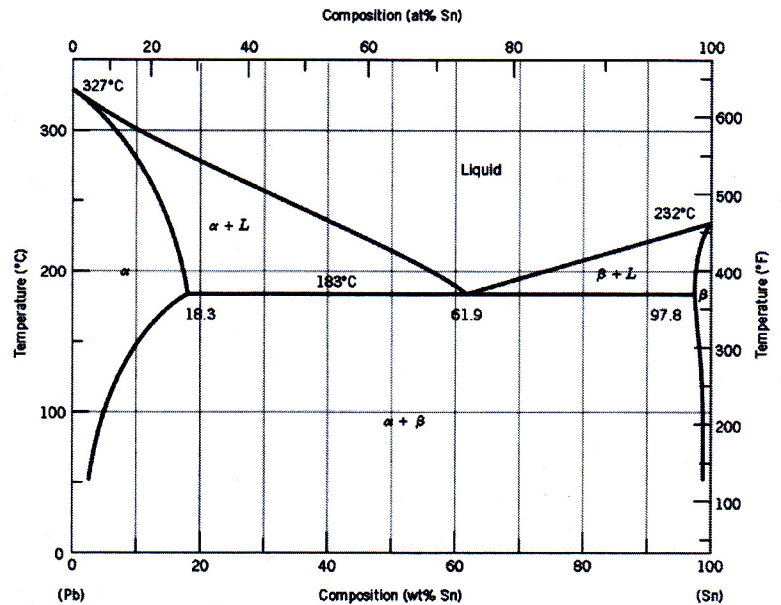
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- [illegible]



3. In Figure, for a 40 wt% Sn-60 wt% Pb alloy at 150°C, in below phase diagram: (4 Marks)
- What phase(s) is (are) present?
 - What is (are) the composition(s) of the phase(s)?
 - Calculate the relative amount of each phase present in terms of the mass fraction.
 - Describe in detail the phase diagram shown below and state the different equilibrium lines.



Best wishes,