

4- a) What the meaning of the gas elasticity, prove that the volumetric isothermal elasticity factor  $\lambda_T$  depends on the pressure of the gas.

b) Consider a gas adiabatically expands, if its volume is doubled while its absolute temperature decreases by (1.32) times, calculate the ratio  $C_p/C_v$ .

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5- a) According to the change of entropy in terms of the pressure and temperature of the gas:

$TdS = C_p dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$ , rewrite this eqn. in terms of  $(\alpha_p)$ , then apply the resulting eqn. on the solid and liquids.

b) Explain the physical significance of the following thermodynamic functions:

(i) The change of enthalpy:  $H = E + PV$ , at constant pressure.

(ii) The change of Helmholtz free energy:  $F = E - TS$ , for isothermal process.

أ. د. عبد المنعم سلطان . انتهت الأسئلة

Assiut university  
Faculty of science  
Department of physics

1<sup>st</sup> term  
Date: 13\1\2026  
Time allowed: 2 hours

Course title: Principles of Modern Physics

Code: 225P

Answer the following questions:

Q.1 (10 marks)

Choose the correct answer in the following:

- 1) An electron is moving with a kinetic energy of 10 eV, hence its de Broglie wavelength equals:  
A) 2.1 Å  
B) 2.6 Å  
C) 3.9 Å
- 2) An electron is accelerated by a potential difference of 100 V. What is its momentum in Kg m/s?  
A)  $3.45 \times 10^{-24}$   
B)  $3.54 \times 10^{-24}$   
C)  $4.53 \times 10^{-24}$   
D)  $5.43 \times 10^{-24}$
- 3) If the scattering angle in Compton's scattering is 90 degree. What is the wavelength shift?  
A)  $1.22 \times 10^{-12}$  m  
B)  $2.43 \times 10^{-12}$  m  
C)  $3.65 \times 10^{-12}$  m
- 4) A monochromatic light is incident on the surface of a metal with work function 2.50 eV. If a 1.0-V stopping potential is required to make the photocurrent zero, what is the wavelength of Light?  
A) 354 nm  
B) 423 nm  
C) 497 nm  
D) 744 nm
- 5) A metal has a work function of 4.5 eV. Find the maximum kinetic energy of the photoelectrons if the wavelength of light is 250 nm.  
A) zero  
B) 0.37 eV  
C) 0.46 eV
- 6) A metal has a work function of 4.5 eV. Find the maximum kinetic energy of the photoelectrons if the wavelength of light is 250 nm.  
A) zero  
B) 0.37 eV  
C) 0.46 eV
- 7) When an electron is accelerated to a higher speed, there is a decrease in its  
A) energy.  
B) frequency.  
C) wavelength

8) As a particle travels faster, its de Broglie wavelength

- A) increases.
- B) decreases.
- C) remains constant.

9) In a Compton scattering experiment, what scattering angle produces the greatest change in wavelength?

- A) zero degree
- B) 90 degree
- C) 180 degree

10) Which color of light has the lowest energy photons?

- A) red
- B) yellow
- C) green

Q. 2 (10 marks)

Write true (T) or false (F) in the following:

- 1) The spectral distribution of radiation in a black body depends only on the temperature of the body ( )
- 2) Rest mass of a particle can be converted into energy ( )
- 3) According to plank theory , each atomic oscillator emits quanta of energy E is which proportional to its frequency( )
- 4) The speed of light is different in deference frames( )
- 5) In the photo electric effect the maximum current is proportional to the intensity of the incident light( )
- 6) Energy and momentum are not conserved in pair production( )
- 7) The square of the wave function gives a measure for finding the electron at some point in space at a certain time( )
- 8) UV light is more effective than Red light in production of photoelectrons( )
- 9) The stopping voltage does not depend on the incident light intensity( )
- 10) Pair production cannot occur in empty space( )

Q. 3 (5 marks each):

Solve the following problems:

- 1) The threshold wavelength for potassium is 564 nm
  - a) what is the work function for potassium?
  - b) what is the stopping potential when light of wavelength 400 nm is used?

- 2) A positron collides head on with an electron, both are annihilated. Each particle had kinetic energy of 1 MeV. find the wavelength of the resulting photon.

