(*ii*) In 64_{Zn} nucleus the one phonon state 2^+ is observed at 0.99 MeV. excitation energy. Find out the energies of two and three phonon excitation levels and phonon frequency.

OR

(*b*) Discuss the theory of collective oscillations. Explain the energy spectrum for shape oscillations.

6. (*a*) (*i*) What are the main features of rotational spectra of the nucleus ? Establish the energy spectrum of for even-even nuclei

(*ii*) The first excited state of 234_U is observed at 0.0435 MeV above the ground state. At what energy you would expect the 4^+, 6^+ and 8^+ states ? Draw the energy spectrum.

OR

(*b*) Calculate the quadrupole moment

$$Q = \left\langle e\frac{1}{2}\,jj \middle| Q^{op} \middle| e\frac{1}{2}\,jj \right\rangle$$

where $Q^{op} = e\left(\frac{16\pi}{5}\right)\left\langle r^2 \right\rangle_{Ne} y_{20}$ is the quadrupole moment operator.

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2016

NUCLEAR SCIENCE - I

Time : Three Hours] [*Maximum Marks* : 80

Answer from both the Sections as directed. The figures in the right hand margin indicate marks.

SECTION-A

1. Answer any **four** of the following : 4×4

(*a*) Define spherical tensors. Express position vector in spherical basis in terms of spherical harmonics.

(*b*) Two nucleons are coupled together to form a resultant spin $S = 1$, $Ms = 1$ state. Write down the Clebsh Gordon coefficients which would be involved in the construction of the resultant spin function.

(*c*) Define the striping and pickup reactions.

(*d*) Explain the function of real and imaginary nuclear potentials in the optical potential.

(*e*) Discuss the vibrational model of nuclei with example.

(*f*) Show that the quadrupole moment Q with regard to symonetry axis of a homogeniously charged spheroid is $\frac{2}{5}Z\left(b^2-a^2\right)$. The half axis are given by a and b.

OR

2. Answer **all** the questions from the following : 2×8

(*a*) Define scalar product of two spherical vectors.

(*b*) Show that the total angular momentum is independence of particular direction or coordinate system.

(*c*) Derive the expression b or (d, p) reaction.

(*d*) What is direct nuclear reaction mechanism.

(*e*) Consider the vibration spectra of 110_{cd} :

E(MeV)	G.S.	0.656	1.318	1.415	1.54
J	0^+	2^+	2^+	?	4^+

Predict the spin and parity of unknown level.

(*f*) In above spectra (*e*) what would be the value of $\hbar w_\lambda$.

(*g*) Discribe the phenomenon of backbending.

(*h*) Show that the electric quadrupole moment of a nucleus vanishes for spin $I = 0$ or $I = ½$.

SECTION-B

Answer **all** the questions : 16×4

3. (*a*) State and prove Wigner-Eckart theorem. Explain with the help of diagrams how coupling of three angular momentum can be carried out.

OR

(*b*) Using Racah algebra reduce the two body matrix element of *NN* interaction,

$$\left\langle n_1^1 l_1^1 J_1^1; n_2^1 l_2^1 J_2^1; JM \middle| V_{12} \middle| n_1 l_1 J_1, n_2 l_2 j_2; JH \right\rangle$$

to matrix elements in relative quardinates.

4. (*a*) Discuss the important features of optical model of nuclear reactions. Show that the imaginary part of complex potential $V = -(U + iw)$ in the optical model has the effect of removing particle flux from the elastic channel.

OR

(*b*) Explain the Bruckner theory and evaluate the matrix element is case of triplet state.

5. (*a*) (*i*) Explain the vibrational energy spectrum of even-even nuclei. What are its distinguishing features ?