7. (b) $_3Li^6 + _0n^1 \rightarrow _2He^4 + _1H^3$

8. (c) $_7N^{14} + _0n^1 \rightarrow _6C^{14} + _1H^1$

9. (c) $_{17}Cl^{37} + _1H^2 \rightarrow _{18}Ar^{38} + _0n^1$

10. (d) Because of its high unstability.

12. (c) $_{90}Th^{234} \xrightarrow{-\beta} _{91}X^{234} \xrightarrow{-\beta} _{92}Y^{234} \xrightarrow{-\alpha} _{90}Z^{230}$.

13. (c) Isotopes of an element have similar chemical properties but different physical properties.

14. (c) A nuclear reaction must be balanced in terms of mass and energy.

15. (c) $_{52}Te^{130} + _1H^2 \rightarrow _{53}I^{131} + _0n^1$

16. (c) The emission of positron takes place.

18. (c) An ion is electrically charged atom or a group of atoms.

19. (a) Charge on positron and proton is about $+1.602\times10^{-19}\,C$.

20. (b) $_{12}Mg^{24} + _2He^4 \rightarrow _0n^1 + _{14}Si^{27}$

21. (b) The radioactive isotope $_6C^{14}$ is produced in the atmosphere by the action of cosmic ray neutrons on $_7N^{14}$

$_7N^{14} + _0n^1 \rightarrow _6C^{14} + _1H^1$

23. (b) Tritium is the isotope.

24. (d) $_{21}Sc^{45}(n,p)\,_{20}Ca^{45}$ according to Beath's notation

25. (c) $_7N^{14} + _1H^1 \rightarrow _8O^{15} + \gamma$

26. (c) $_{93}Np^{239} \rightarrow _{94}Pu^{239} + _{-1}e^o$

27. (b) Equate atomic no. and mass no.

28. (c) Magic no. are 2, 8, 20, 28, 50 and 82 protons in nucleus or 2, 8, 20, 28, 50, 82, 126 neutrons in nucleus. These numbers imparts stability to nucleus.

30. (a) $\frac{n}{p}$ of $_{82}Pb^{208} = \frac{126}{82} = 1.53$

$\frac{n}{p}$ of $_{83}Bi^{209} = \frac{126}{83} = 1.51$

31. (c) According to Beath's notation $_{13}Al^{27}(n,p)\,_{12}Mg^{27}$.

32. (d) Azimuthal quantum no. is related to angular momentum.

33. (b) The value of $n = \frac{238-218}{4} = \frac{20}{4} = 5-1 = 4$

34. (d) Mass number increases by one unit.

36. (b) Equal atomic number and mass number.

37. (b) 1 *amu* = 931.478 *MeV*.

38. (a) Positron is anti-particle of electron.

39. (a) Isotopes are formed by the emission of one α - and two β - particles respectively.

40. (a) The $\frac{n}{p}$ ratio of stable nucleoide is $\frac{n}{p} = 1$.

41. (b) Neutrino have no mass and no charge and thus known as ghost particles.

42. (b) Equate mass number and atomic number on both sides.

43. (a) Due to mass decay.

44. (d) Mesons (μ) have 200-300 times mass of electron and + *ve*, 0 or – *ve* charges.

45. (b) $_{+1}e^o$ is positron.

46. (d) *Pb* is the most stable atom.

47. (b) Anderson discovered positron in 1932.

48. (a) Even-Even are most stable
Odd- Odd are most unstable

49. (b) The atom which have lower value of packing fraction is stable.

50. (d) Number of neutrons in $_{88}Ra^{226} = 226 - 88 = 138$.

51. (d) Nuclear reactions involves exchange of nuclear energy.

52. (a) $_{11}Na^{23} + _1H^1 \rightarrow _{12}Mg^{23} + _0n^1$

53. (b) $_{92}U^{235}$ is radioactive because it is most unstable.

54. (c) Equate atomic no. and mass no.

57. (b) $_4Be^9 + _2He^4 \rightarrow _6C^{12} + _on^1$

58. (d) According to group displacement law.

