PHL 101: Physics for Engineers

Mid Semester 2025 Examination, Max Marks: 35

Please submit your question paper with the answer sheet.

No need to write/mark answers on question paper.

Roll no ________

Formula sheet (symbols have their usual meanings)

1. h (planck's constant)= 6.626× 10^{-34} m^2kg/s
2. $\Delta x \Delta p \geq \frac{h}{4\pi}$
3. $\Delta x \Delta v \geq \frac{h}{4\pi m}$
4. $\Delta E \Delta t \geq \frac{h}{4\pi}$
5. $\lambda = \frac{h}{p}$; $p = \sqrt{2mE_{kinetic}}$; $v \ll c$
6. $E = h\upsilon = \frac{hc}{\lambda}$; $P = \frac{E}{t}$
7. $[A, B] = AB - BA$
8. $\lambda_2 - \lambda_1 = \frac{h}{m_o c}(1-\cos\theta)$; $m_o c = 0.0242\ angstrom$
9. $h\upsilon = \phi + KE_{max};\ \phi = h\upsilon_o$
10. $h\upsilon = h\upsilon_o + KE_{max}$
11. $\lambda_{peak} = \frac{2.9X10^{-3}\ m}{T\ (Kelvin)}$
12. No. of modes = $\frac{8\pi v^2\, dv}{c^3}$
13. Planck's blackbody radiation $\frac{8\pi v^2\, dv}{c^3}\{\frac{hv}{e^{hv/kT}-1}\}$

Alpha decay	${}_{Z}^{A}X$	${}_{2}^{4}He + {}_{Z-2}^{A-4}Y$
Beta decay	${}_{Z}^{A}X$	${}_{-1}^{0}e + {}_{Z+1}^{A}Y$
Gamma decay	${}_{Z}^{A}X$	${}_{0}^{0}\gamma + {}_{Z}^{A}Y$
Positron emission	${}_{Z}^{A}X$	${}_{+1}^{0}e + {}_{Y-1}^{A}Y$
Electron capture	${}_{Z}^{A}X$	${}_{-1}^{0}e + {}_{Y-1}^{A}Y$

14.

Particle	Mass (kg)	Mass (u)	Mass (MeV/c^2)
Proton	1.6726×10^{-27}	1.007276	938.28
Neutron	1.6750×10^{-27}	1.008665	939.57
Electron	9.1×10^{-31}	5.486×10^{-4}	0.511
${}_{1}^{1}H$	1.6736×10^{-27}	1.007825	938.79

15. Binding energy= $[Z\, m({}_{1}^{1}H) + N\, m(n) - m({}_{1}^{1}H)] \times 931.5$ MeV/u
16. $N = N_o e^{-\lambda t}$
17. $\lambda = \frac{0.693}{T_{1/2}}$; $T = \frac{1}{\lambda}$
18. $\sigma = ne\mu$, $e = 1.602176634 \times 10^{-19}$ C
19. $\alpha = \frac{\Delta l}{l_o \Delta T} = \frac{l_f - l_i}{l_o(T_f - T_i)}$
20. $\frac{Q}{A} = -k\frac{\Delta T}{\Delta x}$
21. $t' = \gamma$; K.E. = $(\gamma - 1)\, m_o c^2$
22. $l' = \frac{l}{\gamma}$; $E = \gamma m_o c^2$
23. $\gamma = \frac{1}{\sqrt{1-(v/c)^2}}$

1. Rayleigh–Jeans law predicts that the energy density of blackbody radiation at short wavelengths tends to:
   a) Zero b) Infinity c) A finite value d) Constant

2. What is the binding energy per nucleon of ${}^2_1H$.
   a) 1.1 eV/nucleon (b) 1.1 MeV/nucleon (c) 0.2 MeV/nucleon (d) none

3. The forces holding the nucleus together are primarily
   a) Strong nuclear b) Electromagnetic c) Gravitational d) none

4. The Michelson-Morley experiment failed to detect
   a) Photon b) Electrons c) Ether motion d)Magnetic field

5. Twin paradox arises due to?
   a) Both are inertial frames b) Absolute rest
   c) Non-inertial motion of spaceship d) Gravitational time