~~Find~~

3) Find:

- a) The shortest wavelength present in the X-ray radiation from an X-ray machine whose accelerating potential equals to 50 Kilo Volts ,
- b) The maximum frequency of this radiation .

4) The threshold wavelength for emission of electrons from a given metal surface is 380 nm .

- a) what will be the max kinetic energy of ejected electrons when the wavelength is changed to 240 nm .
- b) what is the maximum speed of electron?

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5) If an excited state of hydrogen atom has a lifetime of 2.5 seconds , calculate the minimum error with the energy of this state can be measured .

6) What is the energy of gamma ray having a wavelength of  $10^{-14}$  m .

	Assiut University - Faculty of Science First Semester - Final Exam 2025-2026 Physics Department	Program: Physics/ Physics & Chemistry/ Physics & Electronics/ Mathematics & Physics/ Physics & Chemistry Level : (2) Date: 14/1/2026 Time: 3 h	
Instructor: Prof. Dr. Hicham Makhsos Kolb Makhsos		Total Mark: 50 Marks	
Important:	No. of pages: 7	No. of questions: 3	

Constants:  $\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m}/\text{A}$

Answer the following questions

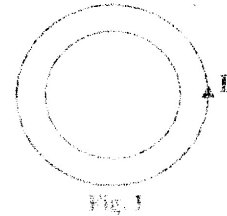
**Q1: Circle the correct answer for the following questions: (14 Marks, 1 mark for each point)**

1. Which of the following is Biot-Savart law?

- (a)  $\vec{B} = \frac{\mu_0 I}{4\pi} \int \left( \frac{d\vec{s} \times \vec{r}}{r^2} \right)$       (b)  $\epsilon = -N \frac{d\phi_B}{dt}$       (c)  $\vec{E} = \vec{I} \times \vec{B}$       (d)  $L = N\phi_B/I$

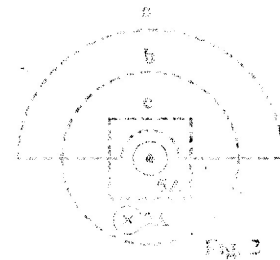
2. In Fig. 1, as the current  $I$  increases in the outer conducting loop, what is the direction of the induced current in the inner conducting loop?

- (a) clockwise      (b) counterclockwise  
 (c) alternating      (d) zero current



3. Rank the magnitudes of  $\oint \vec{B} \cdot d\vec{s}$  for the closed paths in Fig. 2 from least to greatest.

- (a) a, b, c      (b) b, c, a  
 (c) c, a, b      (d) c, a, b



4. The working principle of "Wireless" battery charger is based on

- (a) mutual induction phenomena      (b) Ohm's law  
 (c) resonance condition      (d) Maxwell's equations

5. How much does the maximum EMF produced by a generator (a rotating coil) change if the period of rotation is doubled?

- (a) it is quartered      (b) it is doubled  
 (c) it is quadrupled      (d) it is halved

6. The capacitor in an RC circuit begins to discharge. During the discharge, in the region of space between the plates of the capacitor, there is .....

- (a) an electric field but no magnetic field      (b) a magnetic field but no electric field  
 (c) both electric and magnetic fields      (d) no fields of any type

7. According to Gauss's law in magnetism, the net magnetic flux through any closed surface is .....

- (a) always non-zero
- (b) always imaginary number
- (c) always zero
- (d) always unknown

8. Consider the circuit in Fig. 3 and assume that the battery has no internal resistance. Long time after the switch S is closed, the current in the battery is

- (a) zero
- (b)  $\epsilon/2R$
- (c)  $2\epsilon/R$
- (d)  $\epsilon/R$

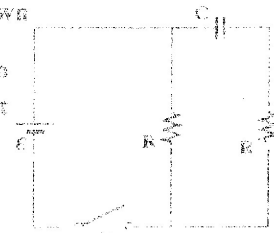


Fig. 3

9. The ..... is the magnetic moment per unit volume due to currents.

- (a) magnetic field strength,  $H$
- (b) magnetic permeability,  $\mu_0$
- (c) magnetic susceptibility,  $\chi$
- (d) Bohr magneton

10. .... materials are those made of atoms that do not have permanent magnetic moments.....

