EXERCISE-1

If required, you can use the follwoing data:

Mass of proton m_p = 1.007276 u, Mass of $_1H^1$ atom = 1.007825 u, Mass of neutron m_n = 1.008665 u, Mass of electron = 0.0005486 u = 511 KeV/c^2, 1 u = 931 MeV/c^2.

SECTION (A) : PROPERTIES OF NUCLEUS

A.1 A neutron star has a density equal to that of the nuclear matter. Assuming the star to be spherical, find the radius of a neutron star whose mass is (i) 4.0×10^{30} kg (twice the mass of the sun) (ii) 6×10^{24} Kg (around mass of the earth).

SECTION (B) : MASS DEFECT AND BINDING ENERGY

B.1 Calculate the mass of an α particles Its binding energy is 28.2 MeV

B.2 Find the binding energy of the nucleus of lithium isotope $_3Li^7$ & hence find the binding energy per nucleon in it. Given atomic masses of $_3Li^7$ atom = 7.016005 amu; $_1H^1$ atom = 1.0007825 amu & $_0n^1$ = 1.008665)

B.4 Find the energy required for separation of a Ne^{20} nucleus into two α – particles and a C^{12} nucleus if it is known that the binding energies per nucleon in Ne^{20}, He^4 & C^{12} nuclei are equal to 8.03, 7.07 & 7.68 MeV respectively.

B.5 (a) Calculate the energy released if ^{238}U emits an α-particle. (b) Calculate the energy to be supplied to ^{238}U if two protons and two neutrons are to be emitted one by one. The atomic masses of ^{238}U , ^{238}Th and ^4He are 238.0508 u , 234.04363 u and 4.00260 u respectively

SECTION (C) : RADIOACTIVE DECAY

C.1 Show that the minimum energy needed to separate a proton from a nucleus with Z protons and N neutrons is

$$\Delta E = (M_{Z-1,N} + M_H - M_{Z,N})c^2$$

where $M_{Z,N}$ = mass of an atom with Z protons and N neutrons in the nucleus and M_H = mass of a hydrogen atom. This energy is known as proton-separation energy.

C.2 A stationary $_{82}Pb^{200}$ nucleus emits an α – particle with kinetic energy T_α = 5.77 MeV. Find the recoil velocity of a daughter nucleus. What fraction of the total energy liberated in this decay is accounted for the recoil energy of daughter nucleus?

C.3 The kinetic energy of an α – particle which flies out of the nucleus of a Ra^{226} atom in radioactive disintegration is 4.78 MeV. Find the total energy evolved during the escape of the α – particle.

C.4 In the decay $^{64}Cu \rightarrow {}^{64}Ni + e^+ + \nu$, the maximum kinetic energy carried by the positron is found to be 0.650 MeV (a) What is the energy of the neutrino which was emitted together with a positron of kinetic energy 0.150 MeV ? (b) What is the momentum of this neutrino in kg–m /s ?Use the formula applicable to photon

C.5 Potassium -40 can decay in three modes It can decay by β^- emission, β^+ emission or electron capture. (a) Write the equations showing the end products. (b) Find the Q-values in each of the three cases. Atomic masses of $^{40}_{18}Ar$, $^{40}_{19}K$ and $^{40}_{20}Ca$ are 39.9624 u , 39.9640u and 39.9626 u respectively.

C.6 Calculate the maximum kinetic energy of the beta particle emitted in the following decay scheme:

$^{12}N \rightarrow {}^{12}C^* + e^+ + \nu$

$^{12}C^* \rightarrow {}^{12}C + \gamma$ (4.43 MeV.)

The atomic mass of ^{12}N is 12.018613 u.

SECTION (D) : STATISTICAL LAW OF RADIOACTIVE DECAY

D.1 A free neutron beta-decays to a proton with a half life of 14 minutes.
(a) What is the decay constant ?
(b) Find the energy liberated in the process.

D.2 The decay constant of $^{197}_{79}Hg$ (electron capture to $^{197}_{79}Hg$) is $1.8 \times 10^{-4}\ s^{-1}$ (a) .What is the half life?

(b) What is the average life ? (c) How much time will it take to convert 25 % of this isotope of mercury into gold ?

D.3 How many β – particles are emitted during one hour by 1.0 μg of Na^{24} radionuclide whose half–life is 15 hours? [Take $e^{(-0.693/15)} = 0.955$, and avagadro number $= 6 \times 10^{23}$]

D.4 The half-life of ^{198}Au is 2.7 days. (a) Find the activity of a sample containing 1.00 μg of ^{198} Au. (b) What will be the activity after 7 days ? Take the atomic weight of ^{198} Au to be 198 g/mol.

D.5 At the initial moment the activity of certain radionuclide totalled 650 particles per minute. What will be the activity of preparation after half its half – life period.
[take $e^{-0.347} = 0.707$]

D.6 Determine the age of ancient wooden items if it is known that the specific activity of C^{14} nuclide in them amounts to 3/5 of that in lately felled trees. The half life of C^{14} nuclei is 5570 years.[take ln 0.6 = – 0.51]

D.7 Calculate the specific activities of Na^{24} & U^{235} nuclides whose half lives are 15 hours and 7.1×10^8 years respectively.

D.8 Radio active phosphorus 32 has a half life of 14 days. A source containing this isotope has an initial activity of 10 m Ci.
(i) What is the activity of the source after 42 days?
(ii) What time elapses before the activity of the source falls to 2.5 m Ci?

D.9 The count rate from a radioactive sample falls from 4.0×10^{6} per seconds to 1.0×10^{6} per second in 20 hours. What will be the count rate 100 hours after the beginning ?

D.10 A piece of ancient wood shows an activity of 3.9 disintegration per sec. per gram of C^{14}. Calculate the age of the wood. $T_{1/2}$ of C^{14} = 5570 years. Activity of fresh C^{14} = 15.6 disintegration per second per gram.

D.11 Half life of radium is 1620 years. How many radium nuclei decay in 5 hours in 5 g radium. [Atomic weight of radium = 226]

D.12 Assuming the age of the earth to be 10^{10} years, what fraction of the original amount of U^{238} is still in existence on the earth? ($T_{1/2}$ of $U^{238} = 4.5 \times 10^9$ years).

D.13 An experiment is done to determine the half – life of radioactive substance that emits one β – particle for each decay process. Measurement show that an average of 8.4 β are emitted each second by 2.5 mg of the substance. The atomic weight of the substance is 230. Find the half life of the substance.