59. (b) $^9_4Be + _1H^1 \rightarrow ^6_3Li + _2He^4$
(p) $(\alpha - particle)$

60. (c) $^{40}_{18}Ar$ having 40 – 18 = 22 neutrons

While $^{40}_{21}Sc$ having 40 – 21 = 19 neutrons.

61. (b) Nuclear reactivity depends upon the number of protons and neutrons.

63. (d) $_{29}Cu^{64} \rightarrow _{28}Ni^{64} + _{+1}e^0$

65. (a) $^{24}_{12}Mg + _1D^2 \rightarrow _2He^4 + ^{22}_{11}Na$

66. (b) Equate atomic no. and mass no.

67. (a) $_{96}X^{227} \rightarrow Y + 4\alpha + 5\beta$

On equating mass number

227 = y + 4 × 4 + 0, $y = 211$

On equating atomic number

96 = y + 2 × 4 – 5, y = 93.

68. (a) Meson was discovered by Yukawa

Radioactivity and α, β and γ- rays

1. (c) γ – rays does not contain material particles.

2. (d) γ -rays are neutral energy packet.

3. (a) The order of penetrating power is : $\alpha < \beta < \gamma$-rays. It is due to lower mass and high speed.

4. (b) α-rays travel with a velocity which is $\frac{1}{10}$ *th* to $\frac{1}{20}$ *th* of that of light.

5. (c) γ-rays have maximum penetrating power.

6. (b) α-particles are 4 time heavier than neutrons.

7. (c) $_{92}U^{235} + _0n^1 \rightarrow _{56}Ba^{145} + _{36}Kr^{88} + 3^1_0n$

8. (c) Rutherford first of all used zinc sulphide (*ZnS*) as phosphor in the detection of α-particles.

9. (b) α-rays consist of a stream of He^{2+}.

10. (b) α-rays are positively charged, β-rays are negatively charged, γ-rays carry no charge and thus not deflected in field.

11. (a) α-particle is identical with $_2He^4$ helium nucleus.

12. (a) γ-rays have maximum penetrating power.

13. (a) Henry Becquerel noticed the emission of penetrating rays from potassium uranyl sulphate and Madam Curie named it as radioactivity.

15. (c) Penetrating powers $\alpha - \text{rays} < \beta - \text{rays} < \gamma - \text{rays}$

17. (a) α-rays are positively charged, β-rays are negatively charged, γ-rays carry no charge.

20. (b) Deflection in β -rays is large.

21. (a) Penetrating power of α -rays are less than β, γ and *X*-rays.

22. (c) Lead is a stable isotope.

23. (d) Neutrons carry no charge.

24. (b) α-rays has least penetrating power.
25. (c) γ -rays carry no charge.
26. (d) Proton is not emitted by radioactive substances.
27. (d) Due to it's nature.
28. (c) $_{88}Ra^{226}$ is radioactive because $\frac{n}{p}$ ratio for it is 1.56 which is greater than 1.5.
30. (a) $Cf-98$ belongs to actinid series.
31. (d) Photons are not carry any charge.
32. (c) $_7N^{14} + _2He^4(\alpha - \text{particle}) \rightarrow _8O^{17} + _1H^1$
33. (a) Definition of binding energy.
34. (b) α – particle is $_2He^4$.
35. (a) Gamma ray doesn't deviate from electromagnetic field, the main reason of it is that there is no charge on gamma rays.
36. (c) Energy liberated = loss of mass $\times$ 931
$= 0.01864 \times 931 = 17.36\, MeV$
38. (acd) Beta emission causes increase in atomic number by one unit.
39. (a) Mass loss = mass of reactant – mass of product.
$= (2.014 + 3.016) - (4.004 + 1.008)$
$= 5.030 - 5.012 = 0.018\, amu$