- (a) ferromagnetic
- (b) paramagnetic
- (c) ferrimagnetic
- (d) diamagnetic

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

- (a) resistance (Ohm)
- (b) energy (Joule)
- (c) voltage (Volt)
- (d) current (Ampere)

12. The total energy in a circuit contains a resistor, inductor and capacitor.....with time.

- (a) is constant
- (b) decreases
- (c) increases
- (d) alternating

13. What is NOT true for Poyating vector?

- (a) Its direction is the direction of propagation
- (b) It is the power per unit area.
- (c) It is time independent.
- (d) The SI units of the Poynting vector are  $J/m^2$ .

14. Which of the following does NOT result in the production of electromagnetic waves?

- (a) charges moving at a constant velocity
- (b) charges that are accelerating or decelerating
- (c) charges moving around in a circle
- (d) an oscillating electric current

**Q2: Solve the following problems, Show all your work, then Circle the choice that match your answer. (16 Marks: 2 marks for each problem)**

1. A cylindrical cable of radius 8.50 mm carries a current of 24.0 A, uniformly spread over its cross-sectional area. At what distance from the center of the wire is there a point within the wire where the magnetic field is 0.282 mT?

- (a) 0.25 mm
- (b) 1.55 mm
- (c) 4.24 mm
- (d) 10 mm

2. A coil is wrapped with 300 turns of wire on the perimeter of a square frame (side length = 20 cm). Each turn has the same area as the frame. A uniform magnetic field is turned on perpendicular to the plane of the coil changes in magnitude at a constant rate from 0.50 T to 0.90 T in 2.0 s. What is the magnitude of the induced emf in the coil while the field is changing?

- (a) 1.6 V
- (b) 2.4 V
- (c) 3.2 V
- (d) 4.0 V

3. Fig. 4 shows a top view of a bar that can slide without friction. The resistor is  $6 \Omega$  and a 2.50 T magnetic field is directed perpendicularly into the paper. Let  $\ell = 1.2$  m. Calculate the applied force required to move the bar to the right at a constant speed of 2 m/s.

- (a) 1.5 N
- (b) 3 N
- (c) 9 N
- (d) 18 N

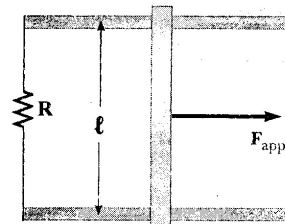


Fig. 4

4. For the two solenoids of Fig. 5, if  $\ell = 50$  cm,  $N_1=N_2=200$  turns and  $r_1=5$  cm and  $r_2=10$  cm, calculate the mutual inductance of the two solenoids.

- (a) 1.58 mH
- (b) 0.79 mH
- (c) 3.20 mH
- (d) 6.31 mH

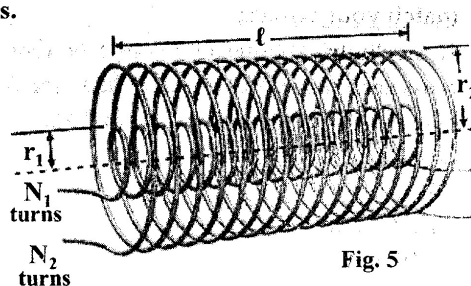


Fig. 5

5. Consider a capacitor of capacitance  $C$  that is being discharged through a resistor of resistance  $R$ , after how many time constants  $\tau$  is the charge on the capacitor one-fourth its initial value?

- (a)  $0.33\tau$
- (b)  $1.39\tau$
- (c)  $2.10\tau$
- (d)  $3.15\tau$

6. A series LC circuit contains a 100 mH inductor, a 36 mF capacitor and a 12 V battery. Calculate the angular frequency of the electromagnetic oscillations that can be generated by this circuit.

- (a)  $36.0 \times 10^{-4}$  rad/s.
- (b)  $6.00 \times 10^{-2}$  rad/s.
- (c) 2.78 rad/s.
- (d) 16.7 rad/s.

7. An RL circuit has a resistance  $R = 25 \Omega$ , an inductance  $L = 5.4 \text{ mH}$ , and a battery of emf = 9.0 V. How much energy is stored in the inductance of this circuit when a steady current is achieved?