SECTION (E) : NUCLEAR FISSION AND FUSION

E.1 Consider the case of bombardment of U^{235} nucleus with a thermal neutron. The fission products are Mo^{95} & La^{139} and two neutrons. Calculate the energy released. (Rest masses of the nuclides U^{235} = 235.0439 u, ${}^{1}_{0}n$ = 1.0087 u, Mo^{95} = 94.9058 u, La^{139} = 138.9061 u). [Use 1amu = 931 Mev]

E.2 The radius of a nucleus of a mass number A is given by $R = R_0 A^{1/3}$, where $R_0 = 1.3 \times 10^{-15}$ m. Calculate the electrostatic interaction (potential) energy between two equal nuclei produced in the fission of ${}^{238}_{92}U$ at the moment of their fission.

E.3 Energy evolved from the fusion reaction is to be $2\,{}^{2}_{1}H = {}^{4}_{2}He + Q$ used for the production of power. Assuming the efficiency of the process to be 30 %. Find the mass of deuterium that will be consumed in a second for an output of 50 MW.
[Atomic masses are ${}^{4}_{2}He$ = 4.002603 u ; ${}^{2}_{1}H$ = 2.014102 u]

E.4 About 185 MeV of usable energy is released in the neutron induced fissioning of a ${}^{235}_{92}U$ nucleus. If the reactor using ${}^{235}_{92}U$ as fuel continuously generates 100 MW of power how long will it take for 1 Kg of the uranium to be used up?

E.5 For the D–T fusion reaction, find the rate at which deuterium & tritium are consumed to produce 1 MW. The Q–value of D–T reaction is 17.6 MeV & assume all the energy from the fusion reaction is available.

E.6 The $_{92}U^{235}$ absorbs a slow neutron (thermal neutron) & undergoes a fission represented by $_{92}U^{235} + {_0}n^1 \longrightarrow {_{92}}U^{236} \longrightarrow {_{56}}Ba^{141} + {_{36}}Kr^{92} + 3\ {_0}n^1 + E$. Calculate:
(i) The energy released E per fission.
(ii) The energy released when 1 g of $_{92}U^{236}$ undergoes complete fission.
Given $_{92}U^{235}$ = 235.1175 amu (atom) ;
$_{56}Ba^{141}$ = 140.9577 amu (atom);
$_{36}Kr^{92}$ = 91.9264 amu (atom) ; $_0n^1$ = 1.00898 amu

E.7 Assuming 1 metric ton (1000 kg) of coal gives heat of combustion equal to 8 K-cal and a single fission of U^{235} releases 200 MeV. Calculate the minimum consumption in kg of U^{235} to be heat equivalent to 100 ton of coal.

E.8 Assuming that the splitting of a U^{235} nucleus liberates the energy of 200 MeV. Find:
(a) The energy liberated in the fission of one Kg of U^{235} isotope, the mass of coal with calorific value of 30 kJ/g, which is equivalent to that for one kg of U^{235} &
(b) The mass of U^{235} isotope required to produce same amount of energy as produced during the explosion of the atomic bomb with 30 x 10^3 kg of trotyle, if the calorific value of trotyle is 4.1 kJ/g.

E.9 In a fusion reactor the reaction occurs in two stages:
(i) Two deuterium $\left({}_1^2\mathrm{D}\right)$ nuclei fuse to form a tritium $\left({}_1^3\mathrm{T}\right)$ nucleus with a proton as product. The reaction may be represented as D (D, p) T.
(ii) A tritium nucleus fuses with another deuterium nucleus to form a helium $\left({}_2^4\mathrm{He}\right)$ nucleus with neutron as another product. The reaction is represented as T(D, n) α. Find:
(a) The energy released in each stage.
(b) The energy released in the combined reaction per deuterium &
(c) What % of the mass energy of the initial deuterium is released.

Given: $\left({}_1^2\mathrm{D}\right)$ = 2.014102 u ; $\left({}_1^3\mathrm{T}\right)$ = 3.016049 u; $\left({}_2^4\mathrm{He}\right)$ = 4.002603 u;
$\left({}_1^1\mathrm{P}\right)$ = 1.00785 u ; $\left({}_0^1\mathrm{n}\right)$ = 1.008665 u, m_e = 0.000549 u and take 1amu = 931 MeV

EXERCISE-2

SECTION (A) : PROPERTIES OF NUCLEUS

A.1 The mass of a netural carbon atom in ground state is
(A) exact 12 u (B) less than 12 u (C) more than 12 u
(D) depends on the form of carbon such as graphite or charcoal.

A.2 The mass number of a nucleus is equal to
(A) the number of neutrons in the nucleus (B) the number of protons in the nucleus
(C) the number of protons in the nucleus (D) none of them

A.3 As compared to ^{12}C atom, ^{14}C atom has
(A) two extra protons and two extra electrons (B) two extra protons but no extra electron
(C) two extra neutorns and no extra electrons (D) two extra neutons and two extra electrons

A.4 The mass number of a nucleus is
(A) always less than its atomic number
(B) always more than its atomic number
(C) equal to its atomic number
(D) sometimes more than and sometimes equal to its atomic number

A.5 The stable nucleus that has a radius 1/3 that of Os^{189} is
(A) Li (B) He (C) B (D) C

SECTION (B) : MASS DEFECT AND BINDING ENERGY

B.1 The minimum energy required to remove a neutron from ${}_{20}^{41}Ca$ is

[Atomic masses are: ${}^{40}_{20}Ca$ = 39.962589 u; m_n = 1.008665 u ; ${}^{41}_{20}Ca$ = 40.962275 u]
(A) 4.3 MeV (B) 8.36 MeV (C) – 4.3 MeV (D) – 8.36 MeV

B.2 As the mass number A increases, the binding energy per nucleon in a nucleus
(A) increases (B) decreases (C) remains the same
(D) varies in a way that depends on the actual value of A.

B.3 Which of the following is a wrong description of binding energy of a nucleus ?
(A) It is the energy required to break a nucleus into its constituent nucleons.
(B) It is the energy made avilable when free nucleons combine to from a nucleus
(C) It is the sum of the rest mass energies of its nucleons minus the rest mass energy of the nucleus
(D) It is the sum of the kinetic energy of all the nucleons in the nucleus

B.4 The energy of the reaction $Li^7 + p \longrightarrow 2\ He^4$ is (the binding energy per nucleon in Li^7 and He^4 nuclei are 5.60 and 7.06 MeV respectively.)
(A) 17.3 MeV (B) – 17.3 MeV (C) 1.46 MeV
(D) depends on binding energy of proton

B.5 The atomic weight of boron is 10.81 and it has two isotopes ${}^{10}_{5}B$ and ${}^{11}_{5}B$. The ratio of ${}^{10}_{5}B : {}^{11}_{5}B$ in nature would be:
(A) 19 : 81 (B) 10 : 11 (C) 15 : 16 (D) 81 : 19

SECTION (C) : RADIOACTIVE DECAY

C.1 The radioactive nucleus ${}_7N^{13}$ decays to ${}_6C^{13}$ through the emission of
(A) positron (B) neutron (C) proton (D) electron

C.2 An α-particle is bombarded on ${}^{14}N$. As a result, a ${}^{17}O$ nucleus is formed and a particle is emitted. This particle is a
(A) neutron (B) proton (C) electron (D) positron

C.3 In beta decay,
(A) the daughter nucleus has one proton more than the parent nucleus
(B) the parent and the daughter nuclei have the same number of protons
(C) the daughter nucleus has one neutron more than the parent nucleus
(D) the daughter nucleus has one proton less than the parent nucleus.