Causes of Radioactivity and Group Displacement Law

1. (b) In $_{95}Am^{241}$ the mass no. division by four gives a residue of 1.
In $_{90}Th^{234}$ the mass no. division by four gives a residue of 2.
2. (d) On emission of α -particles daughter element shift 2 group to the left. On emission of β -particles daughter element shift 1 group to the right.
3. (d) Protons + Neutrons = Nucleons
4. (d) Radioactivity is characteristic property of unstable nucleus.
5. (c) Chemical change is extra nuclear phenomenon.
6. (c) $_{92}U^{238} \xrightarrow[-6\beta]{-8\alpha} _{82}X^{206}$
Number of protons = 82; Number of neutrons = 124
Neutron/proton ratio in the product nucleus $= \frac{124}{82} = \frac{62}{41}$
7. (c) $_{84}X^{218} \rightarrow _{84}Y^{214} + x\, _{+2}\alpha^4 + y\, _{-1}\beta^0$
no. of α-particle = $\frac{218-214}{4} = \frac{4}{4} = 1$
no. of β-particle = $84 - 84 + 2 \times 1 = 2$.
8. (a) When an α-particle is emitted by any nucleus than atomic weight decreases by four units and atomic number decreases by two units
$_{88}Ra^{224} \xrightarrow{-\alpha} _{86}X^{220}$
9. (b) Number of α-particles = $\frac{231-207}{4} = 6$
Number of β-particles $= 89 - 82 - 2 \times 6 = 5$.
10. (a) $_{90}Th^{228} \rightarrow _{83}Bi^{212}$
No. of α -particles = $\frac{228-212}{4} = \frac{16}{4} = 4$
No. of β -particles = $90 - 83 - 2 \times 4 = 1$.
11. (a) $_6C^{14} \rightarrow _7N^{14} + _{+1}e^0$
No. of neutrons in $C^{14} = 14 - 6 = 8$.
12. (c) $_{92}X^{238} \xrightarrow{-\alpha} _{90}Y^{234}$
Number of neutrons = $234 - 90 = 144$.
13. (d) $_ZA^m \rightarrow _{Z+1}B^m + _{-1}e^0$
14. (b) $r = \lambda.N$
15. (a) $_0n^1 \rightarrow _{+1}P^1 + _{-1}e^0$ (β -particle comes out)
16. (a) Element 57 to 71 are placed in III group.
17. (a) $_5X^{14} \xrightarrow{-2\beta} _7N^{14}$ than no. of neutrons in $_5X^{14} = 14 - 5 = 9$.
18. (a,b,c) An emission of β-particle means that atomic number increases by 1 but mass number remains unaffected and neutron- proton ratio decreases.
19. (c) Suppose the no. of α-particles emitted = x and the no. of β-particles emitted = y, then
$_{92}U^{238} \rightarrow _{82}Pb^{206} + x\, _{+2}\alpha^4 + y\, _{-1}\beta^0$
Equating the mass number on both sides, we get
238 = 206 + 4x + 0y or 4x = 32 or $x = \frac{32}{4} = 8$
Hence 8 α-particles will be emitted.
20. (c) Pb is the end product of each natural radioactive series.
21. (b) The $\frac{n}{p}$ ratio of $_{13}Al^{29}$ places it above the belt of stability and thus it emits β -particles.
22. (d) $_YA^X \rightarrow _{Y-10}B^{X-32} + m\, _2He^4 + n\, _{+1}e^0$
Value of m = $\frac{X-(X)-32}{4} = 8$
Value of n = $Y - Y - 10 - 2 \times 8 = 6$.
23. (d) During β -decay atomic mass is unaffected while atomic no. increases by one unit.
24. (a) Equate atomic number and mass no.
25. (b) $_{90}X^{232} \xrightarrow{-2\beta} _{92}Y^{232} \rightarrow _{82}Z^{212} + x\, _2He^4$
No. of α -particles $= \frac{232-212}{4} = \frac{20}{4} = 5$.
26. (d) $_{92}X^{238} \xrightarrow{-\alpha} _{90}Y^{234} \xrightarrow{-\beta} _{91}Z^{234}$
no. of neutrons = 234 – 91 = 143.
27. (b) $\underset{\text{Gr. 2}}{_ZA^M} \xrightarrow{-\alpha} \underset{\text{Gr. 18}}{_{Z-2}B^{M-4}} \xrightarrow{-\alpha} \underset{\text{Gr. 16}}{_{Z-4}C^{M-8}}$.
28. (b) Equate atomic no. and mass no.
29. (b) The mass no. on division by four gives a residue of 2.
30. (a)