- (a) zero
- (b) 0.15 J
- (c) 0.35 mJ
- (d) 0.70 mJ

8. A sinusoidal electromagnetic wave of frequency 40.0 MHz travels in free space in the x direction. At some point and at some instant, the electric field has its maximum value of 750 N/C and is along the y axis. Calculate the magnitude and direction of the magnetic field at this position and time.

- (a)  $2.5 \times 10^{-6} \text{ T}$ , in the y direction
- (b)  $2.5 \times 10^{-6} \text{ T}$ , in the z direction
- (c) 750 T, in the y direction
- (d) 750 T, in the z direction

**Q3. Solve the following problems, Show all your work: (20 Marks)**

I. The segment of wire in Fig. 6 carries a current of  $I$ , where the radius of the circular arc is  $R$ . Starting with Biot-Savart law, determine the magnitude and direction of the magnetic field  $B$  at the center of the arc. (3 marks)

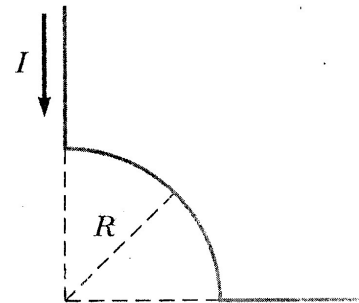


Fig. 6

II. A toroid wound with 60 turns/m of wire carries a current of 5 A. The torus is iron (ferromagnetic), which has a magnetic permeability of  $\mu_m = 5000\mu_0$  under the given conditions. Find the total magnetic field B inside the iron. (3 marks)

III. A long solenoid with 1000 turns per meter and radius 2 cm carries an oscillating current given by  $I = (5 \text{ A}) \sin(100\pi t)$ . Starting with the general form of Faraday's law determine the electric field induced at a radius  $r = 3 \text{ cm}$  from the axis of the solenoid as a function of time? (4 marks)

IV. (Total 10 marks) An inductor ( $L = 250 \text{ mH}$ ), a capacitor ( $C = 2 \text{ }\mu\text{F}$ ), and a resistor ( $R = 500 \text{ }\Omega$ ) are connected in series with a 50-Hz AC source with  $\Delta V_{\text{max}} = 210 \text{ V}$ . Calculate the

(a) impedance of the circuit, (2 marks)

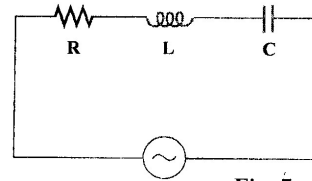


Fig. 7

(b) maximum current passing in the circuit, (1.5 marks)

(c) phase angle  $\phi$  between the current and the applied voltage and draw the phasor diagram. (3 marks)

(d) average power  $P_{\text{avg}}$  delivered by the source to this circuit. (1.5 marks)

(e) What new capacitance  $C_{\text{new}}$  is needed to maximize  $P_{\text{avg}}$  if the other parameters of the circuit are not changed? (2 marks)

**End of Exam**

Best Wishes Prof. Dr. Hicham Mahfoz Kotb

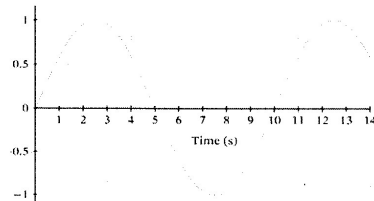
Δ Remember   ■ Understand   ● Apply   ◊ Analyze   \*Evaluate   ○ Create

Assiut University  
Faculty of science - Physics department

Duration of test	3 hours	Course	Physics P212 - Vibrations and waves
Degree	50	Exam	Final Exam

**Part I: Choose the correct answer:**

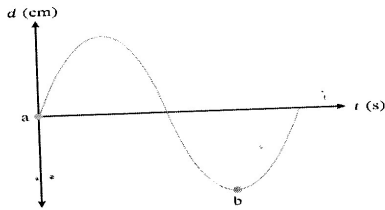
1. A spring completes 4 oscillations in 5 sec. what's the periodic time?  
A. 1.25 s  
B. 0.4 s  
C. 1 s  
D. 0.8 s
2. what's the frequency of the following wave  
A. 10 Hz  
B. 1/10 Hz  
C. 5 Hz  
D. 1/5 Hz