C.4 In a radioactive decay, neither the atomic number nor the mass number changes. Which of the following particles is emitted in the decay ?
(A) proton (B) neutorn (C) electron (D) photon

C.5 During a negative beta decay,
(A) an atomic electron is ejected
(B) an electron which is already present within the nucleus is ejected
(C) a neutron in the nucleus decays emitted an electron
(D) a proton in the nucleus decays emitting an electron

C.6 In which of the following decays the element does not change ?
(A) α-decay (B) β^+-decay (C) β^--decay (D) γ-decay

C.7 In which of the following decays the atomic number decreases ?
(A) α-decay (B) β^+-decay (C) β^--decay (D) γ-decay

C.8 Which of the following are electromagnetic waves ?
(A) α-rays (B) beta-plus rays (C) beta-minus rays (D) gamma rays

C.9 A nucleus raptures into two nuclear parts which have their velocities in the ratio of 2 : 1. What will be the ratio of their nuclear sizes (radii) ?
(A) $2^{1/3} : 1$ (B) $1 : 2^{1/3}$ (C) $3^{1/2} : 1$ (D) $1 : 3^{1/2}$

C.10 A free neutron decays into a proton, an electron and :
(A) A neutrino (B) An antineutrino (C) An α-particle (D) A β-particle

SECTION (D) : STATISTICAL LAW OF RADIOACTIVE DECAY

D.1 In one average-life

(A) half the active nuclei decay (B) less than half the active nuclei decay
(C) more than half the active nuclei decay (D) all the nuclei decay

D.2 A freshly prepared radiocative source of half-life 2 h emits radiation of intensity which is 64 times the permissible safe level. The minimum time after which it would be possible to work safely with this source is
(A) 6 h (B) 12 h (C) 24 h (D) 128 h

D.3 The decay constant of a radoactive sample is λ. The half-life and the average-life of the sample are respectively
(A) $1/\lambda$ and (In $2/\lambda$) (B) (In$2/\lambda$) and $1/\lambda$
(C) 1(In 2) and $1/\lambda$ (D) λ/(In 2) and $1/\lambda$

D.4 The activity of a certain preparation decreases by 75% after 7.0 days. The half life of the sample is [take In (0.4) = – 0.916]
(A) 2.9 days (B) 5.3 days (C) 3.5 days (D) 6 days

D.5 The half life of ${}_{92}U^{238}$ against alpha decay is 4.5×10^9 years. The time taken in years for the decay of 15/16 part of this isotope is
(A) 9.0×10^9 (B) 1.8×10^{10} (C) 4.5×10^9 (D) 2.7×10^{10}

D.6 Two isotopes P and Q of atomic weight 10 and 20, respectively are mixed in equal amount by weight. After 20 days their weight ratio is found to be 1 : 4. Isotope P has a half-life of 10 days. The half-life of isotope Q is
(A) zero (B) 5 days (C) 20 days (D) inifinite

D.7 Ten grams of ^{57}Co kept in an open container beta-decays with a half-life of 270 days. The weight of the material inside the container after 540 days will be very nearly
(A) 10 g (B) proton (C) electron (D) positron

D.8 The half-life of a radioactive substance is 10 days. This means that :
(A) the substance completely disintegrates in 20 days
(B) the substance completely disintegrates in 40 days
(C) 1/8 part of the mass of the substance will be left intact at the end of 40 days
(D) 7/8 part of the mass of the substance disintegrates in 30 days

D.9 The half-life of a radioactive substance depends upon :
(A) its temperature (B) the external pressure on it
(C) the mass of the substance
(D) the strength of the nuclear force between the nucleons of its atom

SECTION (E) : NUCLEAR FISSION AND FUSION

E.1 During a nuclear fission reaction,
(A) a heavy nucleus breaks into two fragments by itself
(B) a light nucleus bombarded by thermal neutrons break up
(C) a heavy nucleus bombarded by thermal neutrons breaks up
(D) two light nuclei combine to give a heavier nucleus and possibly other products.

E.2 ${}_{92}U^{235}$ nucleus absorbs a slow neutron and undergoes fission into ${}_{54}X^{139}$ and ${}_{38}Sr^{94}$ nuclei.The other particles porduced in this fission process are
(A) 1 β and 1 α (B) 2 β and 1 neutron (C) 2 neturons (D) 3 neutrons

E.3 Two lithium nuclei in a lithium vapour at room temperature do not combine to form a carbon nucleus because ?
(A) a lithium nucleus is more tightly bound than a carbon nucleus
(B) carbon nucleus is an unstable particle
(C) it is not energetically favourable
(D) Coulomb repulsion does not allow the nuclei to come very close

E.4 In a uranium reactor whose thermal power is P = 100 MW, if the average number of neutrons liberated in each nuclear splitting is 2.5. Each splitting is assumed to release an energy E = 200 MeV. The number of neutrons generated per unit time is
(A) 4×10^{18} s^{-1} (B) 8×10^{23} s^{-1} (C) 8×10^{19} s^{-1} (D) 8×10^{18} s^{-1}

E.5 A fusion reaction of the type given below ${}_1^2D + {}_1^2D \longrightarrow {}_1^3T + {}_1^1p + \Delta E$, is most promising for the production of power. Here D & T stand for deuterium & tritium, respectively. Assuming the efficiency of the process to be 50 %, the mass of deuterium required per day for a power output of 10^9 W is (Given:

mass of ${}^{2}_{1}D$ = 2.01458 amu; mass of ${}^{3}_{1}T$ = 3.01605 amu; mass of ${}^{1}_{1}p$ = 1.00728 amu & 1 amu = 930 MeV/c^2)

(A) 0.66 Kg/ day (B) 2.64 kg/ day (C) 132 gm/day (D) 1.32 kg/day

E.6 In a nuclear reactor U^{235} undergoes fission liberating 200 MeV of energy. The reactor has a 10 % efficiency and produces 1000 MW power. If the reactor is to function for 10 years, the total mass of uranium required is

(A) 3847 kg (B) 38470 kg (C) 384700 kg (D) 384.7 kg

E.7 A star initially has 10^{40} deutrons. It produces energy via, the processes ${}_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + p$ & ${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + n$. If the average power radiated by the star is 10^{16} W, the deutron supply of the star is exhausted in a time of the order of :

[m_p = 1.007u; m_n = 1.008 u; m (${}_1H^2$) = 2.014u; m(${}_2He^4$) = 4.002 u]

(A) 10^6 sec (B) 10^8 sec (C) 10^{12} sec (D) 10^{16} sec

E.8 Pick out the statement which is true.