Series	Name of the series	Parent element	End stable element
$4n$	Thorium series	Th-232	Pb–208
$4n+1$	Neptunium series	Pu-241	Bi–209
$4n+2$	Uranium series	U-238	Pb–206
$4n+3$	Actinium series	U-235	Pb–207

31. (a) $_8O^{16} + _1H^2 \rightarrow _9F^{18}$
32. (a) $_{84}A^{218} \rightarrow _{84}B^{214} + _2He^4 + 2\, _{-1}e^0$.
33. (c) It is also called Soddy and Fajan rule.
34. (b) $_{84}Po^{215} \rightarrow _{82}Pb^{211} + _2He^4$
35. (a) $_{92}U^{238} \rightarrow _{90}Th^{234} + _2He^4$

36. (b) $N = \frac{N_o}{2^n}$ and $n = \frac{24}{8} = 3$

$N = \frac{40}{2^3} = \frac{40}{8} = 5$

37. (c) $_{20}Ca^{42} \rightarrow _{21}Sc^{42} + _{-1}e^0$

38. (b) $_AX^M \xrightarrow{-\alpha} _{A-2}Y^{M-4}$

39. (c) $^{24}_{12}Mg + \gamma \longrightarrow ^{23}_{11}Na + ^1_1H$.

40. (d) An element formed by losing one α-particle occupies two position left to parent element, *Pb* in IVA, thus *Po* should be in VIA.

41. (a) According to group displacement law.

42. (b) Number of α-particles = $\frac{238-206}{4} = 8$

Number of β-particles = $92 - 82 - 2 \times 8 = 6$.

43. (c) $_{40}X \rightarrow _{41}Y + _{-1}e^0$ (β-emission)

44. (c) $n = \frac{90}{30} = 3 \Rightarrow N = \frac{600}{2^3} = 75$ atoms .

45. (d) Equate mass no. and atomic no.

46. (b) $_{92}U^{236} \rightarrow _{90}X^{232} + _2He^4$

$_{90}X^{232}$ have 90 protons and 142 neutrons.

47. (b) α-rays have high I.P. due to high kinetic energy.

48. (d) Going two positions back from 2nd group gives zero group.

49. (a) *Ra* belongs to $(4n+2)$ series. End product will also belong to the same series.

50. (d) *Ra* contaminated with uranium mineral shows appreciable radioactivity.

51. (a) $_{92}U^{238} \rightarrow _{82}Pb^{206} + x\ _{+2}\alpha^4 + y\ _{-1}\beta^0$

no. of α-particles = $\frac{238-206}{4} = 8$

no. of β-particles = $92 - 82 - 2 \times 8 = 6$

Total no. of particles = $8 + 6 = 14$.

52. (a) According to Group displacement law.

53. (d) Rate = λ × number of atoms.

54. (d) $_{90}Th^{232} \rightarrow _{82}Pb^{208} + x\ _2He^4 + y\ _{-1}\beta^0$

Equating mass no.

232 = 208 + 4x + 0 y or 4x = 24 or x = 6

Equating atomic no.

90 = 82 + 2x – y or 90 = 82 + 2 × 6 – y or $y = 4$

Hence 6α and 4β particles will be emitted.

55. (b) $_ZA^m \rightarrow _{Z+1}B^m + _{-1}e^0$

56. (a) The mass no. division by four gives a residue of 1

57. (d) $_AX^m \xrightarrow{-\beta} _{A+1}Y^m$

58. (c) Suppose the no. of α-particles emitted $= x$ and the no. of β-particles emitted =y. Then

$_{92}U^{238} \rightarrow _{82}Pb^{206} + x^4_{+2}\alpha + y\ ^0_{-1}\beta$

equating the mass number on both sides, we get

238 = 206 + 4x + 0 y or 4x = 32, x = 8

equating the atomic number on both sides, we get

92 = 82 + 2x – y

92 = 82 + 2× 8 –y

y = 6

Hence 8α and 6β are emitted.

