5. ATOMS AND NUCLEI

Q. No	Question	Marks
	Multiple Choice Question	
Q.116	If an electron in a hydrogen atom undergoes transition from 1st to 3rd energy level, by what factor does the time period of revolution undergo a change? A. remains the same B. becomes 3 times the initial value C. becomes 9 times the initial value D. becomes 27 times the initial value	1
Q.117	Hydrogen atom at its ground state is excited by incident photons of energy 12.75 eV. What is the expected count of the distinct spectral lines emitted by this hydrogen atom? A. 3 B. 5 C. 6 D. 8	1
Q.118	An electron in the Bohr model atom is in the nth orbit of radius r and has kinetic energy KE. Which of the following statements does not comply with the postulate of Bohr's model of atom? A. Radius of the orbit in terms of de Broglie wavelength is given as $n\lambda/2\pi$ B. In going from lower to higher orbit, both PE and TE increases but KE decreases. C. If KE = 3.4 eV, the corresponding potential energy PE is 6.8 eV and Total energy TE is 10.2 eV D. If the ionization potential of the given Bohr model atom is 13.6 V, the energy required to remove the electron from its second orbit is 3.4 eV.	1

<table>
<tr><td>Q.119</td><td>Choose the only correct statement.
A. In a stable nucleus, the number of neutrons ≥ number of protons.
B. Nuclei with atomic number greater than 82 show a tendency to fuse.
C. A stable nucleus in general has even number of protons and odd number of neutrons.
D. The proton-proton nuclear force > proton-neutron nuclear force > neutron-neutron nuclear force.</td><td>1</td></tr>
<tr><td>Q.120</td><td>Binding energy values of a few nuclei are given in the table below.
<table>
<tr><th>Lithium-7</th><th>Iron -56</th><th>Lead - 206</th><th>Deuterium -2</th></tr>
<tr><td>40.1 MeV</td><td>492.2 MeV</td><td>1622 MeV</td><td>2.2 MeV</td></tr>
</table>
The least and the most stable nuclei respectively are:
A. Lead and Lithium
B. Lithium and Deuterium
C. Deuterium and Iron
D. Iron and Lead</td><td>1</td></tr>
<tr><td>Q.121</td><td>Study the following statements carefully and identify the correct statement/s.
I. The nuclear pairs, $_{7}N^{14}$ and $_{6}C^{13}$ & $_{15}P^{30}$ and $_{14}Si^{30}$, both constitute isobars.
II. $_{7}N^{14}$ can absorb a neutron and transform into $_{3}Li^{7}$ after emitting 2 alpha particles and a proton.
III. If 5.6 MeV is required to remove 1 neutron from $_{3}Li^{7}$ and transform it to $_{3}Li^{6}$, then it is also the BE per nucleon of $_{3}Li^{6}$
IV. If M is the mass of the nucleus $_{13}Al^{27}$, and m_p & m_n are the masses of protons and neutrons respectively, the binding energy of the nucleus is $[|M - 13m_p - 14m_n|c^2]$
A. Only statement III
B. Only statements I and III
C. Only statements II and IV
D. Only statements III and IV</td><td>1</td></tr>
</table>

Q.122	Which of the following statements are INCORRECT for atomic nuclei? A. As mass number A increases, the density of the nucleus does not change. B. Heavier nuclei tend to have larger Z/N ratio as Coulomb forces have longer range compared to nuclear forces. C. For nuclei with A > 100, the binding energy per nucleon of the nucleus decreases on an average as A increases. D. Two Lithium nuclei do not combine to form carbon nuclei at room temperature because Coulomb repulsions do not allow them to come very close.	1
Free Response Question / Subjective Question		
Q.123	Particles like electron, protons and alpha particles can be used to ionize hydrogen atom. If the ionization energy of hydrogen atom is Ei and all these striking particles carry same kinetic energies, then determine which of these particles will be most effective in ionizing the hydrogen atom? Assume that the collisions are perfectly inelastic and it's the excess KE that is used for ionisation.	3
Q.124	An ultraviolet radiation falls on a H atom. (a) If the H atom is in the ground state when the incident photon of wavelength 80 nm falls on it, will the H atom get excited to the higher energy levels? OR will the H atom get ionized? Justify your answer. (b) Post your answer of part (a), Determine EITHER the quantum number of the energy level to which the H atom gets excited OR determine the KE of the electron emitted out of the H atom. Use value of hc = 1240 eV-nm	2