(A) The energy released per unit mass is more in fission than in fusion

(B) The energy released per atom is more in fusion than in fission.

(C) The energy released per unit mass is more in fusion and that per atom is more in fission.

(D) Both fission and fusion produce same amount of energy per atom as well as per unit mass.

E.9 Fusion reaction takes place at high temperature because

(A) atoms are ionised at high temperature

(B) molecules break-up at high temperature

(C) nuclei break-up at high temperature

(D) kinetic energy is high enough to overcome repulsion between nuclei.

E.10 In 1935, Yukawa suggested that nuclear forces arise as a result of interchange of certain particles between nucleons. These particles are :

(A) protons (B) mesons (C) photons (D) positrons

E.11 The average number of neutrons released by the fission of one uranium atom is :

(A) 1 (B) 2 (C) 2.5 (D) 3

E.12 A radioactive element *X* has atomic number *Z* and atomic mass number *A*. It decays by the emission of an alpha particle and a gamma ray. The new element is :

(A) ${}^{A-2}_{Z-1}Y$ (B) ${}^{A-4}_{Z-2}Y$ (C) ${}^{A+1}_{Z}Y$ (D) ${}^{A+4}_{Z+2}Y$

E.13 In a fission reaction

$$ {}^{236}_{92}U \longrightarrow {}^{117}X + {}^{117}Y + n + n $$

the binding energy per nucleon of X and Y is 8.5 MeV whereas that of ${}^{216}U$ is 7.6 MeV. The total energy liberated will be about :

(A) 200 keV (B) 2 MeV (C) 200 MeV (D) 2000 MeV

E.14 Graphite and heavy water are two common moderators used in a nuclear reactor. The function of the moderator is:

(A) to slow down the neutrons to thermal energies

(B) to absorb the neutrons and stop the chain reaction

(C) to cool the reactor

(D) to control the energy released in the reactor

EXERCISE-3

SECTION (A) : ONLY ONE OPTION IS CORRECT

1. The graph of ln(R/R_0) versus ln A(R=radius of a nucleus and A = its mass number) is

(A) a straight line (B) a parabola (C) an ellipse (D) none of them

2. Let F_{pp}, F_{pn} and F_{nn} denote the magnitudes of the nuclear force by a proton on a proton, by a proton on a neutron and by a neutron on a neutron respectively. When the separation is 1 fm,

(A) $F_{pp} > F_{pn} = F_{nn}$ (B) $F_{pp} = F_{pn} = F_{nn}$ (C) $F_{pp} > F_{pn} > F_{nn}$ (D) $F_{pp} < F_{pn} = F_{nn}$

3. Let F_{pp}, F_{pn} and F_{nn} denote the magnitudes of the net force by a proton on a proton by a proton on a neutron and by a neutron on a neutron respectively. Neglect gravitational force. When the separation is 1 fm,
(A) $F_{pp} > F_{pn} = F_{nn}$ (B) $F_{pp} = F_{pn} = F_{nn}$ (C) $F_{pp} > F_{pn} > F_{nn}$ (D) $F_{pp} < F_{pn} = F_{nn}$

4. Two protons are kept at a separation of 10 nm. Let F_n and F_e be the nuclear force and the electromagnetic force between them.
(A) $F_e = F_n$ (B) $F_e >> F_n$ (C) $F_e << F_n$ (D) F_e and F_n differ only slightly.

5. Four physical quantities are listed in column I. Their values are listed in Column II in a random order.

	Column I		**Column II**
(a)	Thermal energy of air molecules at room temprature	(e)	0.02 eV
(b)	Binding energy of heavy nuclei per nucleon	(f)	2 eV
(c)	X–ray photon energy	(g)	1 KeV
(d)	Photon energy of visible light	(h)	7 MeV

The correct matching of columns I & II is given by :
(A) a – e, b – h, c – g, d – f (B) a – e, b – g, c – f, d – h
(C) a – f, b – e, c – g, d – h (D) a – f, b – h, c – e, d – g

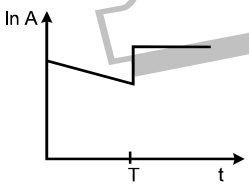
6. On an average neutron loses half of its energy per collision with a free proton. How many collisions, on the average are required to reduce a 2 MeV neutron to a thermal energy of 0.04 eV ?
(A) 22 (B) 26 (C) 18 (D) 30

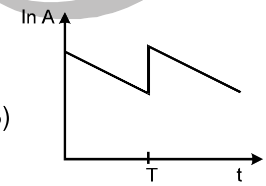
7. Protons and singly ionized atoms of U^{235} & U^{238} are passed in turn (which means one after the other and not at the same time) through a velocity selector (where a magnetic field causes them to describe semicircular path). The protons describe semicircles of radius 10 mm. The separation between the ions of U^{235} and U^{238} after describing semicircle is given by
(A) 60 mm (B) 30 mm (C) 2350 mm (D) 2380 mm

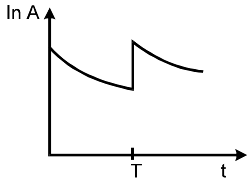
8. When a β^--particle is emitted from a nucleus, the neutron-proton ratio :
(A) is decreased (B) is increased (C) remains the same (D) first (A) then (B)

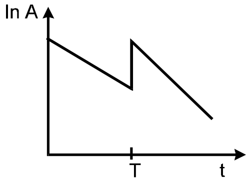
9. The e/m for β-particles emitted out from the nucleus in comparison to the value of e/m for photoelectrons is
(A) equal (B) more (C) less (D) none of these.

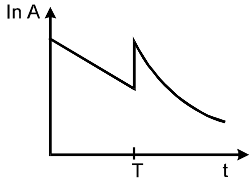
10. At time t = 0, some radioactive gas is injected into a sealed vessel. At time T, some more of the same gas is injected into the same vessel. Which one of the following graphs best represents the variation of the logarithm of the activity A of the gas with time t?

