5) Find an approximate value for the total charge enclosed in an incremental volume $10^{-9}m^3$ located at the origin, if $\bar{D} = e^{-x}sin y\bar{\imath} - e^{-x}cos\, y\bar{\jmath} + 6z\bar{k}$ C/m$^2$.

**Solution:**

**END OF EXAM**

4) Starting with Maxwell's equations in vacuum (no materials, no currents, no charges) derive the wave equation for the E field. [ $curl\ curl\ \overline{A} = grad\ div\ \overline{A} - \nabla^2 \overline{A}$ ]

**Solution:**

3) For an electric field $E = E_o \sin(\omega t)$, what is the phase difference between the conduction current and the displacement current ?

**Solution:**

**2) Check that the fields:**

$$\vec{E}(\mathrm{r},t) = E_o\, exp(-kz)\, cos(kx - \omega t)\bar{J}$$

$$\vec{B}(\mathrm{r},t) = \frac{E_o}{\omega}\, exp(-kz)\, [k\, sin(kx - \omega t)\bar{\imath} + k\, cos(kx - \omega t)\bar{J}\,]$$

satisfy all of Maxwell's equations.

**Solution:**

## Part II: Work Problems (30 Points)

*Show all your work and explain each major step to receive full credit.*

1) Consider a one-dimensional world with two point conductors located at $x = 0\ m$ and at $x = 10\ m$. The conductor at $x = 0\ m$ is grounded ($V = 0\ V$) and the conductor at $x = 10\ m$ is kept at a constant potential of $200\ V$. Determine $V$.

Solution:

**Part I(b): Check the appropriate box ("Vector", "Scalar", or "Nonsense") for each quantity (5 Points).**

| No. | Quantity | Vector | Scalar | Nonsense |
|---|---|---|---|---|
| 1. | $\nabla \times (\nabla f)$ | | | |
| 2. | $\nabla.(\nabla \times \boldsymbol{F})$ | | | |
| 3. | $div(curl\ \boldsymbol{F})$ | | | |
| 4. | $curl(curl\ \boldsymbol{F})$ | | | |
| 5. | $\nabla(\nabla.\boldsymbol{F})$ | | | |
| 6. | $curl(curl\ f)$ | | | |
| 7. | $grad(div\ f)$ | | | |
| 8. | $div(grad\ \boldsymbol{F})$ | | | |
| 9. | $\nabla.(\nabla f)$ | | | |
| 10. | $div(div\ \boldsymbol{F})$ | | | |
| 11. | $\nabla \times [\nabla(\nabla.\boldsymbol{F})]$ | | | |
| 12. | $Curl[curl(curl\ \boldsymbol{F})]$ | | | |
| 13. | $\nabla[\nabla.(\nabla f)]$ | | | |
| 14. | $\nabla \times \nabla[\nabla.(\nabla f)]$ | | | |
| 15. | $\nabla.(\nabla \times \nabla[\nabla.(\nabla f)])$ | | | |



17

24. What is the curl of the vector field F where F = xi + yzj ?

a) $-x\,\mathbf{i}$ b) $-y\,\mathbf{i}$ c) $-x\,\mathbf{j}$ d) $-y\,\mathbf{j}$

25. Find the Laplace equation value of the following potential field $V = x^2 - y^2 + z^2$

a) 0 b) 2 c) 4 d) 6

26. The force on a charge 2C in a field 1V/m

a) 0 N b) 1 N c) 2 N d) 3 N

27. Find the Gauss value for a position vector in Cartesian system from the origin to one unit in three dimensions

a) 0 b) 3 c) -3 d) 1

28. The divergence theorem value for the function given by $(e^z, \sin x, y^2)$

a) 1 b) 0 c) -1 d) 2

29. What is the divergence of the vector field F where F = xz i + yz j + xy k ?

a) 2z b) 2z + 1 c) 2y d) xyz

30. In free space, if ρ = 0, the Poisson's equation becomes

a. Maxwell's divergence equation $\nabla \cdot \overline{B} = 0$ .

b. Laplace's equation $\nabla^2 V = 0$ .

c. Kirchhoff's voltage equation $\Sigma V = 0$.

d. None of the above.

31. What is the force on a unit charge moving with velocity $\overline{v}$ in presence of electric field $\overline{E}$ and magnetic field $\overline{B}$ ?

a. $\overline{E} - \overline{v} \cdot \overline{B}$ b. $\overline{E} + \overline{v} \cdot \overline{B}$

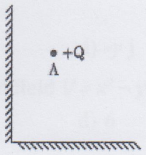
c. $\overline{E} + \overline{v} \times \overline{B}$ d. $\overline{E} + \overline{B} \times \overline{v}$

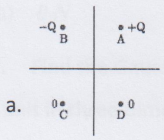
32. Equation $\nabla \cdot \overline{B} = 0$ is based on

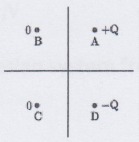
a. Gauss's Law b. Lenz's Law

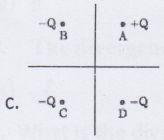
c. Ampere's Law d. Continuity Equation.

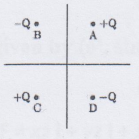
18. A point charge +Q is brought near a corner of two right angle conducting planes which are at zero potential as shown in the given figure. Which one of the following configurations describes the total effect of the charges for calculating the actual field in the first quadrant?




a. 


b. 


c. 


d. 


19. What is the value of total electric flux coming out of a closed surface ?

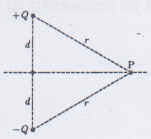
a. Zero.

b. Equal to volume charge density.

c. Equal to the total charge enclosed by the surface.

d. Equal to the surface charge density.

20. Consider the right diagram. Which of the following statements is correct? The electric field *E* at a point P due to the presence of dipole as shown in the above diagram (considering distance r>> distance *d* ) is proportional to




a. $1/r$ b. $1/r^2$ c. $1/r^3$ d. $1/r^4$

21. Gauss's law in differential form is

a) $\nabla \cdot \overline{D} = \rho_v$ b) $\nabla \cdot \overline{E} = \rho_v$ c) $\nabla \cdot \overline{E} = \varepsilon_o \rho_v$ d) $\nabla \cdot \overline{E} = \rho_v / \varepsilon_o$

22. For electrostatic fields in charge free atmosphere, which one of the following is correct?

a. $\nabla \times \overline{E} = 0$ *and* $\nabla \cdot \overline{E} = 0$ b. $\nabla \times \overline{E} \neq 0$ *and* $\nabla \cdot \overline{E} = 0$

c. $\nabla \times \overline{E} = 0$ *and* $\nabla \cdot \overline{E} \neq 0$ d. $\nabla \times \overline{E} \neq 0$ *and* $\nabla \cdot \overline{E} \neq 0$

23. The electric field intensity at a point situated 4 metres from a point charge is 200 N/C. If the distance is reduced to 2 meters, the field intensity will be

a) 400 N/C b) 600 N/C c) 800 N/C d) 1200 N/C

**8.** The Energy of a Continuous Charge Distribution is

a. $W = \frac{1}{2}\int_{all\ space} \bar{D}.\bar{E}\ dv$ b. $W = \frac{\epsilon_o}{2}\int_{all\ space} E\ \ dv$

c. $W = \frac{\epsilon_o}{2}\int_{all\ space} E^3\ dv$ d. $W = \frac{\epsilon_o}{2}\int_{all\ space} E^4\ dv$

**9.** The volume charge density associated with $\bar{D} = \frac{4xy}{z}\bar{\imath} + \frac{2x^2}{z}\bar{\jmath} + \frac{2x^2y}{z^2}\bar{k}$

a. $\frac{4y}{z^2}(x+z^2)$ b. $\frac{4y}{z}$ c. $\frac{4y}{z^2}(x^2+z^2)$ d. 0

**10.** The Fundamental Theorem for Gradients is

a. $\int_a^b (\bar{\nabla} f).d\bar{l} = f(a) - f(b)$ b. $-\int_a^b (\bar{\nabla} f).d\bar{l} = f(a) - f(b)$

c. $\int_a^b (\bar{\nabla} f).d\bar{l} = f(b)/f(a)$ d. $\int_a^b (\bar{\nabla} f).d\bar{l} = f(ab)$

**11.** The Fundamental Theorem for Divergences is

a. $\oint_S \bar{E}\cdot d\bar{a} = \int_S \nabla\cdot\bar{E}\,dv$ b. $\oint_S \bar{E}\cdot d\bar{a} = \int_{vol} \nabla\cdot\bar{E}\,dv$

c. $\oint_{vol} \bar{E}\cdot d\bar{a} = \int_{vol} \nabla\cdot\bar{D}\,dv$ d. $\oint_S \bar{D}\cdot d\bar{a} = \int_{vol} \nabla\cdot\bar{E}\,dv$

**12.** Poisson's equation is

a. $\nabla\cdot\bar{D} = \rho_v$ b. $\nabla^2 V = -\frac{\rho}{\varepsilon_o}$ c. $\nabla\cdot\bar{E} = \varepsilon_o\rho_v$ d. $\nabla^2 V = 0$

**13.** Gauss's law in integral form is

a. $\oint_S \bar{E}\cdot d\bar{a} = \int_S \nabla\cdot\bar{E}\,dv$ b. $\oint_{surface} \bar{D}\cdot d\bar{a} = Q_{enc}$

c. $\oint_{vol} \bar{E}\cdot d\bar{a} = \int_{vol} \nabla\cdot\bar{D}\,dv$ d. $\oint_S \bar{D}\cdot d\bar{a} = \int_{vol} \nabla\cdot\bar{E}\,dv$

**14.** Laplace's equation is

a. $\nabla\cdot\bar{D} = \rho_v$ b. $\nabla^2 V = -\frac{\rho}{\varepsilon_o}$ c. $\nabla\cdot\bar{E} = \varepsilon_o\rho_v$ d. $\nabla^2 V = 0$

**15.** Special Techniques for Calculating Potentials:

a. *Method of Images* b. *Div. Theorem* c. *Gauss's Law* d. *Continuity Eqn.*

**16. For static fields, the scalar potential V obeys:**

a) $\nabla^2 V = 0$ b) $\nabla^2 V = -\rho/\varepsilon_0$

c) $\nabla V = -\partial A/\partial t$ d) $\nabla^2 V = \mu_0\varepsilon_0\partial^2 V/\partial t^2$

**17. In a magnetic field of *2.50 x $10^{-3}$T* such that magnetic force is equal to its weight then proton moves with speed of:**

a. *3.09 x $10^{-5}ms^{-1}$* b. *4.09 x $10^{-5}ms^{-1}$* c. *2.09 x $10^{-5}ms^{-1}$* d. *0.09 x $10^{-5}ms^{-1}$*



17

***Attempt all questions on answer sheet.***

**Part I(a): Multiple Choice (15 Points)**

***Circle the one best answer to each question.***

**1.** The displacement current $J_d = \epsilon_o \partial E/\partial t$ is necessary to:

a) Explain magnetic fields in capacitors.
b) Ensure $\nabla \cdot J = 0$.
c) Make Ampère's law consistent with time-varying fields
d) All of the above.

