Chapter = 21

NUCLEAR PHYSICS

ATOMIC NUCLEUS

What is Rutherford nuclear model? Rutherford model of atom consisted of a small dense, positively charged nucleus with negative electrons orbiting about it.
Neutron was discovered byJames Chadwick In 1932. It is neutral particle which has no charge
Electron was discovered by JJ Thomson in 1897. It has negative charge
Proton was discovered by Gold stein in 1927. It has positive charge
Almost 99.9% of mass of atom is concentrated in nucleus.
Radius of atom is 10^5 times the radius of the nucleus.

Particle	Charge	Charge value(C)	Mass in kg	Mass in amu
Proton	+ive	$1.6*10^{-19}$	$1.673*10^{-27}$	1.007276
Electron	-ive	$-1.6*10^{-19}$	$9.1*10^{-31}$	0.00055
Neutron	no	Zero	$1.675*10^{-27}$	1.008665

What is Atomic number/Charge number?The number of protons inside the nucleus is called charge number or atomic number. It is denoted by Z.
Neutron number: The number of neutrons inside a given nucleus is called neutron number denoted by N.
What is Mass number?Total number of protons and neutrons in a nucleus is called mass number A=N+Z

For example ${}_2^4He$, atomic number is 2, mass number is 4 and number of neutrons is 2. More examples

1. Hydrogen ${}_1^1H$, Z=1, N=0, A=1
2. Helium ${}_2^4He$, Z=2, N=2, A=4
3. Uranium ${}_{92}^{235}U$ Z=92, N=143, A=235 As N=A-Z, 235-92=143

What are ISOTOPES? Give examples.

Isotopes: Those nuclei having same atomic number but different mass number are called isotopes. For example isotopes

Of hydrogen are ${}_1^1H$, ${}_1^2H$, ${}_1^3H$, for helium ${}_2^3He, {}_2^4He$.

Isotopes have same number of electrons and protons but different number of neutrons.
Chemical properties of an element depend on the number of electrons around the nucleus. So isotopes haves same chemical properties.

WHAT IS MASS SPECTROGRAPH? WRITE ITS PRINCIPLE AND EQUATION.

Mass spectrograph: A device which separates the isotopes of elements and determines its masses is called mass spectrograph.
Principle of mass spectrograph: It uses electric and magnetic field to separate the isotopes according to their masses.

Equation of mass spectrograph. $m = (\frac{er^2}{2V})B^2$

Isotopes of neon: Neon has mass number of 20, 21, 22 and most abundant isotope is Ne-20.

Multiple choice questions

1	The amount of energy equailent to 1amu	9.315 MeV	93.45 MeV	**931.5MeV**	1.025MeV

	is				
2	The name electron suggested by	Thomson	Rutherford	Millikan	**Stoney**
3	The number of neutrons in nucleus is	**N=A-Z**	N=A+Z	N=A+Z/2	None
4	The number of protons in any atom are always equal to number of	**Electrons**	Neutrons	Positron	Mesons
5	The chemical properties of an element depend only upon the number of	Protons	Neutrons	**Electrons**	Mesons
6	Neutron was discovered in 1932 by	Bohr	**Chadwick**	dirac	Fermi
7	In mass spectrograph mass of each ion reaching the detector is proportional to	$\sqrt{r}$	**B^2**	V2	$\sqrt{B}$
8	The radius of atom is of the order of	10^{10}m	**10^{-10} m**	10^{-14}m	10^{14}m
9	Hydrogen H-1 is also called	Deuterium	Tritium	**Protium**	All of these
10	The particle which has its mass number and charge number is equal to zero	Proton	Electron	Neutron	**Photon**
11	The chemical properties of any element depends on its	Number of isotopes	Number of isobars	**Atomic number**	Mass number
12	Number of isotopes of helium is	**2**	3	4	5
13	The number of isotopes of cesium are	4	32	**36**	22
14	Xenon and cesium have isotopes	35	**36**	37	38
15	Which is most abundant isotopes of neon	**Neon-20**	Neon-21	Neon-22	All
16					

WHAT IS MASS DEFECT AND BINDING ENERGY? WRITE EQUATIONS.

Mass defect: The mass of nucleus is always less then total mass of its protons and neutrons, this difference in mass is called mass defect. $\Delta m = Zm_p + (A-Z)m_n - m_{nucleus}$

Packing fraction: Mass defect per nucleon is called packing fraction.

$$f = \frac{\Delta m}{A} = \frac{Zm_p + (A-Z)m_n - m_{nucleus}}{A}.$$

Binding energy: The mass defect is converted into energy during formation of nucleus, this energy is called binding energy. OR the energy required to break the nucleus into its nucleons is called binding energy.