(A)


(B)


(C)


(D)


(E)


11. Free ^{238}U nuclei kept in a train emit alpha particles. When the train is stationery and a uranium nucleus decays, a passenger measures that the separation between the alpha particle and the recoiling nucleus beomes x in time t after the decay. If a decay takes place when the train is moving at a uniform speed υ, the distance between the alpha particle and the recoiling nucleus at a time t after the decay, as measured by the passenger will be
(A) $x + \upsilon t$ (B) $x - \upsilon t$ (C) x (D) depends on the direction of the train

12. The half – life of uranium 238 is about 4.5×10^9 years & its end product is Pb^{206}. We find that the oldest uranium bearing rocks on earth contain about 50 – 50 mixture of U^{238} and Pb^{206}. The age of those rocks is [$\ell n(222/103) = 0.768$]
(A) 4.9×10^9 years (B) 4.5×10^9 years (C) 8.3×10^9 years (D) 2.6×10^9 years

13. A radioactive material decays by β-particle emission. During the first 2 seconds of a measurement, n β-particles are emitted and in the next 2 seconds 0.75n β-particles are emitted.The mean-life of this material in seconds to the nearest whole number is (ln 3 = 1.0986 and ln 2 = 0.6931)
(A) 7 sec. (B) 7 minutes (C) 10 sec. (D) 4 sec.

14. Assuming initially no lead is present and all lead forms from uranium only. The ratio of atom of Pb: U after time 1.5×10^9 years is (Given $T_{1/2} = 4.5 \times 10^9$ years Take $2^{1/3} = 1.259$)
(A) 0.741 (B) 0.259 (C) 1.259 (D) 0.482

15. A sample of radioactive material has mass m, decay constant λ, and molecular weight M. Avogadro constant $= N_A$. The initial acitvity of the sample is :
(A) λm (B) $\frac{\lambda m}{M}$ (C) $\frac{\lambda m N_A}{M}$ (D) $mN_A e^{\lambda}$

16. In the previous question, the acitvity of the sample after time t will be :
(A) $\left(\frac{mN_A}{M}\right)e^{-\lambda t}$ (B) $\left(\frac{mN_A\lambda}{M}\right)e^{-\lambda t}$ (C) $\left(\frac{mN_A}{M\lambda}\right)e^{-\lambda t}$ (D) $\frac{m}{\lambda}(1-e^{-\lambda t})$

17. The activity of a sample of radioactive material is A_1 at time t_1 and A_2 at time t_2 ($t_2 > t_1$). Its mean life is T:
(A) $A_1t_1 = A_2t_2$ (B) $\frac{A_1 - A_2}{t_2 - t_1}$ = constant (C) $A_2 = A_1\, e^{(t_1 - t_2/T)}$ (D) $A_2 = A_1\, e^{(t_1/Tt_2)}$

18. Two radioactive source A and B initially contain equal number of radioactive atoms. Source A has a half-life of 1 hour and source B has a half-life of 2 hours. At the end of 2 hours, the ratio of the rate of disintegration of A to that of B is :
(A) 1 : 2 (B) 2 : 1 (C) 1 : 1 (D) 1 : 4

SECTION (B) : ONE OR MORE THAN ONE OPTIONS MAY BE CORRECT

19. As the mass number A increases, which of the following quantities related to a nucleus do not change ?
(A) mass (B) vloume (C) density (D) binding energy

20. The heavier nuclei tend to have larger N/Z ratio because
(A) a neutron is heavier than a proton
(B) a neutron is an unstable particle
(C) a neutron does not exert electric repulsion
(D) Coulomb forces have longer range compared to nuclear forces

21. A free neutron decays to a proton but a free proton does not decay to a neutron. This is beacuse
(A) neutron is a composite particle made of a proton and an electron whereas proton is fundamental particle
(B) neutron is an uncharged particle whereas proton is a charged particle
(C) neutron has larger rest mass than the proton
(D) weak forces can operate in a neutron but not in a proton.

22. Consider a sample of a pure beta-active material
(A) All the beta particles emitted have the same energy
(B) The beta particles originally exist inside the nucleus and are ejected at the time of beta decay
(C) The antineutrino emitted in a beta decay has zero mass and hence zero momentum.
(D) The active nucleus changes to one of its isobars after the beta decay

23. Magnetic field does not cause deflection in
(A) α-rays (B) beta-plus rays (C) beta-minus rays (D) gamma rays

24. For nuclei with A > 100
(A) the binding energy of the nucleus decreases on an average as A increases
(B) the binding energy per nucleon decreases on an average as A increases
(C) if the nucleus breaks into two roughly equal parts, energy is released
(D) if two nuclei fuse to form a bigger nucleus, energy is released.

25. If the activity of Co^{55} radionuclide is known to decrease 4.0 % in one hour. The decay product is non – radioactive, then the decay constant and the mean life time of Co^{55} radionuclide are given by

(A) 1.1×10^{-5} s^{-1}& 1 day (B) 1.1×10^{-3} s^{-1} & 1.5 min.
(C) $1.1. \times 10^{-5}$ s^{-1} & 24 hrs. (D) 1.1×10^{-3} s^{-1} & 90 sec.

26. A U^{238} sample of mass 1.0 g emits alpha particles at the rate 1.24×10^4 particles per second.
(A) The half life of this nuclide is 4.5×10^9 years
(B) The half life of this nuclide is 9×10^9 years
(C) The activity of the preparation is 2.48×10^4 particles/sec
(D) The activity of the preparation is 1.24×10^4 particles/sec.

27. Radio active phosphorus 32 has a half life of 14 days. A source containing this isotope has an initial activity of 10 m Ci.
(A) The activity of the source after 42 days is 1.25 mCi
(B) The activity of the source after 42 days is 2.5 mCi
(C) Time elapses before the activity of the source falls to 2.5 mCi is 42 days
(D) Time elapses before the activity of the source falls to 2.5 mCi is 28 days

28. The quantity of ${}^{210}_{84}Po$ necessary to provide a source of $\alpha-$ particles of 5 mCi strength is
[$T_{1/2}$ of Po = 138 days]
(A) 2.43×10^{-9} kg (B) 1.107×10^{-9} kg (C) 3.56×10^{-6} gm (D) 1.107×10^{-6} gm

29. The ${}_{92}U^{235}$ absorbs a slow neutron (thermal neutron) & undergoes a fission represented by ${}_{92}U^{235} + {}_0n^1 \longrightarrow {}_{92}U^{236} \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + E$. (Given atomic masses : ${}_{92}U^{235}$ = 235.1175 amu ; ${}_{56}Ba^{141}$ = 140.9577 amu; ${}_{36}Kr^{92}$ = 91.9264 amu ; ${}_0n^1$ = 1.00898 amu)
(A) The energy released per fission is 200.68 MeV
(B) The energy released per fission is 20.1 MeV
(C) The energy released when 1 g of ${}_{92}U^{236}$ undergoes complete fission is 22.8 Mwh
(D) Q value of the reaction is negative

30. A nucleus at rest undergoes a decay emitting an α particle of De-Broglie wavelength $\lambda = 5.76 \times 10^{-15}$ m. If the mass of the daughter nucleus is 223.610 a.m.u. and that of the α particle is 4.002 a.m.u. [1 amu = 931.47 MeV/c^2]
(A) The total kinetic energy in the final state is 6.31 KeV
(B) The total kinetic energy in the final state is 6.31 MeV
(C) The mass of the parent nucleus in a.m.u. is 227.62 amu
(D) The mass of the parent nucleus in a.m.u. is 525.23 amu