**2. The symmetry between electric and magnetic fields in Maxwell's equations is broken by:**

a) The absence of magnetic monopoles
b) The displacement current term
c) Both (a) and (b)
d) Neither - the symmetry is perfect

**3. The equation $\nabla \cdot B = 0$ implies that:**

a) Magnetic monopoles do not exist.
b) Magnetic field lines are always closed loops.
c) Both (a) and (b).
d) The magnetic field is conservative.

**4. Which term did Maxwell add to complete the equations?**

a) ∂E/∂t in Faraday's law
b) ∂B/∂t in Ampère's law
c) ∂E/∂t in Ampère's law
d) ∂B/∂t in Faraday's law

**5. Which pair of equations directly leads to wave solutions?**

a) $\nabla \cdot E = 0 \; and \; \nabla \cdot B = 0$

b) $\nabla \times E = -\partial B/\partial t \; and \; \nabla \times B = \mu_0 \varepsilon_0 \partial E/\partial t$

c) $\nabla \cdot E = \rho/\varepsilon_0 \; and \; \nabla \times B = \mu_0 J$

d) All four equations together

**6.** The electric field a distance z above the midpoint of a straight line segment of length 2L, $(z \gg L)$which carries a uniform line charge λ is

a. $E \cong \frac{1}{4\pi\epsilon_o} \frac{2\lambda L}{z^2}$ b. $E \cong \frac{1}{4\pi\epsilon_o} \frac{\lambda L}{z^2}$ c. $E \cong \frac{1}{4\pi\epsilon_o} \frac{2\lambda}{L z^2}$ d. $E \cong \frac{1}{4\pi\epsilon_o} \frac{2\lambda L^3}{z^2}$

**7.** Given the potential field, $V = 2x^2y - 5z$, and a point *P(-4,3,6)*. The value of $\bar{E}$ at point *P* is

a. $57.9V$ b. $570.9V$ c. $5.79V$ d. $5790V$



10

FINAL TERM EXAMINATION-50 MARKS

# Phy312 – Electromagnetic Theory & Electrodynamics

**THIS TEST HAS ELEVEN PAGES**

**DURATION OF TEST: 3 HOURS**

***Date*: 28th May 2025.**

***Examiner*: Dr. Ahmed Mostafa Amry**

## Fundamental Physical Constants

| Quantity | Symbol | Value | Unit | Relative std. uncert. $u_r$ |
|---|---|---|---|---|
| | | UNIVERSAL | | |
| speed of light in vacuum | $c, c_0$ | 299 792 458 | $m\ s^{-1}$ | (exact) |
| magnetic constant | $\mu_0$ | $4\pi \times 10^{-7}$ | $N\ A^{-2}$ | |
| | | $= 12.566\,370\,614... \times 10^{-7}$ | $N\ A^{-2}$ | (exact) |
| electric constant $1/\mu_0 c^2$ | $\varepsilon_0$ | $8.854\,187\,817... \times 10^{-12}$ | $F\ m^{-1}$ | (exact) |
| characteristic impedance of vacuum $\sqrt{\mu_0/\epsilon_0} = \mu_0 c$ | $Z_0$ | 376.730 313 461... | $\Omega$ | (exact) |
| Newtonian constant of gravitation | $G$ | $6.673(10) \times 10^{-11}$ | $m^3\ kg^{-1}\ s^{-2}$ | $1.5 \times 10^{-3}$ |
| | $G/\hbar c$ | $6.707(10) \times 10^{-39}$ | $(GeV/c^2)^{-2}$ | $1.5 \times 10^{-3}$ |
| Planck constant | $h$ | $6.626\,068\,76(52) \times 10^{-34}$ | J s | $7.8 \times 10^{-8}$ |
| in eV s | | $4.135\,667\,27(16) \times 10^{-15}$ | eV s | $3.9 \times 10^{-8}$ |
| $h/2\pi$ | $\hbar$ | $1.054\,571\,596(82) \times 10^{-34}$ | J s | $7.8 \times 10^{-8}$ |
| in eV s | | $6.582\,118\,89(26) \times 10^{-16}$ | eV s | $3.9 \times 10^{-8}$ |
| Planck mass $(\hbar c/G)^{1/2}$ | $m_P$ | $2.1767(16) \times 10^{-8}$ | kg | $7.5 \times 10^{-4}$ |
| Planck length $\hbar/m_P c = (\hbar G/c^3)^{1/2}$ | $l_P$ | $1.6160(12) \times 10^{-35}$ | m | $7.5 \times 10^{-4}$ |
| Planck time $l_P/c = (\hbar G/c^5)^{1/2}$ | $t_P$ | $5.3906(40) \times 10^{-44}$ | s | $7.5 \times 10^{-4}$ |

4) Compute the Debye length for the plasma found in a typical plasma television cell with the following parameters: $N_e = 10^{19}$ m$^{-3}$, $k_B T$ = 1 eV. The cell dimensions are on the order of 100 μm and the plasma is excited using a 250 V signal at 100 kHz.

**Solution:**

3) a. Write the formula for the electron plasma frequency.

b. Write the formula for the ion cyclotron frequency.

c. Write the formula for the Debye length

**Solution:**

2) **Calculate mean free path $\lambda$ of $Xe^+$ ions for elastic collisions in a weakly ionized plasma in xenon atmosphere at room temperature (20 °C) at the pressure:**

   **a) 1000Pa**

   **b) 10Pa**

   **c) 0.1Pa**

**Solution:**

## C. Work Problems (30 Points)

*Show all your work and explain each major step to receive full credit.*

1) **Calculate the fraction of ionized hydrogen ($H^+$) in a plasma at T = 10,000 K and electron density $n_e = 10^{21}\ m^{-3}$.**

**where:**

- **Ionization energy of hydrogen ($\chi$) = 13.6 eV**
- **Partition functions: $Z_0$ (neutral H) = 2, $Z_1$ ($H^+$) = 1**
- **Boltzmann constant (k) = $8.617 \times 10^{-5}$ eV/K**

**Solution:**



C9

## B. True/False Questions (5 Points)

***State whether the statement is true or false:***

| STATEMENTS | TRUE | FALSE |
|---|---|---|
| 1. Plasma is referred to as the fourth state of matter because it requires higher energy than gases to form. | | |
| 2. The Saha equation estimates the degree of ionization in a plasma based on temperature and density. | | |
| 3. In a glow discharge, the electron temperature ($T_e$) is much lower than the heavy species temperature ($T_h$). | | |
| 4. The E × B drift causes particles to move perpendicular to both the electric and magnetic fields. | | |
| 5. Debye shielding ensures plasmas are neutral on scales much larger than the Debye length. | | |
| 6. Plasma diagnostics are only used for high-temperature plasmas. | | |
| 7. Stark broadening is independent of electron density. | | |
| 8. The Lissajous curve is linear for capacitive loads. | | |
| 9. The Debye length increases with electron temperature | | |
| 10. The blocking effect reduces electron current in Langmuir probes. | | |
| 11. The Ballmer series is observed in nitrogen plasmas. | | |
| 12. Plasma is matter heated beyond its gaseous state. | | |
| 13. By "collective behavior" we mean plasmas are charged fluids. | | |
| 14. Saha equation describes the degree of ionization for any gas. | | |
| 15. Plasma behaves differently than regular gases. | | |
| 16. Waves are small, repetitive motions in a continuous medium. | | |
| 17. The plasma frequency depends only on the plasma density. | | |
| 18. Debye shielding makes plasmas quasi-neutral. | | |
| 19. The condition $n_i \approx n_e$ is called quasineutrality. | | |
| 20. Plasmas are charged fluids which obey Maxwell's equations. | | |
| 21. Pulsed sources operate at lower power. | | |
| 22. In a non-equilibrium (cold) plasma, the electron temperature ($T_e$) can exceed 10,000 K while the heavy species temperature ($hT_h$) remains near room temperature. | | |
| 23. The Saha equation predicts that increasing the density of a plasma at fixed temperature will always increase the degree of ionization. | | |
| 24. The Debye length in a plasma decreases if the electron temperature is doubled while keeping the density constant. | | |

**49. What is the characteristic length of Debye shielding called?**

a) Plasma wavelength
b) Debye length
c) Sheath thickness
d) Electron mean free path

**50. The Langmuir probe is used to measure:**

a) Only electron density
b) Current-voltage (I-V) characteristics
c) Magnetic fields
d) Gas temperature

**51. Laser-induced fluorescence (LIF) is used to study:**

a) Only neutral species
b) Only charged species
c) Both neutral and charged species
d) Only photons

**52. The term "dynamic equilibrium" in plasmas refers to:**

a) A balance between generation and loss of particles
b) A static plasma state
c) Only electron generation
d) Only ion loss

**53. The term "sheath" in plasma refers to:**

a) A region with equal electron and ion densities
b) A region with a high density of photons
c) A region with a potential gradient near a surface
d) A region of neutral gas

**54. Which of the following is a defining characteristic of plasma?**

a) It has a fixed shape and volume.
b) It consists of neutral atoms only.
c) It contains free-moving charged particles (ions and electrons).
d) It cannot conduct electricity.