$B.E = (Zm_p + (A-Z)m_n - m_{nucleus})c^2$ Binding energy of helium is 28.2 MeV

Properties of binding energy per nucleon: There are following properties of B.E/nucleon

i. Binding energy per nucleon increase with mass number
ii. It increase till value of 8.8MeV at mass number 58
iii. After mass number 58 it decrease to a value of 7.6MeV at mass number 238
iv. Binding energy per nucleon is maximum for iron
Iron is most stable elements

Iron is most stable element as it has maximum value of binding energy per nucleon 8.8 MeV.

WHAT IS RADIOACTIVITY? EXPLAIN THE DIFFERENT TYPES OF DECAY.

Radioactive elements& radioactivity: The elements having atomic number greater than 82 emit invisible radiations which affect photo graphic plate, such elements are called radioactive elements and the process is called radioactivity.
Radioactivity is purely nuclear phenomenon which is not affected by physical or chemical reaction. It does not depends on physical state such as temperature, pressure and density. Etc.
Radioactivity discovered by Henry Becquerel in 1896.
Transuranic elements: The elements having atomic number greater than 92 are called transuranic elements.
There are three types of namely, alpha, beta and gamma rays.
Alpha particles: They are helium nuclei, has 2 protons, 2 neutrons and positive charge
Beta particles: They are fast moving electron having negative charge and charge number -1
Gamma particles: they are EM rays like X-rays the wavelength is larger than x-rays and high frequency having no charge.
Radioactive decay: Change in the nucleus of radioactive elements by emission of radiations and elements into a new element is called radioactive decay.
Parent and daughter element: The original element in radioactive decay is called parent element
Daughter element: The element formed due to radioactive decay is called daughter element.
Alpha decay: Such a decay in which charge number Z decrease by 2 and the mass number A decrease by 4 is called alpha decay. ${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$ e.g ${}^{226}_{88}Ra \rightarrow {}^{222}_{86}Y + {}^{4}_{2}He$.
Beta decay: Such a decay in which mass number does not change but charge number increase by one is called beta decay. ${}^{A}_{z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e$, e.g. ${}^{232}_{90}X \rightarrow {}^{232}_{91}PA + {}^{0}_{-1}e$
Gamma decay: Such a decay in which there is no change in charge number as well as mass number is called gamma decay. ${}^{A}_{Z}X \rightarrow {}^{A}_{Z}X^{*} + \gamma$ Radiations. E.g ${}^{60}_{28}Ni \rightarrow {}^{60}_{28}Ni + \gamma$.

WHAT IS HALF LIFE AND DECAY CONSTANT?

Half-life: The time during which half of the atoms of radioactive elements decay is called half-life.
Decay constant: The ratio of fraction of decaying atom per unit time is called decay constant, its unit is s^{-1}.

$$\lambda = \frac{-\Delta N/N}{\Delta t}.$$

Relation b/w half-life and decay constant:

$$T_{1/2} = \frac{0.693}{\lambda}.$$

Formula for finding the remaining number of atoms in half life: $\left(\frac{1}{2}\right)^{2} N_o$

Element	Half life
Uranium-238	$4.5*10^{9}$ years
Radium-226	1620 years
Radon gas	3.8 days
U-239	23.5 min

Define artificial radioactive elements? When very high energy particles are bombarded on stable elements, this excites the nuclei and nuclei after bombarding unstable the radioactive elements, such radioactive elements are called artificial radioactive elements.

What is range of alpha particle? On which factors it depend?

Range of alpha particle: An alpha particle travel a well-defined distance in a medium before coming to rest. This distance is called range of alpha particle.
Range of alpha particle depend on charge, mass, and energy of particle as well as density of medium and ionization potential.

Write the properties of alpha particles

Alpha particle has following properties

i. Alpha particle is 7000 times more massive than electron
ii. They produce fluorescence on striking some substance like ZnSetc
iii. Ionization may be due to direct elastic collision through electrostatic attraction

Write the Properties of beta particles?

There are following properties of beta particles

i. Its ionization ability is 100 times less than alpha particles

ii. Its range is 100 time more than alpha particles
iii. They produce fluorescence on striking ZnSetc

Write the Properties of gamma rays?

There are following properties of gamma particles

i. They produce little ionization as it has no charge
ii. Intensity obey inverse square law
iii. They produce fluorescence

Write Interaction of gamma rays with matter

There are three ways

i. At low energies(less than 0.5MeV), photoelectric effect is occurred at this.
ii. At intermediate energies(b/w 0.5-1.02 MeV) Compton effect
iii. At high energies (more than 1.02 MeV) pair production take place

Neutron being neutral particle has range very large as well as extremely penetrating particle.
To stop or slow a neutron must undergo a direct collision with a nucleus or some other particle that has mass comparable to that of neutron.

