University of Baghdad
College of Science
Department of Physics
Date: 13 / 8 / 2015

Qualifying Examination
for Ph.D Students
Year:2015-2016
Time: 3 Hours

الامتحان التنافسي للمتقدمين للدراسات العليا (الدكتوراه) لقسم الفيزياء-كلية العلوم جامعة بغداد للعام الدراسي ٢٠١٥-٢٠١٦

الاختصاص: فيزياء النووية والبيئية

اولاً:الورقة العامة ٢٠%

1-Multiple Choice Questions:

Q.1) The Coriolis force for dynamics of a particle in a rotating coordinate system is given as:

(a) $F = -m\dot{\omega} \times r$

(b) $F = -2m\omega \times \dot{r}$

(c) $F = -m\omega \times (\omega \times r)$

(d) $F = m\ddot{r}$

Q.2) Semiconductor nano crystals are classified as :

(a)1D (b) 0D (c) 3D (d) 2D

Q.3) The nature of binding for a crystal with alternate and evenly spaced positive and negative ions is:

(a) Ionic (b) metallic (c) covalent (d) Vander walls

Q.4) The characteristic impedance Z_o of free space encountered by electromagnetic wave has the SI units of

(a) Henry (b) Farad. Ohm (c) Ohm (d) $\frac{1}{Farad.Sec}$

Q.5) What is the quantum number n of a particle of mass m confined to a one dimensional box of length L when its energy is $2h^2 / mL^2$?

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

Q.6) Particles in degenerate energy levels all have the same

(a) Energy. (b) Momentum. (c) Quantum numbers. (d) Velocity.

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1- Multiple Choice Questions:

Q.7) The absolute value of the real number x is defined by:

(a) $|x| = \begin{cases} x, & if\ x < 0 \\ -x, & if\ x \geq 0 \end{cases}$, (b) $|x| = \begin{cases} x, & if\ x \geq 0 \\ -x, & if\ x < 0 \end{cases}$,

(c) $|x| = x$ for $-\infty < x < \infty$, (d) $|x| = -x$ for $-\infty < x < \infty$.

Q.8) The result of $\left(e^{x_1}\right)^{x_2}$ is given by:

(a) $e^{x_1+x_2}$, (b) e^{x_1/x_2}, (c) $e^{x_1-x_2}$, and (d) $e^{x_1 x_2}$.

Q.9) The Domain (D_0) and Range (R_g) of the function $y = \sqrt{x+4}$ are given by:

(a) $D_0: x \geq -4$, $R_g: y \geq 0$ (b) $D_0: -\infty < x < \infty$, $R_g: y = 0$

(c) $D_0: x = 0$, $R_g: y = -4$. (d) $D_0: x \geq -4$, $R_g: y = 0$.

Q.10) The energy operator in quantum mechanics, $\hat{H} = -\frac{\hbar^2}{2m}\frac{\partial^2 x}{\partial x^2} + V$

(here given for one particle in one dimension) is called the

a) Lagrangian b) Hamiltonian

c) Hermitian d) Angular momentum

Q.11) The commutator $[L^2, L_y] =$:

a) 0 b) $i\hbar L_x$ c) $-i\hbar L_z$

Q.12) The probability of finding a particle in differential region dx is:

a) $\psi(x,t)\,dx$ b) $\psi(x,t)/\psi^*(x,t)\,dx$ c) $\psi^*(x,t)\psi(x,t)\,dx$

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2- Short Note Questions:

Q.1) An ideal pendulum, its small-angle period is measured on the moon to be 0.4 second long. What must be the length of the pendulum arm? (Hint: assume that $m_{moon} = (1/6)\, m_{earth}$, exactly).

Q.2) A disk of mass M is constrained to roll down an inclined plane without slipping. Solve the Lagrange equations for motion.

Q.3) By plotting the temperature dependence of electrical resistivity, show how to differentiate between metal and semiconductor.

Q.4) There is no perfect solid due to the defects and dislocations , name them.

Q.5) Evaluate $\int \frac{\cos x\, dx}{\sin x}$.

Q.6) Find $\frac{dy}{dx}$ for $y = \cosh^2 5x - \sinh^2 5x$.

Q.7) Prove that : $H = \hbar w\left({}^{+}a\, a + \frac{1}{2}\right)$, where H is the Hamiltonian of the one dimensional harmonic oscillator, ${}^{+}a$ is the rising operator and a is the lowering operator.

Q.8) Hydrogen atom in the state $\psi(\vec{r},t) = \sqrt{\frac{3}{4}}\,\psi_{100}(\vec{r})\, e^{-iE_1 t/\hbar} + \sqrt{\frac{1}{4}}\,\psi_{211}(\vec{r})\, e^{-iE_2/\hbar}$

What is the probability of measurements which give $E = E_2$?

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2 Multiple Choice Question:

Q.1) β^+ – disintegration is possible, if the mass of the parent nucleus is greater than the mass of the daughter nucleus by at least
(a) 1.022 MeV, **(b)** the electron binding energy, **(c)** 0.511 MeV, **(d)** none of these.