3. To quadruple the frequency of an oscillator, we have to.....  
A. double number of vibrations  
B. decreasing periodic time to half  
C. double both of number of vibrations and periodic time  
D. double the number of vibrations and decreasing periodic time to half

4. What's the time between points a and b knowing that the frequency is 60 Hz

- A.  $1/45$  s
- B.  $1/80$  s
- C.  $1/60$  s
- D.  $1/120$  s



5. How much energy must the shock absorbers of a 1200-kg car dissipate in order to damp a bounce that initially has a velocity of 0.800 m/s at the equilibrium position? Assume the car returns to its original vertical position

- A. 330 J
- B. 384 J
- C. 348 J
- D. 584 J

6. The length of nylon rope from which a mountain climber is suspended has a force constant of  $1.40 \times 10^4$  N/m. What is the frequency at which he bounces, given his mass plus and the mass of his equipment are 90.0 kg

- A. 1.99 Hz
- B. 2.223 Hz
- C. 5.9 Hz

7. Find the frequency of a tuning fork that takes  $2.50 \times 10^{-3}$  s to complete one oscillation.
- A. 0.04 Hz
  - B. 400 Hz
  - C. 440 Hz
8. An object of mass 0.2 kg executes simple harmonic motion along the x-axis with a frequency of  $(25/\pi)$  Hz. At the position  $x = 0.04$ , the object has kinetic energy of 0.5 J and potential energy 0.4 J. The amplitude of oscillation is?
- A. 6 cm
  - B. 4 cm
  - C. 8 cm
  - D. 2 cm
9. A spring of force constant 800 N/m has an extension of 5 cm. The work done in extending it from 5 cm to 15 cm is?
- A. 8 J
  - B. 16 J
  - C. 24 J
  - D. 32 J
10. Which of the following functions represents a simple harmonic oscillation
- A.  $\sin \omega t - \cos \omega t$
  - B.  $\sin \omega t + \sin 2 \omega t$
  - C.  $\sin \omega t - \sin 2 \omega t$
  - D.  $\sin^2 \omega t$





3. A novelty clock has a 0.0100-kg mass object bouncing on a spring that has a force constant of 1.25 N/m. What is the maximum velocity of the object if the object bounces 3.00 cm above and below its equilibrium position?

How many joules of kinetic energy does the object have at its maximum velocity?

4. What is the maximum velocity of an 85.0-kg person bouncing on a bathroom scale having a force constant of  $1.50 \times 10^6$  N/m, if the amplitude of the bounce is 0.200 cm?

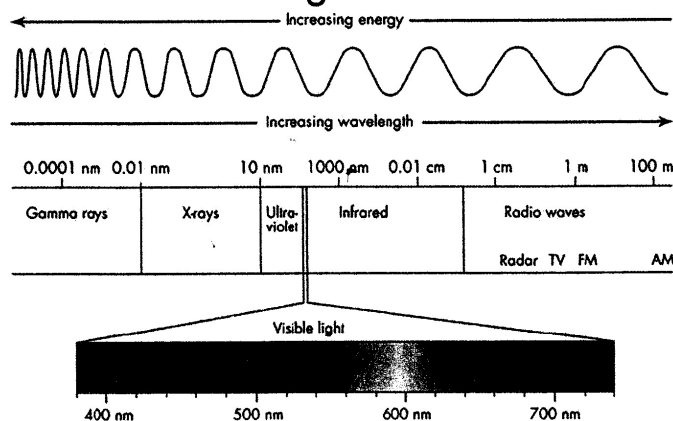
What is the maximum energy stored in the spring?