Multiple choice questions

1)	After two halve lives the number of decayed nuclei of an element are	N	N/2	N/4	**3N/4**
2)	Binding energy can be found by relation	$E=\Delta m/C^2$	**$E=\Delta mC^2$**	$E=1/2\ \Delta mc^2$	E=mgh
3)	Which of the following is similar to electrons	Alpha particles	**Beta particles**	Neutrino	Photon
4)	The rate of decay of radioactive substance	Remains constant with time	Increase with time	**Decrease with time**	May increase or decrease with time
5)	The element formed due to radioactive decay is called	Parent element	**Daughter element**	Mother element	Son element
6)	The energy required to break a nucleus of an atom is called	Atomic energy	Nuclear energy	**Binding energy**	Breaking energy
7)	Which one the following is not the nuclear radiations	Alpha particle	Beta particle	Gamma rays	**X – rays**
8)	Gamma rays consists of	Helium nuclei	Hydrogen nuclei	Neutrons	**Radiations similar to X-rays**
9)	Materials can be identified by measuring their	Hardness	Density	Mass	**Half life**
10)	A sample contains N radioactive nuclei. After 4 half-lives number of nuclei decayed is	N/16	**15N/16**	N/8	7N/8
11)	When alpha particle is emitted from any nucleus, its mass number ---- and its charge number ----	Increase by 2, increase by 2	Decrease by 4, increase by 2	Decrease by 4, increase by 2	**Decrease by 4, decrease by 2**
12)	Extremely penetrating particles are	Neutrons	Alpha particle	Beta particle	**Gamma particle**
13)	By emitting beta particle and gamma particle simultaneously the	Losses by 1	**Increase by 1**	Increase by 2	No charge will be

14)	nucleus change its charge by				observed
15)	Which is true for both alpha particles and gamma rays	They cause ionization in air	They can be deflected by electric field	They can be deflected by magnetic field	**They can penetrate a few millimeter of Al**
16)	Half-life of I-131 is 8 days and its weighs 20mg. after 4 half-lives, the amount left undecayed will be	2.5 mg	**1.25 mg**	0.625 mg	0.312 mg
17)	Which one of the following radiation is extremely penetrating	Alpha rays	Beta rays	**Gamma rays**	None of these
18)	The particle which has its mass number and charge number is equal to zero	Proton	Electron	Neutron	**Photon**
19)	Alpha particles consists of	**Positively charged**	Negatively charged	Neutral particles	Photons
20)	An alpha particle contains	1 proton and 1 neutron	**2 proton and 2 neutrons**	3 protons and 3 neutrons	4 protons and 4 protons
21)	Gamma emission from the nucleus of an atom causes a	Change in Z	Change in A	Change in both A&Z	**No change in A and Z**
22)	Binding energy for deuteron nucleus is given by	2.8MeV	**2.23MeV**	2.28MeV	2.25MeV
23)	Which particle has larger range in air	Alpha	Beta	Gamma	**Neutron**
24)	Alpha particle carries a charge	-e	**+2e**	-2e	No charge
25)	The speed of beta particle	10^6 m/s	**10^8 m/s**	10^5 m/s	10^7 m/s
26)	Speed of alpha particles are	10^6 m/s	10^8 m/s	10^5 m/s	**10^7 m/s**
27)	Pu has life time is	2400 years	**24000 years**	240 years	24 years
28)	The rate of decay of radioactive substance	Remains constant with time	Increase with time	**Decrease with time**	May increase or decrease with time
29)	Alpha rays of energy more than 0.5MeV can produce	Pair production	**Compton effect**	Photo electric effect	Fission process
30)	The emission of beta particle from Polonium-218 result in formation of	**Asatitine-218**	U-222	U-234	H-1

RADIATION DETECTORS

Radiation detectors: The devices which are used for the detection of nuclear radiations are called radiation detectors, for example WC chamber, GM counter, Solid state detector etc.

What is WC chamber? Write its principle.

A device which show the visible path of ionizing particles is called WC chamber.

Principle of working of WC chamber: Supersaturated vapors condense preferentially on ions and these ionizing particle passes through a region in which cloud droplet form, the droplets formed show that path as trail of droplets.
Gas is used in WC chamber: Alcohol vapors
Potential required b/w top and bottom of WC chamber: 1KV=1000 V.
What is the Track of particles in WC chamber? There are following tracks of particles in WC chamber

i. **Alpha particle:** they have thick, straight and continuous track due to intense ionization
ii. **Beta particles:** they are thin and discontinuous track in erratic manner
iii. **Gamma ray:** no definite track along the path, length of track is proportional to energy of incident particles

What is Geiger Muller Counter.