Q.125	(a) Show that it takes more energy, in general, to remove a neutron from a nucleus than a proton. Use the example of ${}_{Z}^{A}X$ and the below data for the purpose-of-explanation. Mass-of ${}_{Z}^{A}X$=63.546u $Mass_{proton}$ =1.0073u $Mass_{neutron}$ =1.0087u Massof ${}_{Z}^{A-1}X$=62.5493u Mass of ${}_{Z-1}^{A-1}Y$ = 62.5467 u (b) Give reason: Why does it take more energy to separate a neutron from the nucleus than a proton?	3

Answer Key & Marking Scheme

Q.No	Answers	Marks
Q.116	D. becomes 27 times the initial value	1
Q.117	C. 6	1
Q.118	C. If KE = 3.4 eV, the corresponding potential energy PE is 6.8 eV and Total energy TE is 10.2 eV	1
Q.119	A. In a stable nucleus, the number of neutrons ≥ number of protons.	1
Q.120	C. Deuterium and Iron	1
Q.121	D. only statements III and IV	1
Q.122	B. Heavier nuclei tend to have larger Z/N ratio as Coulomb forces have longer range compared to nuclear forces.	1
Q.123	The momentum conservation during the collision: mu = (m + mH)v where m is the mass of the ionizing particle and mH is mass of hydrogen atom Initial KE, Ki = (1/2) mu2 Final KE, Kf = (1/2) (m+mH)v_2 [0.5 mark for each of initial and final KE] The decrease in KE is used for ionization of the H atom So (1/2) mu2-(1/2)(m+mH)v_2 = Ei Substituting for v = mu/(m+mH) and transposing, Ei = [mH/(m+mH)] Ki [1 mark for correct expression for ionisation energy] Since Ki is same for all types of striking particles, the particles with minimum mass will be most effective in ionizing the Hydrogen atom. Amongst the given list, electrons having minimum mass will be most effective. [1 mark for the correct conclusion and reason]	3

Q.124	(a) Energy of the incident 80 nm photon E = hc/λ = 1240/80 = 15.5 eV As the ionization energy of the H atom is +13.6eV, it is less than the energy 15.5 eV absorbed from the incident photon, so the H atom gets ionized. [0.5] mark for the calculation of energy of incident photon] [0.5 mark for the correct conclusion] (b) KE of the emitted electron = Energy of the incident 80 nm photon – Ionization energy = 15.5 – 13.6 = 1.9 eV [1 mark for the correct calculation of the KE of the emitted electron]	2
Q.125	(a) Removing a neutron from ZAX : ZAX -> ZA-1X + 01n The binding energy of the missing neutron = mass defect x 931 MeV Mass defect = [Mass of ZA-1X + Massneutron] - Mass of ZAX = 62.5493 u + 1.0087 u - 63.546 u= 0.012 u BE = 0.012 x 931 = 11.172 MeV [0.5 mark for the correct calculation of mass defect] [0.5 mark for the correct calculation of the BE] Removing a proton from ZAX : ZAX -> Z-1A-1Y + 11p The binding energy of the missing proton = mass defect x 931 MeV Mass defect = [Mass of Z-1A-1Y + Massproton] - Mass of ZAX = 62.5467 u + 1.0073 u - 63.546 u= 0.008u BE = 0.008 x 931 = 7.48 MeV Hence BE to remove a neutron is more than that of the proton. [0.5 mark for the correct calculation of mass defect] [0.5 mark for the correct calculation of the BE] b) Protons are bounded by attractive nuclear forces and also experience repulsion due to electrostatic forces. Neutrons are bounded by attractive nuclear forces only. Hence they require greater energy to get separated from the nucleus. [0.5 mark for each correct statement of p and n]	3