**55. What causes the auroras (Northern and Southern Lights)?**

a) Reflection of sunlight off polar ice.
b) Volcanic activity in the Arctic and Antarctic.
c) Charged particles from the Sun interacting with Earth's magnetic field.
d) Lightning strikes in the upper atmosphere

**56. A plasma with $n_e = 10^{18}\,m^{-3}$ and $T_e = 10$ eV has a Debye length of approximately:**

a) 0.1 mm
b) 2.3 μm
c) 10 nm
d) 1 m

**38. The current *i* flowing in the gap is then given by $i = i_o \exp(\alpha d)$ where $\alpha$ is**

a) Transmission coefficient. b) General thermal expansion coefficient
c) Hall coefficient d) Townsend's first ionization coefficient

**39. Pulsed dc discharges are also used in plasma-technological applications because of following advantages:**

a. Operation without power. b. Operation at lower power
c. Operation at higher power. d. None of above

**40. A kind of RF plasma discharge is**

a. Pulsed dc discharges. b. Arc discharge.
c. Capacitive Coupled Discharge. d. None of above

**41. Plasmas can be generated by**

a. Pulsed dc discharges. b. DC glow discharge.
c. Capacitive Coupled Discharge. d. All above

**42. The amplitude of the oscillations of the electrons in the microwave field is**

a. very small. b. very large. c. medium. d. All above.

**43. The plasma oscillation frequency, denoted by $\omega_p$, is given by**

a. $\omega_P = \left(\frac{n\,e}{\epsilon_o\, m}\right)^{1/2} rad/sec$ b. $\omega_P = \left(\frac{n\,e^2}{\epsilon_o\, m^2}\right)^{1/2} rad/sec$

c. $\omega_P = \left(\frac{n\,e^2}{\epsilon_o\, m}\right)^{1/2} rad/sec$ d. $\omega_P = \left(\frac{n\,e^2}{\epsilon_o\, m}\right)^{1/2} rad.sec$

**44. The potential in the sheath must be negative in order to**

a. attract electrons. b. repel electrons.
c. repel positive ions. d. All above

**45. The *cyclotron frequency* $\omega_c$, is independent of velocity and depends only on the**

a. plasma temperature. b. charge-to -mass ratio.
c. positive ions. d. All above

**46. The increase ionization collisions increase the concentration of new electrons and ions at the cathode build the discharge glow of**

a. Pulsed dc discharges. b. Self-sustaining plasma.
c. Capacitive Coupled Discharge. d. All above

**47. What is the primary purpose of plasma diagnostics?**

a) To measure only electron density
b) To characterize plasma sources for process analysis and control
c) To study plasma in outer space
d) To generate new plasma sources

**48. Which of the following is NOT a plasma component?**

a) Electrons b) Ions c) Neutrons d) Photons

**30. Natural plasmas are limited to a few examples:**

a. Aurora Borealis
b. Welding arcs.
c. Fluorescent lights.
d. None of above

**31. The plasma frequency depends only on the**

a. plasma temperature.
b. plasma density.
c. positive ions.
d. All above

**32. At higher temperatures, such as those in nuclear fusion research, plasmas become fully ionized, meaning that**

a) atoms are stripped of at least one electron in their outer shells.
b) atoms are stripped of at least two electron in their outer shells.
c) atoms are stripped of at least four electron in their outer shells.
d) the nuclei have been stripped of all their electrons.

**33. Saha equation, tells us**

a) the amount of excitation to be expected in a gas in thermal equilibrium.
b) the amount of ionization to be expected in a gas in thermal equilibrium.
c) the amount of deionization to be expected in a gas in thermal equilibrium.
d) None of above.

**34. Saha equation can be written in the form:**

a) $\frac{n_n}{n_i} \approx 2.4\times10^5 \frac{T^{3/2}}{n_i}\exp(-u_i/kT)$
b) $\frac{n_i}{n_n} \approx 2.4\times10^5 \frac{T^{3/2}}{n_n}\exp(-u_i/kT)$
c) $\frac{n_i}{n_n} \approx 2.4\times10^5 \frac{T^{5/2}}{n_i}\exp(-u_i/kT)$
d) $\frac{n_i}{n_n} \approx 2.4\times10^5 \frac{T^{3/2}}{n_i}exp(-u_i/kT)$

here $n_i$ and $n_n$ are, respectively, the density (number per $cm^3$) of ionized atoms and of neutral atoms, $T$ is the gas temperature in $^oK$, $k$ is Boltzmann's constant, and $U_i$ is the ionization energy of the gas.

**35. $A^+ + B^- \rightarrow AB + h\nu$ reaction represents**

a) Stable state b) Shifted state c) Recombination d) All above

**36. The collisional cross section is defined as the area around a particle in which:**

a. the center of another particle must be in order for a collision to occur.
b. the radius of another particle must be in order for a collision to occur.
c. the area of another particle must be in order for a collision to occur.
d. the cross section of another particle must be in order for a collision to occur.

**37. An electrical discharge is usually built up mainly by**

a) Stable state.
b) Positive ion collisions processes.
c) Photoelectric processes.
d) Electron collisions processes.

**22. The relative population of the energy states $E_i$ and $E_k$ is given by:**

a) $\frac{n_i}{n_k} = \frac{g_k}{g_i} \exp(-\frac{E_i - E_k}{k_B T})$

b) $\frac{n_i}{n_k} = \frac{g_i}{g_k} \exp(-\frac{E_i - E_k}{k_B T})^{-1/2}$

c) $\frac{n_i}{n_k} = \frac{g_i}{g_k} \exp(-\frac{E_i - E_k}{k_B T})$

d) $\frac{n_i}{n_k} = \frac{g_i}{g_k} \exp(-\frac{E_k - E_i}{k_B T})$

*where* $g_i$ and $g_k$ are the degeneracies of the states *i* and *k*, i.e., the number of substates with the same energy.

**23. The condition $n_j \approx n_e$ is called:**

a) Quasineutrality.
b) Hydromagnetic Equilibrium.
c) Resistive Drift Waves.
d) Landau Damping.

**24. A plasma is a quasineutral gas of charged and neutral particles which exhibits**

a) Soup of electrons.
b) Collective behavior.
c) Resistive Drift Waves.
d) Landau Damping.

**25. What is a plasma?**

a) Mixture of atoms and molecules in gaseous state.
b) Soup of electrons and ions.
c) Ionized gaseous state.
d) Soup of interacting charged particles with no neutrals.

**26. What is a Debye length?**

a) It is the 1/e distance for reducing the momentum.
b) An effective length over which a plasma will shield an electric field.
c) It is the length an electron can travel without collision.
d) Length over which sheath exist in a plasma.

**27. What happens to sheath potential as we go into the sheath (from plasma)?**

a) Potential decreases.
b) Potential increases.
c) Potential remains a constant.
d) Potential increases linearly.

**28. By "collective behavior" we mean motions that depend not only on local conditions but**

a) On a distance for reducing the momentum.
b) On the state inside the gas.
c) On the state inside the plasma.
d) On the state of the plasma in remote regions as well.

**29. A fundamental characteristic of the behavior of a plasma is its ability to shield**

a) Electric potentials that are applied to it.
b) Magnetic fields that are applied to it.
c) Collective behavior.
d) Stable state.

14. **In a plasma, what does quasi-neutrality imply?**
    a) The plasma is always neutral
    b) The number of positive and negative charges is approximately equal
    c) The plasma has no free charges
    d) The plasma is fully ionized

15. **Which of the following is a key application of nonequilibrium (cold) plasmas?**
    a) Nuclear fusion
    b) Plasma etching in the electronics industry
    c) Solar energy production
    d) Gravitational wave detection

16. **What is the guiding center approximation used for?**
    a) To simplify the study of particle motion in complex magnetic fields
    b) To calculate the plasma density
    c) To measure the temperature of a plasma
    d) To determine the degree of ionization

17. **Which of the following is a characteristic of an arc discharge?**
    a) Low current and high voltage
    b) High current and low voltage
    c) No ionization occurs
    d) It is only found in natural plasmas

18. **What is the primary cause of the Aurora Borealis?**
    a) Solar wind particles colliding with Earth's magnetic field
    b) Lightning discharges in the atmosphere
    c) Radio frequency waves in the ionosphere
    d) Thermal ionization of gases

19. **Which of the following statements about the grad-B drift is correct?**
    a) It occurs only in uniform magnetic fields
    b) It causes electrons and ions to drift in the same direction
    c) It is perpendicular to both the magnetic field and its gradient
    d) It is independent of the particle's charge

20. **What is the first adiabatic invariant in plasma physics?**
    a) The total energy of the plasma
    b) The magnetic moment of a gyrating particle
    c) The plasma density
    d) The cyclotron frequency

21. **Plasma is discovered by which English Scientist...**
    a) William Crookes
    b) Wilson
    c) Watson
    d) None of above

**5. In a fully ionized plasma, the degree of ionization ($\alpha$) is:**

a) 0
b) Between 0 and 1
c) 1
d) Greater than 1

**6. What is the Larmor radius?**

a) The radius of a tokamak
b) The radius of the orbit of a charged particle in a magnetic field
c) The distance between two colliding particles
d) The radius of a plasma sphere

**7. Which process describes the capture of an electron by an ion, resulting in the emission of a photon?**

a) Ionization b) Recombination c) Excitation d) Scattering

**8. What is the main difference between thermal and non-thermal plasmas?**

a) Thermal plasmas have $hT_e \approx T_h$, while non-thermal plasmas have $hT_e \gg T_h$
b) Thermal plasmas are always man-made.
c) Non-thermal plasmas cannot be used in industrial applications.
d) Thermal plasmas are only found in space.

**9. What is the primary mechanism for plasma generation in a DC glow discharge?**

a) Radio frequency waves
b) Electric current passing through a gas
c) Laser ionization
d) Gravitational compression

**10. Which of the following is NOT a fundamental process in a plasma?**

a) Scattering
b) Excitation
c) Ionization
d) Magnetic confinement

**11. What is the cyclotron frequency ($\omega_c$) dependent on?**

a) Only the magnetic field strength
b) Only the particle's charge
c) The magnetic field strength and the particle's charge-to-mass ratio
d) The temperature of the plasma

**12. Which type of discharge is characterized by a high electric field near a pointed electrode?**

a) Arc discharge
b) Glow discharge
c) Corona discharge
d) Townsend discharge

**13. What is the role of the Saha equation in plasma physics?**

a) To calculate the collision frequency
b) To estimate the degree of ionization in thermal equilibrium
c) To determine the Larmor radius
d) To measure the plasma density

FINAL TERM EXAMINATION-50 MARKS

# Plasma Physics and its Applications PHYS 332

**THIS TEST HAS THIRTEEN PAGES**

**DURATION OF TEST: 3 HOURS**

*Date*: 27th May 2025.