31. A radioactive nucleus X decays to a nucleus Y with a decay constant $\lambda_X = 0.1\text{sec}^{-1}$. Y further decays to a stable nucleus Z with a decay constant $\lambda_Y = 1/30\ \text{sec}^{-1}$, initially there are only X nuclei and their number is $N_0 = 10^{20}$. The population of the Y nucleus as a function of time is given by $N_Y(t) = (N_0\lambda_X/(\lambda_X - \lambda_Y))\,[\exp(-\lambda_Y t) - \exp(-\lambda_X t)]$.
(A) The time at which N_Y is maximum is 15 In3
(B) The population of X at that instant is $\frac{N_0}{3\sqrt{3}}$ where $N_0 = 10^{20}$
(C) The population of Z at that instant is $N_0\left(1-\frac{4}{3\sqrt{3}}\right)$ where $N_0 = 10^{20}$
(D) None of these

32. A nitrogen nucleus ${}_7N^{14}$ absorbs a neutron and can transform into lithium nucleus ${}_3Li^7$ under suitable conditions, after emitting
(A) 4 protons and 3 neutrons
(B) 5 protons and 1 negative beta particle
(C) 2 alpha particles and 2 gama particles
(D) 1 alpha particle, 4 protons and 2 negative beta particles.
(E) 4 protons and 4 neutrons.

33. ${}_{92}U^{235}$ is 'α'(alpha) active. Then in a large quantity of the element
(A) the probability of a nucleus disintegrating during one second is lower in the first half life and greater in the fifth half life
(B) the probability of a nucleus disintegrating during one second remains constant for all time

(C) every nucleus must integrate by the lapse of the average life of the population
(D) quite and apreciable quantity of U^{235} will remain even after the average life.
(E) the energy of the emitted 'α' particle is less than the disintegration energy of the U^{235} nucleus.

34. In case of radioactive radiations
(A) some are not deviated by electric and magnetic fields
(B) some carry negative charge
(C) all are electromagnetic waves
(D) all produce X-rays when suddenly stopped.

35. Two identical nuclei *A* and *B* of the same radioactive element undergo β decay. A emits a β-particle and changes to *A′*. *B* emits a β-particle and then a γ-ray photon immediately afterwards, and changes to *B′* :
(A) *A′* and *B′* have the same atomic number and mass number
(B) *A′* and *B′* have the same atomic number but different mass numbers
(C) *A′* and *B′* have different atomic numbers but the same mass number
(D) *A′* and *B′* are isotopes

36. When a nucleus with atomic number *Z* and mass number *A* undergoes a radioactive decay process :
(A) Both *Z* and *A* will decrease, if the proces is α decay
(B) *Z* will decrease but *A* will not change, if the process is β^+ decay
(C) *Z* will increase but *A* will not change, if the process is β^- decay
(D) *Z* and *A* will remain unchanged, if the process is γ decay

37. Which of the following assertions are correct ?
(A) A neutron can decay to a proton only inside a nucleus
(B) A proton can change to a neutron only inside a nucleus
(C) An isolated neutron can change into a proton
(D) An isolated proton can change into a neutron

EXERCISE-4

1. The half-life of radioactive Radon is 3.8 days. The time at the end of which $(1/20)^{th}$ of the Radon sample will remain undecayed is (given $\log_{10} e = 0.4343$) **[JEE 81]**
(A) 13.8 days (B) 16.5 days (C) 33 days (D) 76 days

2. If elements with principal quantum number n > 4 were not allowed in nature, the number of possible elements would be **[JEE 83]**
(A) 60 (B) 32 (C) 4 (D) 64

3. β-rays emitted by a radioactive material are :
(A) Electromagnetic waves (B) Electrons orbiting around the nucleus
(C) Charged particles emitted by the nucleus (D) Neutral particles. **[JEE - 83]**

4. The mass number of a nucleus is -
(A) Always less than its atomic number
(B) Always more than its atomic number
(C) Sometimes equal to its atomic number
(D) Sometimes more than and sometimes equal to its atomic number. **[JEE - 86]**

5. During a nuclear fusion reaction **[JEE - 87]**
(A) A heavy nucleus breaks into two fragments by itself
(B) A light nucleus bombarded by thermal neutrons breaks up
(C) A heavy nucleus bombarded by thermal neutrons breaks up
(D) Two light nuclei combine to give a heavier nucleus and possibly other products.

6. During a negative beta decay **[JEE - 87]**
(A) An atomic electron is ejected
(B) An electron which is already present within the nucleus is ejected
(C) A neutron in the nucleus decay emitting an electron
(D) A part of the binding energy of the nucleus is converted into an electron.

7. Two radioactive elements X and Y have half-lives of 50 minutes and 100 minutes respectively. Initial samples of both the elements have equal number of atoms. The ratio of the remaining

number of atoms of X and Y after 200 minutes, is **[REE - 90]**
(A) 2 (B) 1/2 (C) 4 (D) 1/4

8. In the α-decay process occurring in different types of nuclei at rest ;
(A) The kinetic energy of the daughter nucleus is always greater than the kinetic energy of the α-particle
(B) The kinetic energy of the daughter nucleus is always less than the kinetic energy of the α-particle
(C) The magnitude of the linear momenta of the α-particle and the daughter nucleus are always equal
(D) The daughter nucleus is always in a stable state. **[JEE - 94]**

9. Fast neutrons can easily be slowed down by
(A) The use of lead shielding (B) Passing them through water
(C) Elastic collisions with heavy nuclei (D) Applying a strong electric field. **[JEE - 94]**

10. Consider α-particles, β-particles and γ-rays, each having an energy of 0.58 MeV. In increasing order of penetrating powers, the radiations are : **[JEE - 94]**
(A) α, β, γ (B) α, γ, β (C) β, γ, α (D) γ, β, α

11. A slow neutron (n) is captured by a $^{235}_{92}U$ nucleus forming a highly unstable nucleus $^{236}_{92}U^*$ (where * denotes that the nucleus is in an excited state). The fission of the nucleus occurs by **[JEE - 94**
(A) $^{236}_{92}U^* \rightarrow {}^{140}_{50}Sn + {}^{89}_{42}Mo + 6n + Q$ (B) $^{236}_{92}U^* \rightarrow {}^{140}_{54}Xe + {}^{94}_{38}Sr + 4n + Q$
(C) $^{236}_{92}U^* \rightarrow {}^{144}_{52}Te + {}^{89}_{42}Mo + 3n + Q$ (D) $^{236}_{92}U^* \rightarrow {}^{144}_{56}Xe + {}^{89}_{36}Kr + 3n + Q$