	<b>Assiut University</b> <b>Faculty of Science</b> <b>Department of Physics</b> <b>First Semester</b> <b>Final Exam (2025-2026)</b>	<b>Physics Program</b> <b>Level: (2)</b> <b>Date: Jan 5<sup>th</sup>, 2026</b> <b>Time: 3 hours</b>	
	<b>Course Title: Modern Physics</b> <b>Instructor: Prof. Dr. Salah A. Makhoulouf</b>	<b>Code: P 215</b>	
<b>Important: 11 pages, Part One: 21 MCQs + Part Two: Answer 5 of the given 6 Qs</b>			<b>Total Marks: 50</b>

### Constants & Conversion of units

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

### Electromagnetic Waves



**Part One) Choose the correct option for the following questions (1 Mark each) (20 Marks)**

- Ratio of energies  $E_1/E_2$  of two photons whose wavelengths are  $\lambda_1 = 600 \text{ \AA}$  and  $\lambda_2 = 400 \text{ \AA}$  is:
  - $2/3$
  - $3/2$
  - $1/5$
  - $5/1$
- The number of photo electrons emitted for light of a frequency  $\nu$  (higher than the threshold frequency  $\nu_0$ ) is proportional to the:
  - threshold frequency ( $\nu_0$ )
  - intensity of light
  - frequency of light ( $\nu$ )
  - $(\nu - \nu_0)$
- An EM wave of wavelength ( $\lambda$ ) is incident on a photosensitive surface of negligible work function ( $\phi = 0$ ). If the photoelectron emitted from the surface has a mass ( $m$ ) and a de-Broglie wavelength ( $\lambda_d$ ), then:
  - $\lambda = (2h/mc)\lambda_d^2$
  - $\lambda = (2m/hc)\lambda_d^2$
  - $\lambda = (h/2mc)\lambda_d^2$
  - $\lambda = (2mc/h)\lambda_d^2$
- Which characteristic of X-ray spectra does not change when the target material is changed?
  - intensity
  - wavelengths of characteristic lines
  - shape of the continuous spectra
  - cutoff wavelength
- A family of planes of spacing  $d = 0.2518 \text{ nm}$  of NaCl crystal reflects a beam of X-ray in first order at an angle of  $\theta = 30^\circ$ . The wavelength of X-rays is:
  - $0.2518 \text{ nm}$
  - $0.1889 \text{ nm}$
  - $0.3778 \text{ nm}$
  - $0.5036 \text{ nm}$
- A photon of energy  $3 \text{ MeV}$  produces an electron-positron pair. The total kinetic energy of the pair is:
  - $0.51 \text{ MeV}$
  - $1.98 \text{ MeV}$
  - $1.02 \text{ MeV}$
  - $3.00 \text{ MeV}$
- The Davisson-Germer experiment demonstrated:
  - Photoelectric effect
  - Electron diffraction
  - Compton scattering
  - Pair production
- For a particle described by a wave packet with angular frequency  $\omega$  and wave number  $k$ , the group velocity is given by  $v_g = \frac{d\omega}{dk}$ . The group velocity equals the classical particle velocity if the particle obeys which dispersion relation?
  - $E = \hbar\omega$
  - $p = \hbar k$
  - $E = \frac{p^2}{2m}$
  - $E = pc$



Marks of Q

16. In the Bohr model, the angular momentum ( $L$ ) of an electron in the  $n^{\text{th}}$  orbit is:  
 a)  $n\hbar$                       b)  $\hbar/2$                       c)  $n^2\hbar$                       d)  $\hbar/\sqrt{n}$

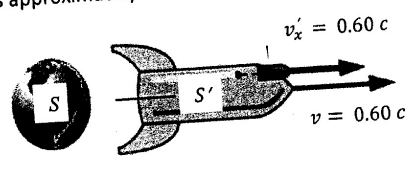
17. A hydrogen atom emits a photon of wavelength  $434 \text{ nm}$ . The transition is:  
 a)  $4 \rightarrow 2$                       b)  $3 \rightarrow 2$   
 c)  $5 \rightarrow 2$                       d)  $6 \rightarrow 2$

18. In laser operation, population inversion means:  
 a) More atoms in excited state than ground state                      b) Equal population in all states  
 c) More atoms in ground state                      d) Random population distribution

19. The rest energy of an electron is  $0.511 \text{ MeV}$ . Its total energy when moving at  $v = 0.8c$  is approximately:  
 a)  $0.409 \text{ MeV}$                       b)  $0.639 \text{ MeV}$   
 c)  $0.852 \text{ MeV}$                       d)  $1.278 \text{ MeV}$