6. Which material has the highest thermal conductivity?
   a) Silver b) Copper c) Steel d) Diamond

7. The photoelectric effect confirms?
   a) Wave nature of light, b) nothing
   c)Dual nature of light, d) Particle nature of light

8. Einstein received Nobel prize?
   a) Photoelectric effect b) Relativity
   c) Compton scattering d) Quantum mechanics

9. Hooke's law states stress is proportional to?
   a) Strain b)Area c) Force d)Elastic limit

10. In the photoelectric effect, increasing the intensity of light increases:
    a) number of photoelectrons b) Kinetic energy of electrons
    c) Work function d) threshold frequency

11. Einstein's first postulate of special relativity states:
    a) speed of light varies with observer b) Energy is conserved
    c) Time is absolute d) Laws of physics are same in all inertial frames

12. How many total angular momentum states does $3d_{5/2}$ have?
    a) 5 (b) 6 (c) 8 (d) 2

13. What kind of decay do you expect from ${}^6_2He$?
    a) negative beta (b) positive beta (c) electron capture (d) Gamma

14. A neutron has almost 2000 times the rest mass of an electron. Suppose they both have 1eV of energy. How do their wavelengths compare?
    a)Both same b)Neutron wavelength>electron wavelength
    c) Neutron wavelength<electron wavelength d)None

15. The conductivity of metal with carrier concentration of $10^{20}/cm^3$ and mobility of $80\ cm^2V^{-1}s^{-1}$ is nearly
a) $1.3 X 10^5$ S/cm b) $1.3 X 10^5$ S/m c) $1.3 X 10^5$ Ω/m d) $1.3 X 10^5$ Ω/cm

16. The number of modes in a chamber of volume 10 cm^3 in frequency range $4X10^{14}$ Hz to $4.01 X 10^{14}$ Hz is nearly.
a) $1.5 X 10^9$ b) $1.5 X 10^{10}$ c) $1.5 X 10^8$ d) $1.5 X 10^7$

17. A green photon collides with a stationary electron. After the collision the photon color is
a) Unchanged b) Shifts towards Blue c) Shifts towards Red d) None

18. The 14C:12C ratio in a fossil bone is found to be 1/8 that of the ratio in the bone of a living animal. The half-life of 14C is 5,730 years. What is the approximate age of the fossil?
a) 7640 years (b) 17200 years (c) 1720 years (d) 17200 months

19. A particle has a kinetic energy of 10 times its rest energy. What is the speed of particle.
a) 0.98c b) 0.99c c) 0.99 d) 0.999c

20. A woman leaves the earth in a spacecraft that makes a round trip to the nearest star, 4 light years distant, at a speed of 0.9c. How much younger is she upon her return than her twin sister who remained behind?
a) 5.6 b) 5.5 c) 5 d) 5.7

(21-23: 5 marks each)

21. In a famous fiction movie, Cooper landed on Miller's planet and experienced that with 1 year passing on their planet is equivalent to 7 years on planet earth.
a) What is the name of concept behind Cooper's observation?
b) What is the speed (in terms of c) of Miller's planet as observed in earth' frame?

22. a) At what speed does the kinetic energy of a particle equal to its rest mass energy?
b) An incident 71-pm X-ray is incident on a calcite target. Find the wavelength of the X-ray scattered at a 30°angle. What is the largest shift that can be expected in this experiment?

23. A semiconductor chip is used to store information. The information can be erased by exposing the chip to ultraviolet light for a period of time. Following data is provided.
a. Frequency of ultraviolet light used $= 9X10^{14}$ Hz
b. Minimum intensity of ultraviolet light required at the chip $= 25Wm^{-2}$
c. Area of chip exposed to radiation $= 1.8 X 10^{-9}\ m^2$
d. Time taken to erase the information = 15 minutes
e. Energy of radiation needed to erase the information = 40.5 μJ

i. Calculate the energy of a photon of the ultraviolet light.
ii. Calculate the number of photons of the ultraviolet light required to erase the information.