12. At a given instant there are 25% undecayed radioactive nuclei in a sample. After 10 seconds the number of undecayed nuclei reduces to 12.5%. Calculate (a) the mean life of he nuclei and (b) the time in which the number of undecayed nuclei will further reduce to 6.25% of the reduced number. **[IIT - 96]**

13. Masses of two isobars $^{64}_{29}Cu$ and $^{64}_{30}Zn$ are 63.9298 u and 63.9292 u respectively. It can be concluded from these data that : **[IIT - 97]**
(A) Both the isobars are stable
(B) ^{64}Zn is radioactive, decaying to ^{64}Cu through β-decay
(C) ^{64}Cu is radioactive, decaying to ^{64}Zn through γ-decay
(D) ^{64}Cu is radioactive, decaying to ^{64}Zn through β-decay

14. In an ore containing uranium, the ratio of U-238 to Pb-206 is 3. Calculate the age of the ore, assuming that all the lead present in the ore is the final stable product of U-238.
Take the half life of U-238 to be 4.5×10^9 years. **[IIT - 97]**

15. The element Curium $^{248}_{96}Cm$ has a mean life of 10^{13} seconds. Its primary decay modes are spontaneous fission and α-decay modes are spontaneous fission and α-decay, the former with a probability of 8% and the latter with a probability of 92%. Each fission releases 200 MeV of energy. The masses involved in α-decay are as follows : (1 u = 931 MeV/c^2). Calculate the power output from a sample of 10^{20} Cm atoms. **[IIT - 97]**

16. Let m_p be the mass of a proton, m_n the mass of a neutron, M_1 the mass of a $^{20}_{10}Ne$ nucleus & M_2 the mass of a $^{40}_{20}Ca$ nucleus. Then: **[JEE '98, 2]**
(A) $M_2 = 2 M_1$ (B) $M_2 > 2 M_1$ (C) $M_2 < 2 M_1$ (D) $M_1 < 10 (m_n + m_p)$

17. Nuclei of radioactive element A are being produced at a constant rate α. The element has a decay constant λ. At time $t = 0$, there N_0 nuclei of the element. **[IIT - 98]**
(a) Calculate the number N of nuclei of A at time t.
(b) If $\alpha = 2N_0\lambda$, calculate the number of nuclei of A after one half-life of A and also the limiting value of N as $t \rightarrow \infty$.

18. Radio isotope $^{234}Ra_{88}$ decays by a series emission of three β-particles and two α-particles. The end product X is **[JEE - 99]**
(A) $^{220}X_{88}$ (B) $^{226}X_{87}$ (C) $^{234}X_{90}$ (D) $^{216}X_{88}$

19. The half-life of ^{131}I is 8 days. Given a sample of ^{131}I at time t = 0, we can assert that
(A) No nucleus will decay before t = 4 days
(B) No nucleus will decay before t = 8 days

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(C) All nuclei will decay before t = 16 days
(D) A given nucleus may decay at any time after t = 0. **[JEE - 99]**

20. The half-life period of a radioactive element X is same as the mean-life time of another radioactive element Y. Initially both of them have the same number of atoms. Then **[JEE - 99]**
(A) X and Y have the same decay rate initially (B) X and Y decay at the same rate always
(C) Y will decay at a faster rate than X (D) X will decay at a faster rate than Y

21. The order of magnitude of density of uranium nucleus is, ($m_p = 1.67 \times 10^{-27}$ kg) : **[IIT - 99]**
(A) 10^{20} kg m^{-3} (B) 10^{17} kg m^{-3} (C) 10^{14} kg m^{-3} (D) 10^{11} kg m^{-3}

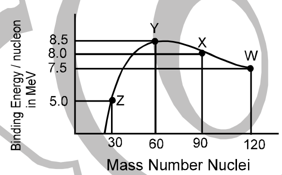
22. 22Ne nucleus, after absorbing energy, decays into two α-particles and an unknown nucleus. The unknown nucleus is : **[IIT - 99]**
(A) Nitrogen (B) Carbon (C) Boron (D) Oxygen

23. Two radioactive materials X_1 and X_2 have decay constants 10λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2 will be 1/e after a time. **[JEE - 99]**
(A) $1/(10\lambda)$ (B) $1/(11\lambda)$ (C) $11/(10\lambda)$ (D) $1/(9\lambda)$

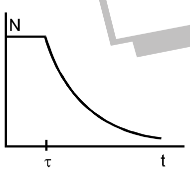
24. Which of the followings is a correct statement ?
(A) beta rays are same as cathode rays.
(B) gamma rays are high energy neutrons.
(C) alpha particles are singly-ionized helium atoms.
(D) protons and neutrons have exactly the same mass. **[JEE - 99]**

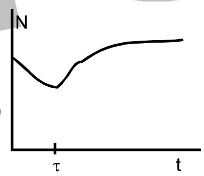
25. The half-life of radioactive Polonium (Po) is 138.6 days. For ten lakh Polonium atoms, the number of disintegrations in 24 hours is - **[REE - 99]**
(A) 2000 (B) 3000 (C) 4000 (D) 5000

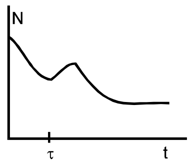
26. Binding energy per nucleon vs. mass number curve for nuclei is shown in the figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is: **[JEE '99, 2]**
(A) Y → 2Z (B) W → X + Z
(C) W → 2Y (D) X → Y + Z

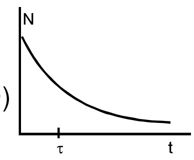


27. A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life time of one species is τ and that of the other is 5τ. The decay products in both cases are stable. A plot is made of total number of radioactive nuclei as a function of time. Which of the following figures best represents the form of this plot? **[IIT 2001]**

(A) 

(B) 

(C) 

(D) 

28. (I) Which of the following processes represents a gamma decay?
(A) ${}^{A}X_Z + \gamma \longrightarrow {}^{A}X_{Z-1} + a + b$ (B) ${}^{A}X_Z + {}^{1}n_0 \longrightarrow {}^{A-3}X_{Z-2} + c$
(C) ${}^{A}X_Z \longrightarrow {}^{A}X_Z + f$ (D) ${}^{A}X_Z + e_{-1} \longrightarrow {}^{A}X_{Z-1} + g$
(II) The half life of ^{215}At is 100 μs. The time taken for the radioactivity of a sample of ^{215}At to decay to 1/16th of its initial value is:
(A) 400 μs (B) 6.3 μs (C) 40 μs (D) 300 μs
[JEE 2002 (Screening) 2 × 3 = 6]

29. A nucleus with mass number 220 initially at rest emits an α-particle. If the Q value of the reaction is 5.5 MeV, calculate the kinetic energy of the α-particle **[IIT 2003]**
(A) 4.4 MeV (B) 5.4 MeV (C) 5.6 MeV (D) 6.5 MeV