Principle of GM counter: The discharge in tube is produced due to the ionization produced by incident radiation.
Pressure gas is filled in GM counter 1/10=0.1 of atmospheric pressure.
Potential difference required in GM counter: 400 Volt
Scalar in GM counter: The counter which provides power to GM counter is called scalar.
Time required for entire electron pulse: Less than 1μs.
Dead time in GM counter : The time during which incoming particles across GM counter cannot be counted as positive ions take more time to reach the cathode due to massiveness , is called dead time. Dead time of counter is 10^{-4} sec.
Spurious count in GM counter: When positive ions strike the cathode, secondary electrons are emitted from the surface, these electrons would give counting is called spurious counting.
What is Self-quenching? Spurious counting is prevented by mixing a small amount of quenching gas with principal (Neon), this process is called self-quenching . The quenching gas must have an ionization potential lower than that of principal gas
What is Electronic quenching?Such type quenching in which large negative voltage is applied to anode after the recording of output pulse which reduced field below the critical value for ionization is called electronic quenching.
Write the Uses of GM counter? There are following uses of GM counter

i. It is used to find the range and penetration power of ionizing particles
ii. It is not suitable for fast counting due to long dead time

WHAT IS SOLID STATE DETECTOR? WRITE PRINCIPLE AND PROPERTIES.

Solid state detector: A specially designed pn junction which is used for fast enough, more efficient and accurate detection of radiations is called solid state detector.
Principle of working of solid state detector: It is based upon following principle
When radiations are allowed to enter the depletion region, electrons hole pairs are produced.
Potential is required for solid state detector: 50 V
Energy is required for producing a current pulse: 3 eV to 4 eV.
Properties of solid state detector: There are following uses of solid state detector.
1.It is useful to detecting alpha and beta particles 2. It is small in size than other detector and operate at low voltage 3. It can count very fast counting than other detectors 4. It is used for detecting low energy particles

Multiple choice questions

1	A detector can count fast and operate at low voltage is	GM counter	**Solid state detector**	WC chamber	Bubble chamber
2	GM tube can be used to detect	Charge	Mass	Charge/mass ratio	**Nuclear radiations**
3	A device which show the visible path of ionizing particle is called	GM counter	Solid state detector	Scalar	**WC chamber**
4	Specially designed solid state detector can be used to detect	Beta rays	Alpha rays	**Gamma rays**	x-rays

5	Beta particle in Wilson cloud chamber have path	**Zig zag**	Curved	Circular	Elliptical
6	In Wilson cloud chamber we use	**Alcohol vapors**	Neon gas	Bromine gas	Water vapors
7	A high potential difference of --- is used in GM counter	**400V**	1000V	50000V	4000V
8	Potential difference applied across the Wilson cloud chamber	400V	**1000V**	50000V	4000V
9	Potential difference applied across the Wilson cloud chamber	400V	1000V	**50V**	4000V
10	Energy is required for producing a current pulse	10 eV to 20 eV	30 eV to 40 eV	**3eV to 4eV**	1 to 2 eV
11	Dead time of counter is	10^{-3} sec	10^{-5} sec	**10^{-4} sec**	10^{-2} sec
11	In nuclear radiations, track of alpha particles is	Thin	Discontinuous	Erratic	**Continuous**

NUCLEAR REACTIONS

Nuclear reactions: The process which changes the structure of nucleus by the bombardment of target nucleus with some fast moving particles such as neutron or alpha particles are called nuclear reactions.

Conditions must be satisfied for nuclear reaction: There are following conditions must be satisfied for nuclear reaction taking place

i. Conservation of mass
ii. Conservation of energy

Neutron discovery: 1932 James Chadwick discovered neutron with following reaction ${}^{9}_{4}Be+{}^{4}_{2}He\rightarrow{}^{12}_{6}C+{}^{1}_{0}n$.

NUCLEAR FISSION

Define nuclear fission? Such a reaction in which a heavy nucleus like U-235 is broken into two nuclei of nearly equal size along with the emission of energy is called nuclear fission.

Nuclear reaction for fission reaction: ${}^{235}_{92}U+{}^{1}_{0}n\rightarrow{}^{141}_{56}Ba+{}^{92}_{36}Kr+3{}^{1}_{0}n+Q$.

235*0.9=**211.5 MeV** is given out in the fission of one uranium nucleus.

What is Fission chain reaction? Such a reaction which can be produced in more uranium atoms such that a fission reaction can continuously maintain itself, this process is called fission chain reaction.

What is Critical mass and critical volume? Such a mass of uranium in which one neutron, out of all the neutrons produced in one fission reaction produces further fission is called critical mass and volume of this mass of uranium is called critical volume.

What is Principle of working of atomic bomb?"If the mass of uranium is much greater then critical mass, then reaction proceeds at high speed and huge explosion is produced".

Why Cadmium is used to absorb large number of neutrons? Cadmium is an element that is capable of absorbing a large number of neutron without becoming unstable and fission reaction is controlled.

What is NUCLEAR REACTOR? Explain its principle, parts and types.

Nuclear reactor: A device in which nuclear fission chain reaction take place at constant rate in controlled manner is called nuclear reactor. It is used to produce nuclear energy.

Principle of nuclear reactor: Fission chain reaction.