**Examiner: Dr. Ahmed Mostafa Amry**

## Physical Constants

$N_A = 6.02214076\times10^{23}\ mol^{-1}$ $K = 1.380\ 648\ 52\times10^{-23}\ J\ K^{-1}$

$\varepsilon_o = 8.854\ 187\ 817\times10^{-12}\ F\ m^{-1}$ $e = 1.602\ 176\ 6208\times10^{-19} C$

$R = 8.31446261815324\ m^3\cdot Pa\cdot K^{-1}\cdot mol^{-1}$

***Attempt all questions on answer sheet.***

**A. Multiple Choice: Identify the choice that answers the question.** **[15 marks]**

1. **What is the primary characteristic that distinguishes plasma from other states of matter?**
   a) Fixed shape and volume
   b) Collective behavior of charged particles
   c) Low electrical conductivity
   d) Absence of free electrons
2. **According to the Saha equation, what happens to the degree of ionization as temperature increases?**
   a) It decreases
   b) It remains constant
   c) It increases
   d) It becomes zero
3. **Which of the following is an example of a natural plasma?**
   a) Neon lights
   b) Fluorescent lamps
   c) Solar wind
   d) Plasma TVs
4. **What is the term for the drift of charged particles caused by a perpendicular electric and magnetic field?**
   a) Gradient drift
   b) Curvature drift
   c) $E\times B$ drift
   d) Centrifugal drift Centrifugal drift

## Question No.4: ( 16 deg.)

### A) Find & correct the mistake in the following sentences

1. *Matter and energy interact to give natural phenomena*

.....

2. *The human used his mind, so he was able to harness and adapt the universe*

.....

.....

3. *The progress in using behaviors &understanding is enormous*

.....

.....

4. *The absolute beginning of the universe is: the material*

.....

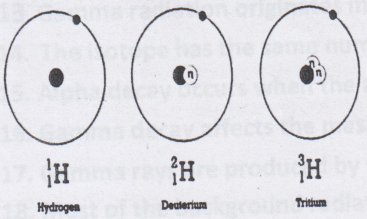
.....

### B). Suggest a title for the following

$H1_1 + H_1^1 \longrightarrow H_1^2(D) + e_{+1}^0 + \nu + energy$ .....

$H_1^1 + H_1^2 \longrightarrow He_2^3 + energy$ .....

$He_2^3 + He_2^3 \longrightarrow He_2^4 + H_1^1 + H_1^1 + h.energy$ .....

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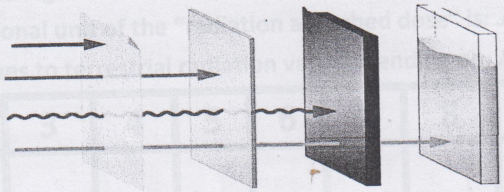

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Best wishes

إنتهت الاسئلة مع التمنيات بالتوفيق

حسام وحيد

9. Beta decay occurs when ..... Is emitted from the nucleus :
(A) an electron (B) proton (C) neutron

10. Gamma radiation can be considered as:.
(A )an energy (B)waves (C)particles

11. Half-life is the time it takes for a radioisotope to decay to half of its starting
(A) mass (B) activity (C) volume

12- Natural radioisotopes produced due to the presence of :.
(A) solar system (B) cosmic rays (C) atmosphere



13. Regions at higher altitudes receive ..... cosmic radiation :
(A) more (B) less (C) less or equal

14. DNA contains information and predictions about genetic:
(A) disease (B) mutation (C) disorders

15. The main factors influencing radiation dose are
(A)time (B) distance (C) shielding

**Question No.3: (15 deg.)**

**Choose and discuss the correct answer-(Or answers):**

1. Radiation that comes from a source can be considered as:
   (A ) energy (B)waves (C) particles

2. Radiation is one of the elements of:
   (A) energy (B) material (C) light

3. Nonionizing radiation can be considered as:
   (A ) energy (B)waves (C)particles

4. Ionizing radiation can be considered as:
   (A ) energy (B)waves (C)particles

5. Electrons move around the nucleus according to:
   (A) Newton's laws (B) Einstein's laws

6. Radioactive decay leads to:
   (A) instability (B) stability

7. Radiation can be defined as the emission of :
   (A) excess energy (B) excess mass

8. The radioactive decay occurs when the atom ejects :
   (A) electrons (B) protons (C) neutrons

## Question No.2: (9 degrees)

**Write in the attached table the symbol indicating the correct answer/s:**

1. Physics is the science which study... *A) Material* *B) radiation* *C) all the above*
2. The human used the universe without suffering thanks to:
   *A) His understanding of the universe* *B) Harness the Creator of the Universe* *C) All the above*
3. Heat transfer in the universe is done from
   *A) Hot to cold* *B) Cold to hot* *C) All of the above*
4. Different colors are: *A) photons* *B) particles* *C) vibrations*
5. Spectra emitted from some materials gives us an idea about:
   *A) Light components* *B) material structure* *C) Nature of light*
6. Atoms are stable, when: *A)* $p \cong n$ *B)* $p = e$ *C)* $p > n$
7. ..... are examples of particulate radiation *A) Alpha* *B) Beta* *C) Gamma*
8. The isotope has the same number of: *A) protons* *B) neutrons*
   but a different number of: *A) protons* *B) neutrons*
9. Gamma radiation originates in the *A) electronic shells* *B) nucleus*
   While x- ray comes from *A) electronic shells* *B) nucleus*
10. Beta decay occurs when ..... is emitted from the nucleus.
    *A) neutron* *B) proton* *C) electron*
11. X-rays are a form of radiation similar to: *A)* $\alpha$ *radiation* *B)* $\beta$ *radiation* *C)* $\Upsilon$ *radiation*
12. X- rays are produced mainly by: *A) natural sources* *B) artificial*
13. The major sources of public exposure to natural radiation is:
    *A) cosmic radiation* *B) inhalation* *C) ingestion*
14. Exposure to natural radiation can occur from indoors (in building materials)
    as a result of the presence of ..... Traces
    *A) Uranium* *B) Thorium* *C) Germanium*
15. Exposure through inhalation comes from:
    *A) Uranium + thorium* *B) Radon+ Thoron* *C) Ne + C*
16. Energy "deposited" in a Kg. of substance by the radiation:
    *A) Absorbed dose* *B) equivalent dose* *C) effective dose*
17. equivalent dose weighted for susceptibility to harm of different tissues:
    *A) Absorbed dose* *B) equivalent dose* *C) effective dose*
18. The conventional unit of the radiation absorbed dose is:
    *A) joule* *B) rad* *C) gray*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
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| | | |
|---|---|---|
| *Assiut University* | *Radiation Physics* | *Level: III* (الفرقة: الثالث) |
| *Faculty of science* | *P 344* | *24/5/2025* |
| *Physics department* | *2024–2025* | *Time: 3 hours* |

**Question No.1: (10 degrees)** **(Total 50 degrees)**

**Write in the attached table the symbol (*T*) *for true answer* or (*F*) *for false answer*:**

1. Nature is a science that studies the universe
2. Physics a science that studies the interaction between energy & matter
3. The stars are not eternal because its transformations from energy to mass
4. The Proton – proton cycle (chain reaction) is the primary fusion process
5. The method of vision according to the latest theories are vibrations and translations
6. A mass of one kilogram or one gram contains energy equivalent to $C^2$
7. Energy has no priority over mass nor mass over energy
8. A nucleon is: $p + e$
9. Atoms are stable, when: $p \cong n$
10. Radioactive decay leads to: *instability*
11. Radiation can be defined as the emission of: *excess mass or excess energy*
12. Gamma and X – ray are examples of particulate radiation
13. Gamma radiation originates in the *electronic shells*
14. The isotope has the same number of: *protons*
15. Alpha decay occurs when the atom ejects: *2 neutrons & 2 electrons*
16. Gamma decay affects the mass of the atom
17. Gamma rays are produced by the combination of: $e^+ + e^-$
18. Most of the background radiation comes from: *Radon gas*
19. The conventional unit of the "radiation absorbed dose" is: *Joule*
20. Exposure doses to terrestrial radiation vary depending on: *location& geology*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| | | | | | | | | | |

10) The depth of penetration in GPR is very limited (less than 100 m)
11) In GPR the attenuation of EM energy is primarily controlled by the electrical conductivity of the subsurface
12) The depth in GPR increases with the increasing of the subsurface electrical conductivity
13) There is a tradeoff between a penetration depth and resolution in GPR method
14) In GPR, the larger the Fresnel zone, the lower the horizontal resolution.
15) The diffraction hyperbola in GPR record result from a point source
16) The electromagnetic (EM) data can be acquired in the time domain only
17) The main disadvantage of the EM methods is that they require direct contact with the ground
18) In EM method, a secondary EM field is produced if a subsurface conductive anomaly is present
19) The EM systems are passive only
20) VLF method is very effective in locating subsurface zones of high electrical conductivity

**C)** Provide short notes of only Ten of the following: ***(Twenty marks total / Two marks each)*** *إجابات مختصرة مع إمكانية التوضيح بالرسم كلما أمكن*

1) Three different applications of IP method
2) Different methods for data acquisition in GPR
3) Parameters that control the IP phenomena
4) The classifications of electrometric method
5) The source mechanisms of induced polarization effects
6) Different parameters that control the propagation of EM waves in the subsurface geologic media using GPR
7) The very low frequency tilt angle measurements
8) Three different applications of GPR methods
9) Advantages and limitations of electromagnetic method relative to DC resistivity
10) Measuring units for induced polarization method in the time and frequency domains
11) Different methods for depth estimation in GPR
12) Three different applications of electromagnetic method

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*End of Questions* *GOOD LUCK*

*Course Instructor*
*Prof. Dr. Gamal Zidan Abdelaal*

كلية العلوم
جامعة أسيوط

جامعة أسيوط

# Final Exam in Electrical Prospection Course (G358)
## (50 marks total – Two pages)

**May: 2025** **Time: 2 hours**

ملحوظة: الرجاء الالتزام بالإجابة فقط على عدد النقاط المذكور في كل سؤال

**A) Answer the following:** *(Ten marks total)*

1) With the help of drawing write on the basic theory of induced polarization (IP) method and electromagnetic (EM) method *(Five marks)*

2) Define only five of the following: *(One mark each)*

| | | |
|---|---|---|
| Chargeability | Dielectric permittivity | Magnetic permeability |
| Skin depth | Membrane polarization | Reflection coefficient |
| Vertical resolution in GPR | | |

**B) Mark the following statements with True or False:** *(Twenty marks total / One mark each)*

1) DC resistivity method depends on the storage of current whereas the induced polarization method depends on the flow of current
2) The presence of metallic minerals in the subsurface will have no effect on the voltage decay during induced polarization measurements
3) Electrode polarization is smaller in magnitude than normal or background IP effect
4) Membrane polarization is largest when a rock contains clay materials scattered through the matrix
5) Surface area is the most important factor controlling the IP effect
6) The IP effect increases with the increasing in surface charge density at mineral-fluid interface
7) Dipole-dipole array is best suited for IP measurements to minimize the electromagnetic coupling effect
8) IP method can be used to map lithologic variations in the subsurface
9) The GPR method is best suited for the archaeological investigation



٣٥

**السؤال الثالث: (اختياري - 11 درجة)**

**3.** a) Illustrate by the eqns. the necessary conditions required for studying the crystal structure by neutron diffraction.