59. (c) $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{1000s} = 0.000693 = 6.93 \times 10^{-4}\ s^{-1}$

60. (a) *Bi* is a stable end product of Neptunium series.

62. (c) *Pb* – 208 is the stable end product of thorium series.

63. (d) Definition of disintegration series.

64. (d) $_6X^{14} \xrightarrow{\beta} _{6+1}N^{14}$

in $_6X^{14}$ no. of neutrons 14 – 6 = 8.

65. (a) $_{18}Ar^{40}$

Total no of protons = 18

Total no of neutrons = 22

Mass defect $= [m \times p + m \times n] - 39.962384$

$= [1.007825 \times 18 + 1.008665 \times 22] - 39.962384$

$= [18.14085 + 22.19063] - 39.962384 = 0.369$

Binding energy = mass defect × 931

$= 0.369 \times 931 = 343.62\ MeV$

66. (d) $_{90}Th^{232} \longrightarrow _{82}Pb^{208}$

No. of α - particle $\Rightarrow \frac{232-208}{4} = 6$

No. of β - particle $\Rightarrow 82 - [90 - 6 \times 2] = 4$

67. (b) $_{92}M^{238} \longrightarrow _yN^x + 2\ _2He^4$

$_yN^x \longrightarrow _BL^A + 2\beta^+$

$_yN^x = _{(92-2\times2)}N^{(238-4\times2)} = _{88}N^{230}$

$_{88}N^{230} \xrightarrow{2\beta^+} _{(88-2)}L^{(230)} = _{86}L^{230}$

Total no of neutrons in $_{90}L^{330}$

$230 - 86 = 144$

68. (c) $_{90}E^{232} \longrightarrow _{86}G^{220}$

No. of α particle = $\frac{232-220}{4} = 3$

No. of β particle $= 86 - [90 - 2 \times 3] = 2$

69. (b) $K = \frac{0.693}{t_{1/2}} = \frac{0.693}{1600}$

$= 4.33 \times 10^{-4}\ year^{-1}$

70. (a) $_{92}U^{238} \longrightarrow _{90}Th^{234} \longrightarrow _{91}Pa^{234}$

No. of α particle $= \frac{238-234}{4} = \frac{4}{4} = 1$

No. of β particle $= 91 - 90 = 1$

72. (c) $K = \frac{0.693}{t_{1/2}}$

$t_{1/2} = \frac{0.693}{K} = \frac{0.693}{0.58} \Rightarrow 1.2\ hrs$

73. (d) A radioisotope first emits α or β particles, then it becomes unstable and emits γ -rays.

74. (a) $^{180}_{72}X \xrightarrow{2\alpha} ^{172}_{68}P \xrightarrow{\beta} ^{172}_{69}Q \xrightarrow{\gamma} ^{172}_{69}X$.

75. (b) Loss of beta particle is equivalent to decrease of one neutron only.

$n \to p + e^- + \bar{v}$.

Rate of decay and Half-life

1. (c) $n = \frac{16}{8} = 2,\ N = \frac{N_o}{2^n} = \frac{16.0}{2^2} = \frac{16.0}{4} = 4.0\,gm.$

2. (a) Mass of 6 neutrons = 6.05358 *amu,* Mass of 6 protons = 6.04884 *amu,* Mass of n + Mass of p =12.10242 *amu*
Mass defect = 12.10242 – 12.00710 = 0.09532
Binding energy = 0.09532 × 931 = 88.74292 *MeV.*
Binding energy per neucleon = 88.74292/12
=7.39 *MeV*

3. (b) $T = t_{1/2} \times n,\ \therefore\ n = \frac{80}{20} = 4$

Amount left $= \frac{1}{2^n} = \frac{1}{2^4} = \frac{1}{16}$.

4. (a) ${}_{92}X^{232} \to {}_{89}Y^{220} + x\,{}_2He^4 + y\,{}_{-1}e^o$

no. of α -particles = $\frac{232-220}{4} = 3$

no. of β -particles = 89 –[92 – 2 × 3] = 3.

5. (d) It is occurs by β -decay.