Principle of working of nuclear reactor: It is like a furnace in thermal power station. Heat energy is produced in fission reaction, this energy is used to rotate turbine, and this turbine rotates the generator which produce electricity.

Core of nuclear reactor: It is the main part of nuclear reactor. Here fuel is kept in the form of cylindrical tubes.
Fuel in nuclear reactor: Uranium is used as fuel. The quantity of U-235 is increased from 2 to 4 percent.
Naturally occurring uranium U-235: Only 0.7%
Moderator in nuclear reactor: The part of nuclear reactor which slow down the speed of neutrons produced during fission process by means of fuel rods in substance of small atomic weight such as water, heavy water etc. is called moderator**.** In KANUP heavy water is used as moderator.
Types of reactors: There are two types of reactor

i. Thermal reactors
ii. Fast reactors

Thermal reactors: The thermal reactor are one in which moderator are used to slow down the fast neutrons to thermal energies so that they can produce further fission either natural or enriched uranium is used as fuel in it.
Fast reactors: The reactors in which natural uranium is used as fuel which is nearly 99% of uranium, fast neutron can produce fission, so moderators are not required in fast reactors.
Enriched uranium: Such a uranium in which percentage of U-235 is greater than its percentage in natural uranium is called enriched uranium.

FUSION REACTION

Define Fusion reaction?Such a nuclear reaction in which two light nuclei merge to form a heavy nucleus is called fusion reaction.
What are the Methods for producing fusion reaction?There are following methods

i. By using accelerator
ii. By increasing temperature

Multiple choice questions

1	In a fast nuclear reactor U-238 absorb a fast neutron and is ultimately transformed into --- by emitting beta particles	U-238	**Pu-239**	Pb-208	Th-232
2	Which of the following isotopes of natural uranium undergoes a fission reaction with slow neutrons	U-234	**U-235**	U-238	None of these
3	The PU-239 breeder reactor is called	ACR	**PWR**	LMFBR	HWR
4	Hydrogen bomb is an example of	Nuclear fission	Nuclear fusion	Chemical reaction	**Fission Chain reaction**
5	The process by which a heavy nucleus splits up into lighter nuclei is called	**Fission**	Fusion	Alpha decay	A chain reaction
6	Energy liberated when one atom of uranium undergoes fission reaction is	28MeV	60MeV	140MeV	**200MeV**
7	The energy emitted from sun is due to	Fission reaction	**Fusion reaction**	Chemical reaction	Pair production
8	Which nuclear reaction takes place	Fission	Chemical	**Fusion**	Mechanical

	in the sun and stars				
9	Nuclear fission chain reaction is controlled by using	Steel rods	Graphite rods	**Cadmium rods**	Platinum rods
10	The energy released by fusion of two deuterons into helium nucleus is about	**24MeV**	200MeV	1.02 MeV	7.7MeV

RADIATION EXPOSURE

What are Cosmic rays?Cosmic radiation consists of large energy charge particles and electromagnetic radiations.

How Ozone layer is most important?The ozone layer and atmosphere acts as a shield against radiations and absorb ultraviolet rays which can cause eye and skin diseases.

How Depletion of ozone layer suspected? The depletion of ozone layer is suspected due to use of some chemicals in atmosphere such CFC used in refrigeration, aerosol spray and plastic foam industry.

What are the Sources of radiation exposure

There are following sources of radiation exposure

i. Nuclear waste of reactor
ii. Hospital, research and industrial units
iii. Television
iv. Luminous watches
v. Tobacco leaves

BIOLOGICAL EFFECTS OF RADIATIONS(Definitions)

Activity of radioactive elements: Number of disintegrations per unit time is called activity of radioactive element.

Becquerel (Bq): One Bq is equal to one disintegration per second.

Curie: Curie is larger unit. One curie is equal to $3.7*10^{10}$Bq.

Radioactive absorbed dose: The amount of energy absorbed from an ionizing radiation per unit mass of absorbing body is called absorbed dose. D= energy absorbed/ mass D= E/m, its SI unit is Gray.

Gray and rad: The amount of energy equal to one joule absorbed by a body of mass 1kg is called gray. 1Gy= 1J/kg

And one rad=0.01 Gy.

Equivalent dose: The product of RBE and absorbed dose is called equivalent dose. De=RBE*D/

Sv and rem:SI unit of equivalent dose is Sievert, 1Sv=1Gy*RBEAnd old unit is 1rem=0.01 Sv

Amount of radiations is normally considered safe:1mSv

Diseases are caused by low level radiations: Low level radiations can cause diarrhea, vomiting and fever known as radiations sickness, loss of hair, ulceration, stiffening of lungs and drop in white blood cells.

BIOLOGICAL AND MEDICAL USES OF RADIATIONS

Write the Uses of radioisotopes?