(given: $m_n = 1.67x10^{-27}\,Kg$ , $h = 6.62x10^{-34}\,J.s$ , $R = 8.31J/mol.k$ , $N_A = 6.023x10^{23}\,atom/mol$ )

b) Considering the energy of (1 KeV) of x-ray incident on a certain crystal, calculate:

(i)The radius of the simple reflection circle, (ii) The reciprocal lattice vector with the glancing angle of $30^0$ .

(Consider the refractive index of the crystal material, $\mu \approx 1$ )

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**السؤال الرابع (اختياري - 11 درجة)**

**4.** a) Prove that the length of the unit cell of the reciprocal crystal is inversely proportional with lattice constant of the direct crystal, then explain the necessary conditions required for using the reciprocal lattice to study the XRD.

b) X- ray beam with energy ( $2.7\,KeV$ ) incident on BCC crystal with angle $30^0$, determine the crystal plane reflected the first order spectrum ( given: the atomic radius 0.2 nm, and $h = 6.62x10^{-27}\,J.sec.$)

---

**السؤال الخامس (اختياري - 11 درجة)**

**5.** a) Consider BCC system of atomic radius ( $r$ ), prove that the $1^{St}$ order reflected angle in terms of M. indices, and incident wavelength obtained as: $\theta = sin^{-1}\left[\frac{\lambda^2(h^2+k^2+l^2}{37r^2}\right]^{1/2}$

b) Explain the theoretical method used to study the crystal structure by XRD, and if the M. indices satisfy: $h^2 + k^2 + \ell^2 = 2, 15, 17$, determine the corresponding crystal planes and draw the crystal plane of value 2

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انتهت الأسئلة

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أ.د. عبد المنعم سلطان

كلية العلوم – قسم الفيزياء

جامعة أسيوط

**Final Exam. "Diffraction rays & its applications" (352 P)**

Jun. 2025

time: 3 hours

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السؤال الأول (إجبارى): 17 درجة

## I) Choose the right answer between brackets:

1) The central atoms of the cubic system attached two corner atoms in (S. cubic – FCC – BCC).

2) The incident x-ray beam must be (parallel – normal – align) to the simple reflection circle.

3) A continuous X-ray beam used to study the crystal structure of (polycrystalline – single crystal – semimetal) material.

4) For a simple cubic lattice $d_{110} / d_{111}$ equal (1.522 – 1.225 – 1.252)

5) The intensity of the incident x-ray beam is (totally – partially – linearly) absorbed through the material medium.

6) The atomic radius of FCC system equal (0.345 a – 0.453 a – 0.354 a) , where a is the lattice constant.

7) Due to linear atomic packing each face of the simple cubic system contain (quarter - half – one) atom.

8) Thermal neutron energy of 1 eV corresponding wavelength of (8.26 nm – 6.28 nm – 2.86 nm).

## II) Transfer the following sentences after putting a check mark right or wrong:

1) The reciprocal crystal is existing in the free-space with unit cell length of $(2\pi / a)$.

2) The energy of the incident neutron beam nearly equals the vibration energy at high temperature.

3) A monochromatic X-ray beam used to study the structure of polycrystalline material.

4) The XRD at the center of the simple reflection circle make an angle equal to half of the glancing angle.

5) Polycrystalline material is characterized by different broadening peaks thus the XRD contains circular spots.

6) The intensity of the incident x-ray beam decreases by increasing the order of reflection.

7) According to Bragg's low the angle at the third reflection is twice the angle of the first reflection.

8) The crystal plane passing through the center of the simple reflection circle is parallel to reciprocal lattice vector.

9) The diffusion property through the simple cubic system is faster than other cubic systems.

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أجب عن ثلاثة أسئلة فقط ممايلى:

السؤال الثانى: (اختياري- 11 درجة)

2. a) Prove that the correction factor of Bragg's low for the reflection order ($n \succ 3$) depends on the refractive index($\mu$) of the crystal given as: $C = [1 - \frac{2d^2(1-\mu^2)}{n^2\lambda^2}]$, express the Bragg's low for the forth reflection.

b) Determine the energy of X-ray beam when Bragg's angle of $19.21^0$ is observed during in (111) plane of FCC structure (given: w = 27, $\rho$=2.7 gm/cm$^3$, $N_A$= 6.023 x10$^{23}$).

للأسئلة بقية فى الورقة التالية ←

**13.** If a nucleus A has radius R and contains 8 nucleons, what is the radius of a nucleus with 64 nucleons?

*a)* 2R *b)* 4R *c)* 1.5R *d)* 2.5R

**14.** Consider a nuclear reaction $^{20}A + {}^{30}B \rightarrow {}^{50}X + Q$. If **the binding energy** per nucleon for A, B and X are 8.0 MeV, 8.1 MeV and 7.5 MeV respectively, what is the energy in MeV absorbed or released in the reaction:

*a)* +28 (released) *b)* +20 (released) *c)* -20 (absorbed) *d)* –28 (absorbed)

**15.** The energy released in the decay of $^{210}\text{Po} \rightarrow {}^{206}\text{Pb} + \alpha$ is 5.3 MeV. What fraction of this energy is carried by the alpha particle?

*a)* ~98% *b)* ~75% *c)* ~50% *d)* ~25%

**16.** The minimum energy needed to separate two neutrons from $^{18}_{8}\text{O}$ is equal to :

*a)* 951.72MeV *b)* 12.15MeV *c)* 27.47 MeV *d)* 931.5 MeV

**17.** The maximum energy $E_{max}$ emitted with $\beta^-$ in the case of $^{14}\text{C}$ is equal to :

*a)* 0.156 MeV *b)* 0.018 MeV *c)* 0.078 MeV *d)* 1.56 MeV

**18.** Which of the following nuclei has a radius approximately half that of $^{208}\text{Pb}$:

*a)* $^{52}\text{Cr}$ *b)* $^{26}\text{Mg}$ *c)* $^{90}\text{Zr}$ *d)* none of these

**19.** The ratio of the surface energy term per nucleon for $^{27}\text{Al}$ to t hat of $^{125}\text{Te}$ is:

*a)* 0.29 *b)* 1.73 *c)* 1. 67 *d)* 0.53

**20.** Which of the following does not obey inverse square law force:

*a)* electrostatic force *b)* magnetic force *c)* gravitational force *d)* nuclear force

**Part II : Answer the following questions** **(30 Marks)**

**1.** Alpha particles with kinetic energy **7.7MeV** are Coulomb scattered by a silver (**Ag, Z=47**) foil.

***a) Calculate*** the impact parameter for $\alpha$-particles that are scattered through an angle of **120°**.

***b) What*** is the distance of closest approach of these alpha particles to the silver nucleus for this scattering?

**2.** ***a. What*** is meant by: *Mass spectrometer – Magnetic dipole moment.*

***b.*** $^{27}\text{Si}$ is a positron emitter with an end point energy of 1.35 MeV.

***Determine*** $E_{th}$ of the reaction $\text{p} + {}^{27}\text{Al} \rightarrow {}^{27}\text{Si} + {}^{1}_{0}\text{n}$, if the difference $M_{^{1}_{0}\text{n}} - M_{\text{H}} = 0.78$ MeV.

**3.** ***a. Show*** that the electric quadrupole moment of a nucleus vanishes for spherically symmetric charge distribution.

***b. Find*** whether $^{11}\text{C}$ is stable or not. If not, determine the decay mode.

1. ***Draw*** a diagram for this decay.
2. ***What*** is the most important characteristic of this decay?

Given : $M(^{11}_{6}C) = 11.01054326u$

$M(^{11}_{5}B) = 11.0093064u$

**4.** ***Describe briefly :*** The various terms in the Semi-Empirical Mass Formula.

[NB: detailed mathematical expressions and values of constants are not required].

********* *Good Luck* ******** ***Dr. Ahmed A. Ebrahim***

$^{18}_{8}\text{O} = 17.9992$ u, $^{16}_{8}\text{O} = 15.994915$ u, $^{1}_{0}\text{n} = 1.008665$ u, $^{14}_{6}\text{C} = 14.003241$u, $^{14}_{7}\text{N} = 14.003074$ u

| Assiut University<br>Faculty of Science<br>Department of Physics | كلية العلوم<br>جامعة أسيوط | Term: Spring 2024- 2025<br>Date: 15 May, 2025<br>Time: 3 Hours |
|---|---|---|

**Course Title: Nuclear Physics 1 – Code P342 – Final Exam. (50%)**

**Part I: Chose the correct answer for the following questions:** **(20 Marks)**

**1.** In which of the following decays does the atomic number increase but mass number remain unchanged?

*a)* $\alpha-decay$ *b)* $\gamma-decay$ *c)* $\beta^{-}-decay$ *d)* $\beta^{+}-decay$

**2.** Which of the following nuclei is likely to emit an alpha particle?

*a)* $^{6}C$ *b)* $^{239}Pu$ *c)* $^{14}N$ *d)* $^{3}H$

**3.** Which of the following pairs are isobars?

*a)* $^{14}N$ and $^{14}C$ *b)* $^{15}N$ and $^{16}O$ *c)* $^{12}C$ and $^{10}B$ *d)* $^{23}Na$ and $^{24}Mg$

**4.** Which nucleus has the largest binding energy per nucleon?

*a)* $^{4}He$ *b)* $^{5}Li$ *c)* $^{20}Ne$ *d)* $^{56}Fe$

**5.** The energy needed to remove two neutrons from $^{6}Li$ is called:

*a)* decay energy *b)* separation energy *c)* threshold energy *d)* excitation energy

**6.** The unit of nuclear cross-section "barn" is equivalent to:

*a)* $10^{-28}\ m^2$ *b)* $10^{-24}\ m^2$ *c)* $10^{-18}\ m^2$ *d)* $10^{-20}\ cm^2$

**7.** The nuclear force between two nucleons is:

*a)* long-range and attractive *b)* short-range and attractive
*c)* short-range and repulsive *d)* long-range and repulsive

**8.** The most stable nuclei lie in the region of:

*a)* low binding energy per nucleon *b)* high neutron-to-proton ratio
*c)* maximum binding energy per nucleon *d)* equal number of protons and neutrons

**9.** Which of the following is **not conserved** in beta decay?

*a)* charge *b)* mass number *c)* energy *d)* mass

**10.** If a nucleus with mass number A splits into two nuclei in a given mass ratio 1:3, what can be said about the radii of the two resulting nuclei?