30. A radioactive material decays by β-particle emission. During the first 2 seconds of a measurement, n β-particles are emitted and the next 2 seconds 0.75 n β-particles are emitted. Calculate the mean-life of this material in seconds to the nearest whole number. (ln 3 = 1.0986 and ln 2 = 0.6931). **[IIT - 2003]**

31. A 280 days old sample of a radioactive substance has activity of 6000 dps. In next 140 days activity falls to 3000 dps. Then initial activity of sample would have been **[JEE 2004 (Scr.)]**

(A) 9000 (B) 24000 (C) 12,000 (D) 18,000

32. The age of a rock containing lead and uranium is equal to 1.5×10^9 yrs. The uranium is decaying into lead with half life equal to 4.5×10^9 yrs. Find the ratio of lead to uranium present in the rock, assuming initially no lead was present in the rock. (Given $2^{1/3} = 1.259$) **[IIT - 2004]**

33. Helium nuclie combines to form an oxygen nucleus. The binding energy per nucleon of oxygen nucleus is if $m_O = 15.834$ amu and $m_{He} = 4.0026$ amu **[JEE 2005 (Scr.) 3]**

(A) 10.24 MeV (B) 0 MeV (C) 5.24 MeV (D) 4 MeV

34. Half life of a radio active substance 'A' is 4 days. The probability that a nucleus will decay in two half lives is: **[JEE 2006 3/184]**

(A) $\frac{1}{4}$ (B) $\frac{3}{4}$ (C) $\frac{1}{2}$ (D) 1

35. **Match the following** **[JEE 2006 5/184]**

Column 1		**Column 2**
(a) Fission	(P)	Matter - energy
(b) Fusion	(Q)	In atoms of high atomic number only
(c) β - decay	(R)	In atoms of low atomic number only
(d) Exothermic nuclear reaction	(S)	Involves weak nuclear forces

ANSWER

Exercise # 1

SECTION (A) :

A.1 (i) 15 km (ii) 158.4 m.

SECTION (B) :

B.1 4.0016 u
B.2 19.5 MeV, 2.78 MeV
B.4 11.9 MeV
B.5 (a) 4.255 Me V (b) 24.03 Me V

SECTION (C) :

C.2 3.4×10^5 m/s, 0.020
C.3 4.87 MeV.
C.4 (a) 500 Ke V (b) 2.67×10^{-22} kg–m/s
C.5 (a) ${}^{40}_{19}K \rightarrow {}^{40}_{20}Ca + e^- + \bar{\nu}$,
$\quad {}^{40}_{10}K \rightarrow {}^{40}_{18}Ar + \overset{+}{e} + \nu$,
$\quad {}^{40}_{19}K + e^- \rightarrow {}^{40}_{18}Ar + \nu$
(b) 1.3034 MeV, 0.4676 MeV, 1.490 MeV
C.6 11.88 MeV

SECTION (D) :

D.1 (a) 8.25×10^{-4} s^{-1} (b) 782 KeV
D.2 (a) 64 min (b) 92 min (c) 1600s
D.3 1.125×10^{15} **D.4** (a) 0.244 Ci (b) 0.040
D.5 4.6×10^2 particles/minute
D.6 4.1×10^3 years
D.7 3.2×10^{17} & 0.8×10^5 dps
D.8 (i) 1.25 mCi (ii) 28 days
D.9 3.9×10^3 per second **D.10** 11140 yrs
D.11 323.19×10^{13} **D.12** 0.2143
D.13 1.7×10^{10} years

SECTION (E) :

E.1 207.9 MeV **E.2** 239.3 MeV
E.3 2.9×10^{-7} kg **E.4** 8.781 days
E.5 1.179×10^{-9} kg/s, 1.769×10^{-9} kg/s
E.6 (i) 200.68 MeV (ii) 22.86 MWh
E.7 $M = 4.077 \times 10^{-8}$ kg
E.8 (a) 8.2×10^{10} kJ, 2.7×10^6 kg (b) 1.5 gm.
E.9 (a) 3.496 MeV, 17.58 MeV (b) 7.2 MeV (c) 0.384 %

Exercise # 2

SECTION (A) :

A.1	A	**A.2**	C	**A.3**	C
A.4	D	**A.5**	A		

SECTION (B) :

B.1	B	**B.2**	D	**B.3**	D	**B.4**	A
B.5	A						

SECTION (C) :

C.1	A	**C.2**	B	**C.3**	A	**C.4**	D
C.5	C	**C.6**	D	**C.7**	AB	**C.8**	D
C.9	B	**C.10**	B				

SECTION (D) :

D.1	C	**D.2**	B	**D.3**	B	**D.4**	B
D.5	B	**D.6**	D	**D.7**	A	**D.8**	D
D.9	D						

SECTION (E) :

E.1	C	**E.2**	C	**E.3**	D	**E.4**	D
E.5	D	**E.6**	B	**E.7**	C	**E.8**	C
E.9	D	**E.10**	B	**E.11**	C	**E.12**	B
E.13	C	**E.14**	A				

Exercise # 3

SECTION (A) :

1.	A	**2.**	B	**3.**	D	**4.**	B
5.	A	**6.**	B	**7.**	A	**8.**	A
9.	C	**10.**	B	**11.**	C	**12.**	A
13.	A	**14.**	B	**15.**	C	**16.**	B
17.	C	**18.**	C				

SECTION (B) :

19.	C	**20.**	CD	**21.**	C	**22.**	D
23.	D	**24.**	BC	**25.**	AC	**26.**	AD
27.	AD	**28.**	BD	**29.**	AC	**30.**	BC
31.	ABC	**32.**	CDE	**33.**	BDE	**34.**	AB
35.	A	**36.**	ABCD	**37.**	BC		

Exercise # 4

1.	B	**2.**	A	**3.**	C	**4.**	CD
5.	D	**6.**	C	**7.**	D	**8.**	BC
9.	B	**10.**	A	**11.**	D		

12. (a) 14.43 s; (b) 40 s **13.** D
14. 1.867×10^9 years
15. 3.32×10^{-5} Js^{-1} **16.** C
17. (a) $N = \frac{1}{\lambda}\,[\alpha - (a - \lambda N_0)\, e^{-\lambda t}]$; (b) $2\,N_0$

18.	B	**19.**	D	**20.**	C	**21.**	B
22.	B	**23.**	D	**24.**	A	**25.**	D
26.	C	**27.**	D	**28.**	(I) C		(II) A
29.	B	**30.**	6.954 sec	**31.**	B		
32.	0.259	**33.**	A	**34.**	B		

35. (A) (a) → (P) and (Q), (b) → (P) and (R), (c) → (P) and (S), (d) → (P) and (R)