There are following uses of radioisotopes

i. To study complex reactions and chemical reactions taking place in plants and animals
ii. To measure amount of fertilizer absorbed by plant
iii. To improve varieties of crops such as rice
iv. To improve the structure of plants

Write Uses of radioactive tracer?

There are following uses of radioactive tracer

i. **In medicine**: It is used to detect malignant tumors
ii. **In agriculture**: It is used to uptake the fertilizer by a plant

iii. In understanding the complex process of photosynthesis
iv. In identification of faults in underground pipes of fountain system

Which isotope is used for blood circulation checking: Sodium-24
Which isotope is used to cure cancer in radiotherapy: Cobalt-60
Which isotopes is used to cure thyroid cancer: Iodine-131 is used
Which isotope is used for skin cancer: Phosphorous-32, strontium-90
What is Radiography? "Such a technique which is used for producing a photographic image of an opaque specimen by transmitting a beam of X-ray or gamma rays, it is also used for internal imaging of brain is called radiography".

BASIC FORCES OF NATURE

Write the names of any four Basic forces of nature: There are following basic forces of nature

i. Gravitational force
ii. Magnetic force
iii. Electric force
iv. Weak nuclear force
v. Strong nuclear force

Faraday and Maxwell unified the electric and magnetic force.
Strong nuclear force It is short range force which kept the nucleus stable and range of 10^{-15} m.
Electromagnetic force: It is long range force cause all chemical reactions, binds all atoms, molecules, crystals, tree, building and man. It cause friction, cohesion, adhesion.
Weak nuclear force: It is short range force responsible for transition of radioactive elements. It is repulsive force of range 10^{-17}m.
Gravitational force: It is long range force which kept the atmosphere and sea fixed to surface of earth, it give rise to ocean tides and forces earth to orbit around sun.
Unification of electromagnetic and weak forces: In 1979, Glashow, Weinberg and Abdul Salam unified electromagnetic force and weak nuclear force and won the Nobel Prize.

BUILDING BLOCK OF MATTER(definitions)

There are three types of subatomic particles
i. Photons
ii. Leptons
iii. Hadrons

All photons and leptons are elementary particles and hadrons are composed of quarks
Hadrons: These are the particles that experience strong nuclear force.e.g protons, neutrons, mesons are hadrons.
Baryons: The particles equal in mass or greater than protons are called baryons.
Mesons: The particles lighter than protons are called mesons
Leptons: The particles which do not experience strong nuclear force like electrons, muons and neutrino are leptons.
Quark theory was given by M Gell Mann and G zweig

Multiple choice questions

1	Two up and one down quarks make	**Proton**	Neutron	Electron	Meson
2	3 quarks make a	Proton	Neutron	Electron	**Baryon**
3	One up and two down quark makes a	Proton	**Neutron**	Electron	Baryon
4	Which is used for monitor radiations received by worker in nuclear facilities	**Film badge dosimeter**	Radiation detector	x-ray source	Potentiometer

5	Radioactive waste are of ----types	**3**	4	5	6
6	On what surface ozone becomes vital to life as it absorb all UV radiations	10-20 km	20-25 km	**20-50 km**	20-30 km
7	UV radiations cause	Sunburn	Blindness	Skin cancer	**All of these**
8	RBE for heavy recoil nuclei	10	2	**20**	15
9	Two down and one up quarks make	Proton	**Neutron**	Photon	Positron
10	A pair of quark and anti quark makes a	Proton	Neutron	Electron	**Meson**
11	Which of the following belongs to “hadrons” group	**Protons**	Electrons	Muons	Neutrinos
12	One curie is equal to	$3.70x10^{-10}$Bq	**$3.70x10^{10}$ Bq**	1 Bq	103 Bq
13	For a person absorb average radiations doses by watching television during one year	50mSv	40mSv	30mSv	**10mSv**
14	The number of Quarks are	2	3	4	**6**
15	Dr. Abdul Salam unified electromagnetic force and	**Weak nuclear force**	Strong nuclear force	Magnetic force	Gravitational force
16	One joule of energy absorbed in a body per kilogram is equal to	One rad	One rem	**One gray**	One Sievert
17	Thyroid gland plays a major role in the distribution of	**Iodine**	Glycerin	Germanium	All of these
18	Three up quarks combine to form a new particle, the charge no on this particle is	**2**	3	4	5
19	Which group belong to hadrons	Protons and neutrons	**Mesons and neutrons**	Photons and electrons	Positron and electrons
20	The old and new units of absorbed dose are related by	1Gy=10 rad	**1Gy=100 rad**	1Gy= 1000 rad	1Gy=10000 rad
21	The maximum safe limit dose for person working in nuclear reactor is	**1 rem**	2 rem	3 rem	5 rem
22	Mass of meson is	Greater than proton	**Less than proton**	Equal to proton	Equal to neutron
23	Which one belongs to leptons group	Electron	Muons	Neutrinos	**All of these**
24	A pair of quark and anti-quark makes	**Meson**	Baryon	Photon	Proton
25	A particle is made up of two up quarks and one down quark is	**Proton**	Neutron	Boson	Lepton