*a)* 1:3 *b)* $1:\sqrt{3}$ *c)* 1:2 *d)* $1:\sqrt[3]{3}$

**11.** If a nucleus of A = 100 splits into two parts in the ratio 2:3, the radii of the two products in *fm* are approximately:

*a)* 4.1, 4.7 *b)* 3.3, 5.6 *c)* 4.4, 3.9 *d)* 4.8, 4.4

**12.** The energy required to overcome the Coulomb barrier for a 5 MeV alpha particle approaching a lead nucleus (Z = 82) is closest to:

*a)* 18.2 MeV *b)* 33.2 MeV *c)* 39.9 MeV *d)* 26.2 MeV

**Question 3** **(10 point)**

**A)** What happen when the value of the anode current $i_A$ is increased than the Latching current in the thyristor (2 Point)

**B)** A single phase Full-wave bridge uncontrolled rectifier circuit has a purely resistive load (R = 2.4 Ω). The input dc voltage is Vs = 48 V. Calculate (8 Point)

I) Draw the single phase Full-wave bridge uncontrolled rectifier circuit
II) Draw the input voltage and the output voltage
III) the rms output voltage .
IV) the output power
V) the peak diod current
VI) the average diode current
VII) the peak inverse voltage of the diode

**Question 4** **(10 point )**

**A)** What are the Thyristor turn-on methods? (2 point)

**B)** Draw the waveforms of the load voltage and the load current for the following circuit in fig. (1). (2 point)

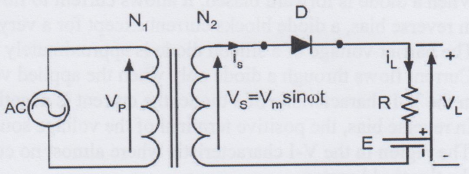



Figure (1)

**C)** For Fig. (1) If the battery voltage is 12 V, and its capacity is 100 W hr. The dc value of the load current is 5 A. the voltage source is 120 V and the transformer turns ratio is 2 : 1. Calculate:

1- the firing angle $\alpha$ 2- the turn-off angle $\beta$ 3- the conducting angle $\delta$
4- the resistance R 5- the charging time for the battery 6- the rectification efficiency

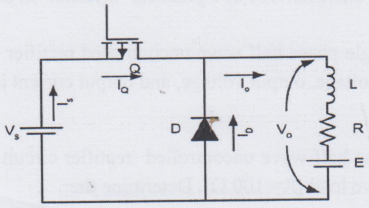
**Question 5** **(10 point )**

**A)** How the average output voltage of the DC chopper can be controlled? (3 point)

**B)** The DC chopper has a resistive load of R = 10 Ω and the input voltage Vs = 220 V. The voltage drop across the electronic switch is 2 V. the chopping frequency is f = 1 KHz. The duty cycle is 50 %. Calculate: (3 point)

I) The average output voltage II)The rms output voltage III)The chopper efficiency

**C)** Draw the waveforms of the transistor ($I_Q$ ), the diode current ($I_D$ ), the load voltage ($V_0$) and the load current ($I_0$ ) for the following circuit? (4 point)




*Good luck*

*Dr. hammad abozied*

| Physics and electronics<br>Faculty of Science<br>Assiut University | Academic year 2024/2025 | |
|---|---|---|
| Course Name: Industry Electronics | | |
| Third Level | Course Code: EP 325 | |
| Date: 15/5/2025 | Allowed Time: 3 hr | Max. Marks: 50 |

**Question 1** **(11 point )**

**A) Put True or False for the following statements:** (4 Point)

I) When a diode is forward biased, it allows current to flow.
II) In reverse bias, a diode blocks current except for a very small leakage current.
III) The barrier voltage of a silicon diode is approximately 0.3 volts.
IV) Current flows through a diode only when the applied voltage exceeds the barrier potential.
V) In the V-I characteristic of a diode, the current is negative in forward bias.
VI) In reverse bias, the positive terminal of the voltage source is connected to the cathode
VII) The region in the V-I characteristic where almost no current flows in forward bias is called the threshold region
VIII) If the reverse voltage exceeds a certain limit, the diode may undergo breakdown.

**B)** Draw the V-I characteristic of a practical diode in details? (3 Point)

**C)** Complete the following statements: (4 Point)

I) The power diode is used as ..... in power electronic circuits
II) The construction of the power diode is consists of ..... layers and ..... junction P-N
III) The power electronics is the circuits which contain an element or more from the .....
IV) Types of power diodes are ..... , ..... , and .....
V) In DC chopper, Variable frequency operation generate ..... at unpredictable frequency

**Question 2** **(9 point)**

**A)** What is the power electronics? (2 Point)

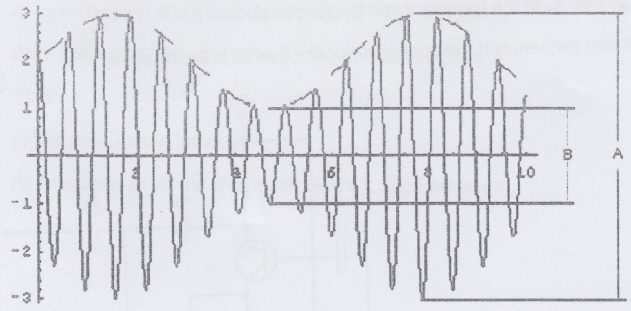
**B)** Draw the V-I characteristic of a practical thyristor in details. (3 Point)

**C)** Draw the single phase half wave uncontrolled rectifier circuit? And also, draw the waveforms of the input voltage, output voltage, and output current in case of resistive load. (2 point)

**D)** A single phase half-wave uncontrolled rectifier circuit has an input voltage 200 sin (wt ) and purely resistive load (R= 100 Ω). Determine the: (2 Point)

I) Efficiency
II) Form factor
III) Ripple factor
IV) Peak inverse voltage of diode .

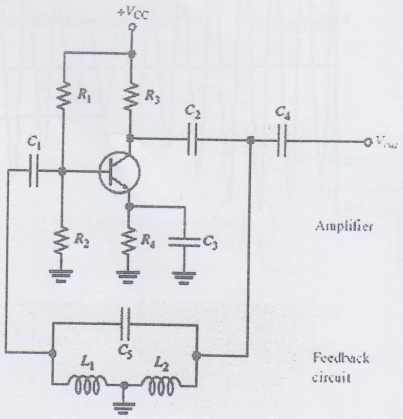
10.a. For the modulated wave shown in fig. Find the modulation index (μ)




10.b. It is desired to obtain a bandwidth of 12 kHz at an operating frequency of 800 kHz, using a double-tuned circuit. What value of co-efficient of coupling should be used ?

9. If $L_2 = 10mh$ , $L_1 = 1\ mh$ what is the value of the Capacitor C for the output frequency equal 20 KHz.? The voltage gain $A_V$ of the transistor and the feedback ratio β.

b. What is the oscillator frequency If the quality factor Q = 8 what is the frequency?



8. For the given waves

A) $y = 10 \cos (1800 \pi t) + 30 \cos 2000 \pi t + 10 \cos 2200 \pi t$

B) $y = 10 \cos (2700 \pi t) + 20 \cos 3000 \pi t + 10 \cos 3300 \pi t$.

Find:

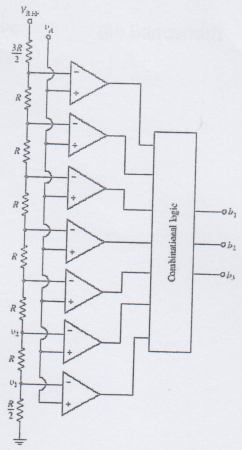
(i) The modulation index ($\mu$)

(ii) Frequencies off the modulated wave. (iii) Bandwidth

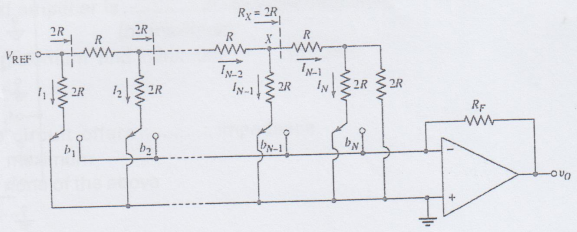
7. A carrier wave of frequency f = 1MHz with a pack voltage of 20V is used to modulate a signal of frequency 2kHz with a pack voltage of 10V. Find out the following:

(i) μ (modulation index) (ii) Frequencies of the modulated wave (iii) Bandwidth

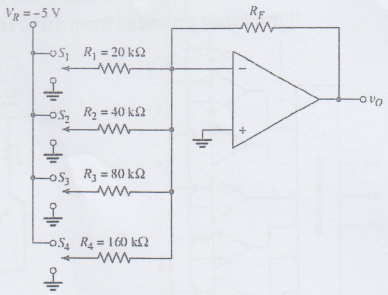
5. A 6-bit flash A/D converter, similar to the one in Figure, is to be fabricated. How many resistors and comparators are required?



4. The N-bit D/A converter with an *R-2R* ladder network in Figure 16.92 is to he designed as a 6-bit D/A device. Let $V_{REF}$ = -5.0 V and $R = R_F$ = 5.0 kΩ. (a) What are currents $I_1$, , $I_2$, $I_3$, $I_4$, $I_5$, and $I_6$? (b) The input changes by 1 LSB. What is the change in the output voltage? (c) What is the output voltage if the input is 01001 1? (d) What is the change in output voltage if the input changes from 101010 to 010101?



3. An analog signal in the range 0 to 3.3 V is to be converted to a digital signal with a quantization error of less than 0.5 percent. (a) What is the required number of bits? (b) What input voltage value represents 1 LSB? (c) What digital output represents an input voltage of 2.5321 V.