6. (a) $N = \left[\frac{1}{2}\right]^n \times N_o$ = 125 *mg* = $\left(\frac{1}{2}\right)^n \times 1000\,mg$

$\left(\frac{1}{2}\right)^n = \frac{125}{1000} = \frac{1}{8}$

$\left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^3, n = 3,$ so number, of $t_{1/2} = 3$

Total time = 24 hours, Half-life time $= \frac{24}{3} = 8$ hours .

8. (d) ${}_{35}X^{88} \xrightarrow{-\beta} {}_{36}W^{88} \to {}_{36}W^{87} + {}_on^1$

9. (d) 75% of the substance disintegrates in two half lives.

2 half lives = 30 min $\therefore t_{1/2} = 15$ min .

10. (c) γ -rays are electromagnetic waves.

11. (a) Average life

$(\tau) = 1.44\ t_{1/2} = 1.44 \times 69.3 = 99.7\ \approx 100$ minutes.

12. (d) $N = \left[\frac{1}{2}\right]^n \times N_o$

$1.25 = \left[\frac{1}{2}\right]^n \times 10$

$\left[\frac{1}{2}\right]^n = \frac{1.25}{10} = \frac{1}{8} = \left[\frac{1}{2}\right]^3, n = 3$

Half-life time = $\frac{15}{3}$ = 5 days.

13. (d) $n = \frac{12}{3} = 4$

$\therefore\ N_o = N \times 2^n = 3 \times 2^4 = 48g$.

14. (a) ${}_6C^{14} \to {}_7N^{14} + {}_{-1}e^o$, β-active.

15. (c) $2.303 = \frac{2.303}{0.693} \times t_{1/2} \log 10$

$\because\ N = \frac{N_o}{10}\ \therefore \frac{N_o}{N} = 10$.

16. (d) Amount left $= \frac{N_o}{2^3} = \frac{100}{8} = 12.5\%$

17. (b) $N = \frac{N_o}{64} = \frac{N_o}{2^6}\ \ \therefore n = 6$

Thus total time $= 2 \times 6 = 12hr$.

18. (c) β-decay occurs by the nuclear change $n \to p + {}_{-1}e^0$.

19. (b) $t_{1/2} = \frac{\log_e 2}{\lambda}$, Average life $= \frac{1}{\lambda}$

20. (a) $N = \frac{N_o}{2^n}, n = \frac{60}{20} = 3; N_o = 1g,$ then $N = \frac{1}{2^3} = \frac{1}{8}$.

21. (b) $t_{1/2}$ of zero order reaction is independent of the concentration.

22. (a) Half-life is 1 *hr* and thus in each half-life, half of the sample decays.

23. (c) $t = \frac{2.303 \times t_{1/2}}{0.693} \log \frac{N_o}{N}, N = 0.798 N_o$

24. (a) Half-life is independent of initial amount.

25. (a) 80 years = 4 half lives

Activity after n half lives $= \frac{1}{2^n} \times a$.

26. (b) $t_{1/2}$ is independent of all external factors and is constant for a given species.

27. (a) In nucleus electrons formed by the following decay. ${}_0n^1 \to {}_{+1}P^1 + {}_{-1}e^0$

28. (c) $t_{1/2} = 2.95$ *days*

= 2.95 × 24 × 60 × 60*s* = 254880

$\lambda = \frac{0.693}{t_{1/2}} = \frac{0.693}{254880} = 2.7 \times 10^{-6}\,s^{-1}$

29. (a) When a radioactive element emits an α-particle, the atomic no. of the resulting nuclide decreases by two units and atomic mass decreases by 4 units.

30. (b) $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{2.31 \times 10^{-4}} = 0.3 \times 10^4\,yrs$

$= 3.0 \times 10^3\,yrs.$

31. (a) $N = N_0\left(\frac{1}{2}\right)^n .\ n = \frac{40}{10} = 4$

$\frac{125}{1000} = N_0\left(\frac{1}{2}\right)^4, N_0 = \frac{125}{1000} \times 2 \times 2 \times 2 \times 2 = 2g$

32. (c) Binding energy per nucleon = $\frac{127}{16} = 7.94\,MeV$.