20. The relativistic momentum of a proton (rest mass  $938 \text{ MeV}/c^2$ ) with kinetic energy  $938 \text{ MeV}$  is approximately:  
 a)  $938 \text{ MeV}/c$                       b)  $1328 \text{ MeV}/c$   
 c)  $1625 \text{ MeV}/c$                       d)  $1876 \text{ MeV}/c$

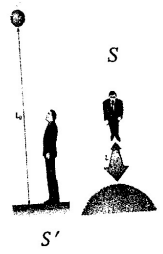
21. A spaceship moves away from Earth at  $0.6c$  and fires a missile forward at  $0.6c$  relative to the spaceship ( $S'$ ). The speed of the missile relative to Earth ( $S$ ) is approximately:  
 a)  $0.88c$                       b)  $1.2c$   
 c)  $0.97c$                       d)  $1.0c$



Marks of Q

**Part Two: Answer Five (5) only of the following questions** **(30 Marks)**

- Q1)** Consider the point of view of an observer ( $S$ ) who is moving toward the Earth with the Muon whose velocity  $v = 0.998c$  crossing the height of the atmosphere whose thickness ( $L_0$ ) is 9500 m for an observer at the earth ( $S'$ ).
- In the reference frame of the observer who is moving with the Muon ( $S$ ), what is the apparent thickness ( $L$ ) of the Earth's atmosphere?
  - How much time does the Muon take to reach the Earth's surface?
  - If the proper lifetime of the muon is  $t_0 = 2.2 \times 10^{-6}s$ , explain whether the Muon reaches the Earth or not?
  - For the observer on the earth ( $S'$ ), what is the apparent lifetime ( $t$ ) of the Muon? Comment on your answer?



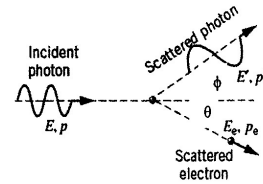
5

**Q2)**

**(6 Marks)**

In the Compton scattering event illustrated in the Figure, the scattered photon has an energy ( $E'$ ) of  $120 \text{ keV}$  and the recoiling electron has a kinetic energy ( $E_e$ ) of  $40 \text{ keV}$ . Find:

- the wavelength of the incident photon ( $\lambda$ ) and scattered photon ( $\lambda'$ ) in ( $\text{pm}$ ) units?
- the angle ( $\phi$ ) at which the photon is scattered?
- the recoil angle ( $\theta$ ) of the electron?



Marks of Q

**Q3)**

**(6 Marks)**

A transmission electron microscope (*TEM*) is used to image a carbon nanotube with atomic-scale resolution, specifically to resolve two carbon atoms separated by  $d = 0.14$  nm (the bond length in graphene). The resolving power of a microscope depends on the wavelength used such as  $\lambda = \frac{d}{2}$  to resolve detail of size  $d$ .

- a) Calculate the momentum ( $p$ ) of such an electron in ( $kg \cdot m/s$ ) and ( $eV/c$ ) units?
- b) Determine the kinetic energy ( $K.E$ ) of this electron in ( $eV$ ) units?
- c) Find the accelerating voltage ( $\Delta V$ ) in (*Volts*) required to give the electron the kinetic energy from (b).
- d) Determine the photon energy in ( $eV$ ) needed for equivalent resolution? Why are electrons preferred?

Marks of Q

**Q4)**

**(6 Marks)**

An electron is confined to moving freely in a one-dimensional box with a width  $L = 1.0 \text{ nm}$ , determine:

- the allowed energy  $E_3$  for  $n = 3$  state expressed in (eV) units?
- the speed of the electron in  $n = 3$  state in ( $\frac{m}{s}$ ) units? Is the electron behaving as a relativistic or a classical particle? Explain why?
- the de Broglie wavelength of the electron in the  $n = 3$  state in (nm) units?
- Show that the  $n = 3$  state satisfies standing wave conditions?