**Question 2.**

1. A tuned amplifier uses ..... load.

(a) resistive (b) capacitive (c) LC tank (d) inductive

Answer:.....

2. The voltage gain of a tuned amplifier is ..... at resonant frequency.

(a) minimum (b) maximum

(c) half way between maximum and minimum (d) zero

Answer:.....

3. At series resonance, the circuit offers ..... impedance.

(a) zero (b) maximum

(c) minimum (d) none of the above

Answer:.....

4. A resonant circuit contains .....elements.

(a) *R* and *L* only (b) *R* and *C* only (c) only *R* (d) *L* and *C*

Answer:.....

5. When either *L* or *C* is increased, the resonant frequency of *LC* circuit .....

(a) remains the same (b) increases

(c) decreases (d) insufficient data

Answer:.....

6. At series or parallel resonance, the circuit behaves as a ..... load.

(a) capacitive (b) resistive

(c) inductive (d) none of the above

Answer:.....

7. The dimensions of *L*/*CR* are that of .....

(a) farad (b) henry

(c) ohm (d) none of the above

Answer:.....

8. At series resonance, the net reactive component of circuit current is .....

(a) zero (b) inductive

(c) capacitive (d) none of the above

Answer:.....

9. If the resistance of a tuned circuit is increased, the *Q* of the circuit .....

(a) is increased (b) is decreased

(c) remains the same (d) none of the above

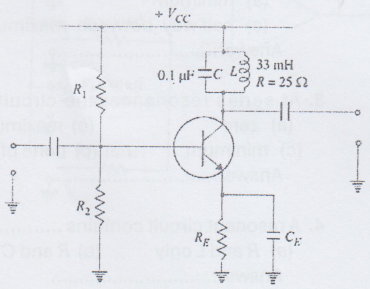
Answer:.....

10. At series resonance, the phase angle between applied voltage and circuit current is .....

(a) 90° (b) 180° (c) 0° (d) none of the above

Answer:.....

1.a. For the tuned amplifier shown in fig. determine: (i) the resonance frequency (ii) the Q of the tank circuit (iii) band width of the amplifier and (iv) cut off frequencies



**Question 2** *16 Marks*

i) Suppose that AL = 00001100 B, write the assembly lines to preform the following operations without using the command `MUL`, and then show the contents of AL: *(6 Marks)*

a) Multiply AL by 4
b) Multiply AL by 10
c) Multiply AL by 21

ii) Show the contents of BX and the flag bits (CF, ZF, SF, OF, PF and AF) after the execution of the following assembly lines: *(6 Marks)*

```
MOV BL,4AH
XOR BL,73H
STC
MOV BH,0D6H
ADC BH,62H
```

iii) Write the assembly code that: *(4 Marks)*

- initializes AX with 237D H
- initializes BX with 1F5B H
- performs the following subtraction AX = AX - BX without using the command `SUB` or `SBB`

---

**Question 3** *14 Marks*

i) Check if the jump will occur or not in the following cases: *(6 Marks)*
(Note: answer with occur or not occur, and also write the reason)

a)
```
MOV AX,93A2H
CMP AX,643BH
JL NEXT
```

b)
```
MOV AL,0E8H
ADD AL,6AH
JNC NEXT
```

c)
```
MOV AL,8CH
XOR AL,59H
JS NEXT
```

ii) Write the assembly lines that perform the following operations: *(8 Marks)*

a) Set the bits No. 0, 2 and 5 in AL
b) Clear the bits No. 1, 3, 4 and 6 in BL
c) Toggle the bits No. 2, 3 and 7 in CL
d) Clear the contents of DX without using the command `MOV`

---

**Question 4** *10 Marks*

Write the assembly code that: *(8 Marks)*

- adds and counts the multiples (مضاعفات) of the number 3 in a series of byte size data (9, 21, 14, 36, 50, 84, 46, 75, and 0)
- stores the sum of these multiples in CL
- stores the count of these multiples in CH
- stops when the number 0 is read

then show the contents of CX after the execution of the assembly code. *(2 Marks)*

---

*Best Wishes* *Dr. Abdelrahman Morsi*

Physics Department
Faculty of Science
Assiut University
2nd Semester - 2024/2025
3rd Year
Final-term Exam

Physics and Electronics Program
Course Code: EC 325
Microprocessors
(معالجات دقيقة)
Date: June 3rd, 2025
Time: 9:00 am - 12:00 pm **(3 hours)**

**Important Notes:** Marks: 50, Number of Pages: 2, Number of Questions: 4

**Answer All the Following Questions:**

**Question 1** *10 Marks*

Choose the correct answer to each of the following statements: *(1 Mark for Each Point)*
(Note: multiple choices are not allowed)

1. The ..... bus selects the memory or I/O device and causes them to perform a read or write operation.
   A data B control C address D non of the previous
2. Consider DS = 3000 H, the ending address of the data segment is .....
   A 2FFFF H B 32FFF H C 3FFFF H D 32000 H
3. The first microprocessor in Intel which has 32-bit address bus and 64-bit data bus is .....
   A Intel 80386 B Intel 80486 C Intel Pentium D Intel Pentium Pro
4. The main processing unit in Intel 8086 which contains the IP register is .....
   A BIU B ALU C EU D non of the previous
5. The maximum size of a memory segment in the real mode is .....
   A 1 MB B 64 KB C 4 MB D 256 KB
6. IF SP = 37CD H, the offset address of the first location in the stack to push data into is .....
   A 37CC H B 37CD H C 37CE H D 37CB H
7. The computing machine which can be considered the first general-purpose computer is .....
   A Colossus B Z3 C ENIAC D Abacus
8. ..... can be considered a suitable combination of segment:offset registers.
   A CS:IP B DS:SP C SS:SI D ES:BP
9. Consider CF = 1 and AL = 10100011 B. After the execution of `RCL AL,2` .....
   A CF = 1 and AL = 01000111 B B CF = 0 and AL = 10001111 B
   C CF = 0 and AL = 10001110 B D CF = 1 and AL = 11101000 B
10. The data addressing mode in `MOV AX,[SI+8]` is .....
    A register indirect B base plus index
    C register relative D base relative plus index

Question 2: Write short notes with drawings on the following sentences: (12 marks)

- Depletion region in PN junction.
- P-type semiconductor.
- Voltage ripples in AC circuits.
- Zener voltage.

Question 3: Sketch a circuit that provides: (10 marks)

- Triple the input voltage. Using only diodes and capacitors.
- A magnified current by 10 times. Without using diodes.

Question 4: Consider an NPN BJT common emitter circuit with $V_{CC}$= 10 V, $V_{in}$= 3 V, $R_C$ =1.5 kΩ, $R_E$ =330 Ω, $R_B$ =10 kΩ. Knowing the transistor has a β of 100, $V_{BE}$(on)=0.7 V, $V_{CE}$(sat)=0.2 V. **Sketch the circuit in your answer sheet.** Then find: (16 marks)

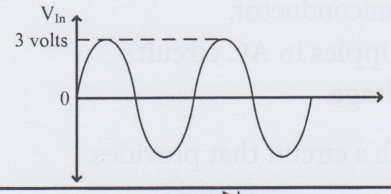
- What are the conditions for switching the transistor ON?
- Describe the different regions of the characteristic curve between $I_C$ and $V_{CE}$.
- What would be the approximate collector current ($I_C$) and collector-emitter voltage ($V_{CE}$) when the transistor is in saturation?
- What would be the approximate collector current ($I_C$) and when the transistor is in active region?

An important note in your sketch $V_{CC}$ is connected in the emitter-collector circuit and $V_{in}$ to the emitter-base circuit.

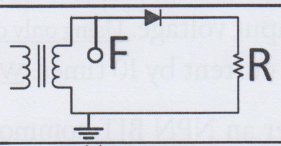
| | | |
|---|---|---|
| **Assiut University**<br>**Faculty of Science**<br>**Department of Physics** | | **Date: June 2nd 2025.**<br>**Duration: 2 hr.**<br>**Course: Basic electronics & Instrumentations 304phy** |

Question 1: Draw the output wave between F and the ground for the following circuits: (12 marks)

Given the input signal, and assuming an ideal diode (zero $V_D$).




1.

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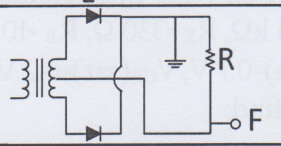


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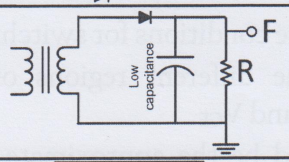


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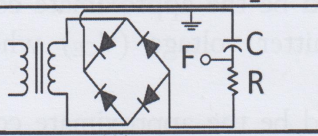
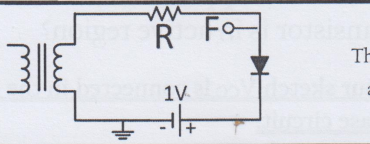


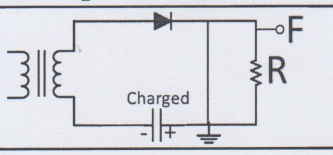

High capacitance

5.




The diode is not ideal and $V_D$=0.7 V

6.




Low capacitance

**D. State the Environmental Applications of Nanotechnology?**

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**E. Discuss the mechanism of Photo Catalysis in purification of Water by $TiO_2$ ?**

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**End Of Exam**

With all my best wishes

7/7

Prof. Dr. Essam F. Abo Zeid

B. Compare between spontaneous emission and stimulated emission?

C. Illustrate the mechanism of drug delivery by the application of nanotechnology?

## Part (II) (25 Marks)

**Q2: Discuss part :** **(5 Mark each)**

**A. Discuss how sensors work with examples and mechanism of touch sensor and applications of nanosensors?**

40. Which device is NOT based on the photoelectric effect?

C. Photovoltaic cell B. X-ray machine A. Solar panel

41. ..... Only detects natural energy (like light or heat) without emitting anything.

C. Touch sensors B. Passive sensors A. Active sensors

42. When ..... fibers are woven together, they become stronger and stronger, high energy absorption properties and lightweight.

C. CTNs B. NCTs A. CNTs

43. ..... is an advanced oxidation process which is based on the oxidative elimination of micro pollutants and microbial pathogens.

C. Photo catalysis B. Antimicrobial A. Oxidation

44. ..... is the most popular and widely used Photo catalyst.

C. NaOH B. SiO2 A. TiO2

45. ..... is used for fabrication of chips.