Q.2) The excited nucleus can de-excite itself by the emission of
(a) γ – ray, **(b)** α – particles, **(c)** β – particles, **(d)** none of these.

Q.3) Which of the following emissions has electromagnetic phenomenon
(a) α – particles, **(b)** γ – ray, **(c)** β – particles, **(d)** none of these?

Q.4) Isomeric states are mostly found among nuclei for which either N (the neutron number) or Z (the proton number) is near
(a) the end of the shell, **(b)** the mid-shell,
(c)the beginning of the shell, **(d)** none of these.

Q.5) Radioactive $^{215}_{83}Bi$ decays into $^{215}_{84}Po$. Which of these particles is released in the decay?
(a) a proton, **(b)** an electron, **(c)** a positron,
(d) an alpha particle, (e) a neutron, **(f)** none of these.

Q.6) For all stable nuclei **(a)** there are equal numbers of protons and neutrons, (b) there are more protons than neutrons, **(c)** there are more neutrons than protons, and **(d)** none of the above have to be true.

Q.7) Of the hypothetical nuclear reactions below, which would violate conservation of charge?
(a) $^{10}_{5}B + {}^{4}_{2}He \rightarrow {}^{13}_{7}N + {}^{1}_{1}H$,
(b) $^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{11}_{5}B + \beta^- + \bar{\nu}$,
(c) $^{23}_{11}Na + {}^{1}_{1}H \rightarrow {}^{20}_{10}Ne + {}^{4}_{2}He$,
(d) $^{14}_{7}N + {}^{1}_{1}H \rightarrow {}^{13}_{6}C + \beta^+ + \nu$,
(e) none of them, (f) all of them, **(g)** all except for (c), and (h) (a) and (d).

Q.8) Of the hypothetical nuclear reactions below, which would violate conservation of nucleon number?
(a) $^{10}_{5}B + {}^{4}_{2}He \rightarrow {}^{13}_{7}N + {}^{1}_{1}H$,
(b) $^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{11}_{5}B + \beta^- + \bar{\nu}$,
(c) $^{23}_{11}Na + {}^{1}_{1}H \rightarrow {}^{20}_{10}Ne + {}^{4}_{2}He$,
(d) $^{14}_{7}N + {}^{1}_{1}H \rightarrow {}^{13}_{6}C + \beta^+ + \nu$,

Q.9) In a fusion reaction, two deuterons produce a helium-3 nucleus. What is other product of the reaction?
(a) an electron, **(b)** a proton, **(c)** a neutron,
(d) an alpha particle, **(e)** a positron, **(f)** a neutrino.

Q.10) Which of these are appropriate units for the decay constant λ of a radioactive nuclide?
(a) sec, **(b)** rad, **(c)** MeV, **(d)** sec^{-1}, **(e)** rem, **(f)** curie **(g)** Becquerel.

Q.11) The nucleus $^{244}_{94}Pu$ is an alpha-particle emitter. Into which of the following nuclei does it decay:
(a) $^{240}_{93}Np$, **(b)** $^{240}_{92}U$, **(c)** $^{248}_{96}Cm$, **(d)** $^{244}_{95}Am$?

Q.12) Suppose that a $^{238}_{92}U$ nucleus swallows a neutron and then decays not by fission but by beta decay, emitting an electron and a neutrino. Which nucleus remains after this decay?
(a) $^{239}_{94}Pu$, **(b)** $^{238}_{93}Np$, **(c)** $^{239}_{93}Np$, **(d)** $^{238}_{91}Pa$?

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2 Short Note Questions

Q.1) The activity of a radioactive nuclide decreases to $1/8$ its initial value in a time interval of 96 days. Determine the value of the half-life of the radioactive nuclide.

Q.2) What type of gamma-ray transition is likely predominant if the initial and final states of the nucleus are $3/2^- \rightarrow 7/2^-$.

Q.3) What target isotope must be used to form the compound nucleus ${}^{21}_{9}F$ when the projectile is (a) an alpha-particle, (b) a proton, (c) a neutron?

Q.4) The radius of a spherical nucleus is measured, by electron scattering methods, to be 3.6 fm. What is the likely mass number of the nucleus?

Q.5) Calculate the value of the density of nuclear matter ρ_{nm}. Use $m = 1.6\times10^{-27}\ kg$ for the mass of the nucleon.

Q.6) If the atomic masses of ${}^{239}_{94}Pu$, ${}^{1}_{1}H$ and ${}^{1}_{0}n$ (i.e. a neutron) are 239.05216 u, 1.00783 u and 1.00867 u, respectively. What is the binding energy per nucleon for ${}^{239}_{94}Pu$.

Q.7) Calculate the energy released during the alpha decay of ${}^{238}U$, where the decay process is ${}^{238}U \rightarrow {}^{234}Th + {}^{4}He$ and the atomic masses of the concerned nuclei are: ${}^{238}U = 238.05079u$, ${}^{234}Th = 234.04363u$, and ${}^{4}He = 4.00260u$.

Q.8) Match the items in these two columns:

(1) Muon	(a) Quark
(2) Kaon	(b) Lepton
(3) Lambda	(c) Meson
(4) Positron	(d) Baryon
(5) Strange	(e) Antiparticale