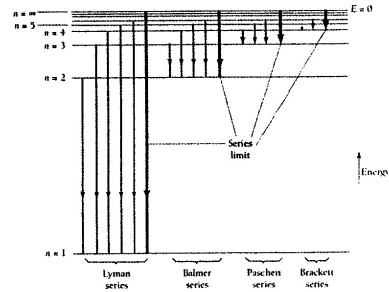
Marks of Q

**Q5)**

**(6 Marks)**

The figure below shows the spectral series of Hydrogen. A hydrogen atom initially in the  $n = 2$  state absorbs a photon and the electron jumps to the  $n = 5$  state.

- What is the wavelength of absorbed photon ( $\lambda$ ) in (nm) units?
- How many photons might be emitted from this atom following this absorption?
- Compute the wavelengths ( $\lambda_1 : 5 \rightarrow 4$ ), ( $\lambda_2 : 5 \rightarrow 2$ ) and ( $\lambda_3 : 4 \rightarrow 1$ ) of the emitted photons?
- Among  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$ , which photon (or photons) lies in the IR, visible or UV region of the spectrum?



2

Marks of Q

**Q6)**

**(6 Marks)**

In interstellar space, highly excited hydrogen atoms called **Rydberg** atoms have been observed with a principal quantum number  $n = 500$ .

- Calculate the wavelength in (*meters*) of the photon produced during a transition from  $n = 500$  to  $n = 400$  state, in which part of the *EM* spectrum does this photon fall?
- Determine the orbital radius in (*meters*) for an electron in the  $n = 500$  state?
- What is the speed ( $v$ ) in (*m/s*) for the electron moving in a Rydberg atom for with  $n = 500$ ?
- Find the orbital period ( $T$ ) in (*seconds*) of the electron for which  $n = 500$ , assuming a circular orbit?

c/c



كلية العلوم - قسم الفيزياء



جامعة أسيوط

"Final examination in thermodynamics" P 223

الزمن: ثلاث ساعات

طلاب من الخارج (يناير 2026)

**Answer the following question:**

**A) Choose the right answer between brackets:**

- 1) The internal energy of one mole of diatomic gas equal  $[(5/2)KT - (3/2)KT - (5/2)RT - (3/2)RT]$
- 2) Due to adiabatic expansion the volume of the gas increases and its temp. (increases – decreases- still const.)
- 3) Homogenous mixture of two liquids (or gases) represents (reversible – irreversible – adiabatic) process.
- 4) The surface pressures taken into consideration for (real gas – ideal gas – both of them).
- 5) Both the heat capacities  $C_p$ ,  $C_v$  of a gas are related to the no. degree of freedom.
- 6) One of the Maxwell eqn.  $(\partial P / \partial S)_V$  equal  $\{(\partial T / \partial P)_S, (\partial S / \partial P)_V, -(\partial T / \partial V)_S\}$
- 7) The internal energy of real gas depends on (temperature – volume – both of them).

**B) Transfer the following sentences after putting a check mark right or wrong:**

- 1) The volumetric thermal expansion coeff.  $\alpha_p$  of ideal gas is inversely proportional with its temperature.
- 2) The change of entropy for adiabatic process  $\Delta S > 0$
- 3) The thermal equilibrium state due to heat exchange between two different bodies represents reversible process.
- 4) At const. pressure the absorbent heat converted only to work done.
- 5) Both the isothermal and adiabatic volumetric elasticity depends on the gas pressure.
- 6) The work done by ideal gas during isothermal process is related to the change of its volume and pressure.
- 7) The change of enthalpy represents the law of energy conservation.

**Answer only three questions:**

- 2- a) Use the eqn. of state for ideal gas to find the isothermal work done in terms of : (i) volume, (ii) pressure.  
b) Calculate the change of entropy in terms of gas constant when ideal gas isothermally expands to four times its original volume.

- 3- a) Prove that the volumetric thermal expansion ( $\alpha_p$ ) of the ideal gas depends inversely with its temperature.  
b) Express the Maxwell's eqns., and if the change of entropy in terms of volume and temperature:  
 $TdS = C_v dT + T(\frac{\partial P}{\partial T})_V dV$ , apply the exact differential:  $dZ = Mdx \pm Ndy \Rightarrow (\frac{\partial M}{\partial x})_y = \pm (\frac{\partial N}{\partial y})_x$  to prove that the heat capacity  $C_v$  for ideal gas is a constant quantity.

لأسئلة بقية خلف هذه الورقة