C. Nanowires B. Nanolithography A. Nano-electronics

46. A nanoparticle carries the pharmaceutical agent inside its ....., while its shell is functionalized with a 'binding' agent.

C. Core B. Cladding A. Buffer

47. The fibers are designed to guide light through the principle of total internal ....., enabling the transmission of data, voice, and video with exceptional speed, clarity, and efficiency..

C. Diffraction B. Reflection A. Refraction

48. .....is a branch of Optics that deals with the study of propagation of light(rays or modes) through transparent dielectric waveguides conditions.

C. Fiber Optics B. Fiber glass A. Fibro electronics

49. ..... nanoparticles with a high refractive index are a powerful addition to fiber optics technology, as they improve light transmission efficiency. field.

C. Carbon B. Silicon A. Magnesium

50. Lasers modify the surface properties, like roughness or..... of materials.

C. Strength B. Hydrophobicity A. Hardness

25. ..... conduction is the movement of ions through a medium allowing electrical current to pass that occurs in Electrolyte solutions.

C. Ionic B. Electronic A. Atomic

26. ..... sensors respond to mechanical force variations.

C. Motion B. Light A. Pressure

27. ..... sensors detect resistance changes due to heat.

C. Pressure B. Temperature A. Light

28. Light sensors measure light ..... and convert it into electrical output.

C. Density B. Intensity A. Energy

29. The ..... is the minimum energy needed to release an electron from a metal surface.

C. Binding enery B. Threshold frequency A. Work function

30. The ..... is the minimum light frequency that provides this energy.

C. Binding energy B. Threshold frequency A. Work function

31. ..... are flexible, transparent fiber made up of high quality glass (Silica) or plastic , slightly thicker than human hair.

C. Fiber optics B. Fiber glass A. Fiber carbon

32. .....Protects against environmental factors such as moisture and mechanical damage.

C. Buffer B. Cladding A. Outer Jacket

33. ..... Surround core and Reflects light signals back into core.

C. Buffer B. Cladding A. Outer Jacket

34. ..... emission happens naturally when an excited atom returns to a lower energy level, releasing a photon in a random direction and phase.

C. Spontaneous B. Stimulated A. Natural

35. ..... emission Occurs when a photon hits an excited atom, causing it to emit another photon identical in direction, energy, and phase.

C. Spontaneous B. Stimulated A. Activated

36. An ..... resonator is the part of the laser that holds the active medium and helps amplify the light through reflections.

C. Optical B. Thermal A. Electrical

37. Which sensor works by detecting changes in capacitance?

C. Gas sensor B. Touch sensor A. Motion sensor

38. Which sensor is found in smart watches to monitor heart rate?

C. Heart rate sensor B. Proximity sensor A. Pressure sensor

39. Factors Affecting of Electronic conduction except.... ..... .

C. Crystal structure B. Material composition A. Temperature

10. Which property of elements is determined using XPS .

C. Magnetic field B. Density A. Elemental composition

11. Which instrument component measures the kinetic energy of ejected electrons in XPS?

C. Spectrometer B. X-ray source A. Electron detector

12. The purpose of the monochromatic X-ray source in XPS is to improve .....

C. Magnetic properties B. Photon energy A. Energy resolution

13. Fiber Optics made up of high quality ..... or plastic.

C. Metal B. Glass A. Metal oxide

14. Fiber optics works by transmitting light pulse through a ..... surrounded by ....., using the principle of total internal reflection.

C. Cladding –core B. Core - buffer A. Core -cladding

15. Silicon nanoparticles with a ..... refractive index are a powerful addition to fiber optics technology.

C. Medium B. High A. Low

16. The type of resonator which used in solid-state lasers like the Ruby laser is ..... Resonator.

C. Internal B. External A. Fiber optic

17. The type of emission which is responsible for producing laser light is.....emission.

C. Radioactive B. Spontaneous A. Stimulated

18. One of the applications of laser-generated nanoparticles is..... ..... .

C. Road construction B. Wood carving A. Drug delivery

19. The optical resonator mirror which allows the laser beam to exit is ..... mirror.

C. Fully reflective B. Semi transparent A. Convex

20. In drug delivery, the shell of the nanoparticle which carries the pharmaceutical agent inside, is functionalized with ..... .

C. Both A&B B. Antibody A. Binding agent

21. Textiles which have the property of water repellence, are made from .....

C. Silica NPs B. Phosphate A. Titanium

22. Magnetic nanowires made of an alloy of ..... are being used to create dense memory devices.

C. Cupper - Iron B. Iron – Nickel A. Cupper -Nickel

23. .....used to Check for pesticide residues and fortified substances in fruits and vegetables to maintain process parameters.

C. Color changing labels B. Nano-composites A. Nano-sensors

24. The Sensors function by detecting physical changes and converting them into ..... signals.

C. Magnetic B. Electrical A. Optical

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|---|---|---|---|
| | Assiut University - Faculty of Science<br>First semester- Final Exam 2024-2025<br>Department of Physics | Program: Materials science<br>Level : (3 )<br>Date:30/5/2025<br>Time: 2 hours | كلية العلوم<br>جامعة أسيوط |
| Course title: Electrical, Optical, Magnetic Materials | | | Code: 302 Phy |

| Important: | No. of pages 7 | No. of questions 2 | Total marks: 50 degrees |
|---|---|---|---|

## تنبيه هام

**قبل البدء فى الأجابة الرجاء قراءة هذة التعليمات جيدا**

1. تأكد من أن كراسة الإمتحان تتكون من (7) صفحات مختلفة (4) ورقات و فى حالة التكرار أو النقص يطلب إستبدالها فورا.
2. الإمتحان يتكون من سؤالين فقط: السؤال الأول اختيار من متعدد والسؤال الثاني مقالي و مطلوب الإجابة عليها جميعا.
3. يجب تخصيص الوقت المناسب لإجابة كل سؤال و مراعاة عدم تجاوزة حتى يتسنى لك إجابة جميع الأسئلة.
4. محاولة الإستعانة بالآخرين أو إعانتهم فى إجابة الإمتحان يعرضك للمسائلة القانونية من الجامعة وما يترتب عليها.

## Part (I) (25 Marks)

**Q1: Choose the correct answer A, B, or C:** **(1 Mark each)**

1. In drug delivery, the shell of the nanoparticle which carries the pharmaceutical agent inside, is functionalized with …… …….. .

   C. both, A and B  B. binding' agent  A. antibody

2. SiO2 nano-coatings have …… properties.

   **C.** natural  **B.** hydrophobic  **A.** hydrophilic

3. Which of the following is NOT a characteristic of laser light.

   C. Monochromatic  B. Divergent  A. Coherent

4. What is the depth of analysis typically achieved by XPS?.

   C. 100-200 nm  B. 1-10 nm  A. 50-20 nm

5. XPS provides information on the ……states of elements.

   C. Oxidation  B. Magnetic  A. Physical

6. The binding energy (BE) in XPS is calculated using …… equation.

   C. $BE = h\nu + \Phi - KE$  B. $BE = KE + h\nu + \Phi$  A. $BE = h\nu - KE - \Phi$

7. What type of radiation is used in XPS?

   **C.** Gama rays  **B.** X-rays  A. Ultrviolte rays

8. XPS is commonly used in the analysis of ……..

   C. Bulk metals  B. Thin films  A. Liquids

9. XPS is primarily a technique for analyzing which part of a material?

   **C.** Surface properties  **B.** Bulk properties  A. Enter volume

**Question 4**: When a particle with an energy $E$ coming from $-\infty$ is encountered by a potential step $V_0$. An Interesting phenomenon is observed which we call the "tunneling effect". Using the time-independent Schrödinger equation find the wave function that describe the behavior of this particle, if the potential was described by $V(x) = \begin{cases} V_0 & x \geq a \\ 0 & elsewhere \end{cases}$. Discuss when the tunneling effect occur and why it was not predicted classically. (12 marks)

Use these standard integrals if needed:

$$\int_0^\infty x^n e^{-\mu x} = \frac{n!}{\mu^{n+1}}, \qquad sin^2(\theta) = \frac{1-\cos 2\theta}{2}, \qquad sin^2(\theta) + cos^2(\theta) = 1,$$

$$\int \frac{1}{\sqrt{a^2-x^2}} dx = \sin^{-1}\frac{x}{a} + C, \qquad \int \frac{1}{(a^2-x^2)} dx = \frac{1}{2a} ln\left|\frac{a+x}{a-x}\right| + C.$$

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|---|---|---|
| **Assiut University**<br>**Faculty of Science**<br>**Department of Physics** | | **Date: May 31st 2025.**<br>**Duration: 3 hr.**<br>**Course: Quantum Mechanics 311p** |

**Question 1** (16 marks)

**Part I**: Determine the constant $A$, for the following wave functions:

| | |
|---|---|
| 1. | $\psi(x) = \frac{A}{\sqrt{a^2 - x^2}}$ in the range $(-a/2, 0)$. |
| 2. | $\psi(x) = Ae^{3\frac{x}{2}}$ in the range $(-\infty, 0)$. |

**Part II**: Given the wave function $\psi(x) = \frac{1}{\sqrt{L}} e^{i\frac{2\pi}{L}x}$, with $0 < x < L$. Calculate $< x >, < P_x >$ for this normalized wave function and then calculate the probability of finding the particle between 0.3 and 0.5 if $L = 2$Å.

**Part III**: Build a comparison between the ground state energy of harmonic oscillator in classical and quantum mechanics. (Provide the equation, minimum value and depending parameters).

**Question 2**: Starting from Hook's law ($F = -kx$), find the expression for the potential energy of a typical harmonic oscillator in one dimension. Then find the differential equation of the harmonic oscillator using the classical mechanics and quantum mechanics approaches. (10 marks)

**Question 3**: A particle is confined in an infinite potential well described by the potential:

$$V_1(x) = \begin{cases} 0 & -L \leq x \leq L \\ \infty & elsewhere \end{cases},$$

Solve the time-independent Schrödinger equation to find all the possible wave functions that describes this particle. If the potential expression changed to $V_2(x) = \begin{cases} 0 & 0 \leq x \leq \frac{L}{2} \\ \infty & elsewhere \end{cases}$, compare the wave functions in these two cases and calculate the energy of the particle at the first energy level (i.e., $n = 1$). Mention which energy is higher.

knowing that $L = 15$ Å, $m = 9.1 \times 10^{-31} kg$ *and* $h = 6.625 \times 10^{-34} J.s.$ (12 marks)