26	Which of the following are elementary particles	Protons	Neutrons	**Photons**	Mesons
27	Three up quarks combine to form a new particle the charge on this particle	1	**2**	3	4
28	SI unit of absorbed dose is	**Gray**	Roentgen	Curie	Rem
29	An electric eye operates because of	Compton effect	Photo refraction	**Photo electric effect**	Gamma ray counter
30	Thyroid cancer is caused by	C-14	Na-24	**I-131**	Co-60
31	Color TV (while operating) emits	Alpha rays	Beta rays	Gamma rays	**X-rays**

Tid bits

What were the results of alpha scattering experiment: From alpha particles scattering experiment Rutherford discovered that most of part of atom is empty and max mass is concentrated in a very small region called nucleus.

Isotopes of Xenon and cesium have: Both have 36, 36 isotopes.

Beta decay occur: It occur when a neutron in an unstable parent nucleus decay into a proton and electron, the electron being emitted as beta particle.

Range and benefit of ozone: It is on the surface is Earth and corrosive and poisonous gas but at height of 20-50km from earth surface, it become vital to life as it absorb almost all UV radiations which are harmful to living things/

Diseases caused by ultraviolet radiations: UV radiations cause

i. Sunburn, blindness and skin cancer
ii. Severe crop damage
iii. Decay of micro organism
iv. Disrupt the ocean ecosystem

Device is used to monitor radiations received by worker in nuclear facilities: Film badge dosimeter

Types of radioactive waste: There are three types of radioactive waste. High level, medium level, and low level. All these wastes are dangerous for ground water and land environment

Half-life of Pu: 24,000 years

Table regarding mcqs

Isotope	Half life	Example of use
Sodium-24	15 hours	Plasma volume
Iron-59	45 days	Iron in plasma
Te-99	6 hours	Thyroid scans
I-131	8 days	Kidney tests
I-125	60 days	Plasma volume vein flow

properties	Alpha particles	Beta particles	Gamma rays
Nature	Helium nuclei charge 2e	Electron or positron charge ±e	EM waves with no charge
Typical source	Radon-222	Strontium-94	Cobalt-60
Ionization	About 10^4	About 10^2	About 1
Range in air	Several centimeters	Several meters	Obey inverse square law
Absorbed by	A paper	1-5 mm of Al sheet	1-10 cm of lead sheet
Energy spectrum	Emitted with same energy	Variable energy	Variable energy
Speed	10^7 m/s	$1*10^8$ m/s	$3*10^8$ m/s

The half-life of $^{91}_{38}Sr$ is 9.70 hours. Find its decay constant.

Given data : Half life $= T_{1/2} = 9.70h = 9.70*60*60 = 34920$ sec, Decay constant $= \lambda = ?$

$$\lambda = \frac{0.693}{T_{1/2}} = \frac{0.693}{34920} = 1.98*10^{-5}\, s^{-1}$$

The element $^{234}_{91}Pa$ is unstable and decays by β-emission with a half-life 6.66 hours. State the nuclear reaction and the daughter nuclei.

Given Data : Nuclear reaction = ? Daughter nuclei = ?

Using eq of β decay $^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}\beta$

$^{234}_{91}P \rightarrow {}^{234}_{92}U + {}^{0}_{-1}\beta$ Parent element $= {}^{234}_{91}P$, Daughter element $= {}^{234}_{92}U$

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21.6: If $^{233}_{92}U$ decays twice by α-emission, what is the resulting isotope?

Using eq of α decay $^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$ in $^{233}_{92}U$

after first decay $^{233}_{92}U \rightarrow {}^{229}_{90}Y + {}^{4}_{2}He$, after 2nd decay $^{229}_{90}X \rightarrow {}^{225}_{88}Y + {}^{4}_{2}He$

Resulting isotope $^{225}_{88}Y$ radium - 88 is formed.

EXERCISE SHORT QUESTIONS

1.What are isotopes? What do they have in common and what are their differences?**

Isotopes are those nuclei, which have same atomic number but have different mass number.

i. The isotopes have the same number of protons and have different number of neutrons.
ii. They have same chemical properties but different physical properties

2.Why are heavy nuclei unstable?**

The heavy nuclei have very small value of their binding energy per nucleon. So they are unstable, and less energy is required to break it. For example U-238.

3. If a nucleus has a half-life of 1 year, does this mean that it will be completely decayed after 2 years? Explain.**

No, it does not mean that it will completely decay after 2 years. Because infinite time is required to decay completely. And after two half-life only 75% atoms will be decayed.

4.What fraction of a radioactive sample decays after two half-lives have elapsed?**

¾ of radioactive sample decay after two half lives

If n is number of half-lives, N_o is original no of atoms

Number of undecayed atom after n half-lives = $(1/2)^n N_o$

Put n=2, = $(1/2)^2 N_o = N_o/4$ = No/4*100=25%So number of decayed atoms=75%

5.The radioactive element $^{226}_{88}Ra$ has a half-life of 1.6×10^3 years. Since the Earth is about 5 billion years old, how can you explain why we still can find this element in nature?

We still can find Ra-226 in nature because there is an infinite time required to for an element to decay completely.

6.Describe a brief account of interaction of various types of radiations with matter.**

There are three ways

i. At low energies(less than 0.5MeV), photoelectric effect is occurred at this.
ii. At intermediate energies(b/w 0.5-1.02 MeV) Compton effect
iii. At high energies (more than 1.02 MeV) pair production take place.

7. Explain how α and β-particles may ionize an atom without directly hitting the electrons? What is the difference in the action of the two particles for producing ionization?

There are following methods for ionization by alpha and beta particles without hitting

i. It may ionize an atom by pulling the electron through electrostatic attraction
ii. Beta particles may ionize by electrostatic repulsion

Because alpha particle attract electrons and beta particle repel electron due to same charge.

8. ** **A particle, which produces more ionization, is less penetrating? Why?**
A particle which produces more ionization is less penetrating because it loses most of its energy in ionizing the atoms. So, it travel very small distance in medium before coming to rest.
9.What information is revealed by the length and shape of the tracks of an incident particle in Wilson cloud chamber?**

i. **Alpha particle:** they have thick, straight and continuous track due to intense ionization
ii. **Beta particles:** they are thin and discontinuous track in erratic manner
iii. **Gamma ray:** no definite track along the path, length of track is proportional to energy of incident particles

10.Why must a Geiger Muller tube for detecting α-particles have a very thin end window? Why does a Geiger Muller tube for detecting γ -rays not need a window at all?
It detect alpha particle because this window provides easy way for these low penetrating particles, to enter into the tube.
For detecting rays, there is no need of such a window because rays are highly penetrating
11. ** **Describe the principle of operation of a solid-state detector of ionizing radiation in terms of generation and detection of charge carriers.**
It is based upon following principle
"When radiations are allowed to enter the depletion region, electrons hole pairs are produced that generate current pulse used for detection process".
12. What do we mean by the term critical mass?**
Such a mass of uranium in which one neutron, out of all the neutrons produced in one fission reaction produces further fission is called critical mass.

13. Discuss the advantages and disadvantages of nuclear power compared to the use of fossil fuel generated power

Nuclear power	Fossil fuel power
It is cheaper for electricity	It is not cheaper
It is permanent for a given period of time	It is not permanent and not for long period of time
It does not produce smoke	It produces smoke
It is of large amount	It is not of large amount

Disadvantages it is dangerous and injurious and harmful to living things.
14. ** **What factors make a fusion reaction difficult to achieve?**
The fusion reaction requires temperature up to 10 million degree centigrade and high energy. These requirements are very difficult to achieve.
15. Discuss the advantage and disadvantages of fusion power from the point of safety, and resources.
Advantage: As the fusion reaction is free from radioactive fossil products, so it is not dangerous. It also gives more energy per nucleon as compared with nuclear fission reaction.
Disadvantage: The fusion reaction requires temperature up to million degree centigrade and high energy. These requirements are very difficult to achieve
16. What do you understand by "background radiation"? State two sources of this radiation.**
The radiation present due to cosmic rays and due to presence of radioactive materials under crest of earth, are called background radiations. Two sources of radiations
Radioactive potassium and carbon in body.
17.If someone accidently swallow an α-source and a β-source, which would be the more dangerous to him? Explain why?
Alpha source will be more dangerous than beta source. It is because that ionizing power of alpha particle is greater than beta particle.
18. Which radiation dose would deposit more energy to the body (a) 10 mGy to the hand, or (b) 1 mGy dose to the entire body?
As we know that absorbed dose=energy/mass
Energy=m*D, as energy is proportional to mass so mass of whole body is much greater than hand, so 1mGy deposit more energy.

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19. What is a radioactive tracer? Describe one application each in medicine, agriculture and industry.

Use of radioisotopes behave as normal isotopes in living organism to find what happens in chemical and biological process is called radioactive tracer

The use of phosphorous or nitrogen as a tracer has helped to adopt a better mode of fertilizer supply to plants.

Radioactive iodine can be used to check that a person's thyroid gland is working properly or not. A similar method can be used to study the circulation of blood using sodium-24.

20. How can radioactivity help in the treatment of cancer?**

Radiotherapy with gamma rays from cobalt -60 is used in treatment of cancer of various types. These radiations are carefully focused on malignant tissues. Cancerous cells absorb more radiations and more easily destroyed than normal cells, also thyroid cancer is treated withI-131, and for skin cancer P-32 and Strontium-90 are used

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