33. (d) $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{138.6\,min} = 0.005\,min^{-1}$

34. (a) Half-life period is independent of initial amount.

35. (b) t = Feb 1 to July 1 $= 28 + 31 + 30 + 31 + 30 = 150$ days

$\lambda = \frac{2.303}{150} \log \frac{8}{0.25} = \frac{2.303}{150} \log 2^5 = \frac{0.693}{30}\,\text{day}^{-1}$

$t_{1/2} = \frac{0.693}{0.693/30} = 30$ days .

36. (d) $t = \frac{2.303 \times t_{1/2}}{0.693} \log \frac{N_o}{N}$

37. (d) $n = \frac{480}{120} = 4,\ N = \frac{N_o}{2^n}, N = \frac{4}{2^4} = \frac{4}{16}$ = 0.25 *gm.*

38. (c) $n = \frac{28}{7} = 4, N = \frac{N_o}{2^n}, N = \frac{1}{2^4} = \frac{1}{16} = 0.0625$ *gm.*

39. (c) $\lambda = \frac{2.303}{t} \log \frac{[N_o]}{[N]} = \frac{2.303}{96} \log \frac{1}{1/8}$

$= \frac{2.303}{98} \times 0.9 = 0.0216$

$\therefore\ t_{1/2} = \frac{0.693}{\lambda} = \frac{0.693}{0.0216} = 32.0$ min .

40. (a) $25 = \left[\frac{1}{2}\right]^n \times 100, \left[\frac{1}{2}\right]^n = \frac{25}{100} = \frac{1}{4} = \left[\frac{1}{2}\right]^2$

n = 2, No. of half lives = 2

so time required = $2 \times 5760 = 11520\ yr$.

41. (c) $t_{1/2} = 100$ *years.*

42. (b) Average life $(\tau) = \frac{1}{\lambda}$.

43. (b) $\frac{1}{16} = \frac{1}{2^n}$ or $\frac{1}{2^4} = \frac{1}{2^n}$ or $n = 4$

$\therefore$ Required time $= 4 \times t_{1/2} = 120 min$.

44. (d) The time required for complete decay (I order) is always infinite.

45. (c) After half-life time the half of the substance will be decayed.

46. (c) $n = \frac{15}{5} = 3, N = \frac{N_o}{2^n} = \frac{20}{2^3} = \frac{20}{8} = 2.5 gm.$

47. (c) ${}_6X^{14} \xrightarrow{-3\beta} {}_9Y^{14}$

48. (b) $N = \frac{25}{100} N_o$ (at $t = 32$ *minutes*)

Thus $t = \frac{2.303}{0.693} \times t_{1/2} \log \frac{N_o}{N}$

49. (a) Half-life period is a characteristic of radioactive isotope which is independent of initial concentration.

50. (c) $n = \frac{24}{8} = 3,\ N = \frac{N_o}{2^n} = \frac{1}{2^3} = \frac{1}{8} mg$.

51. (c) Because $t_{1/2} = 4.5 \times 10^9$ years, so after 4.5×10^9 years the amount of ${}_{92}U^{238}$ will be half decayed.

52. (c) $r = \frac{0.693}{t_{1/2}} \times N_o$

$= \frac{0.693}{1600 \times 365 \times 24 \times 60 \times 60} \times \frac{6.023 \times 10^{23}}{226}$

= $3.7 \times 10^{10} dps$.

53. (c) $t = \frac{2.303 \times t_{1/2}}{0.693} \log \frac{N_o}{N}; N = \frac{1}{16}$

54. (b) $t_{1/2} = \frac{0.693}{k\ or\ \lambda}$

55. (c) $n = \frac{3}{1} = 3; N = \frac{N_o}{2^3} = \frac{1}{8}$

56. (b) $N = N_0 \times \left(\frac{1}{2}\right)^n$

$\frac{1}{2} = 1 \times \left(\frac{1}{2}\right)^n$; $n = 1$

$t = n \times t_{1/2} = 1 \times 6000 = 6000$ yrs.

57. (a) For I[st] order $t_{1/2} = 0.693 K^{-1}$.

58. (b) 75% of the substance disintegrates in two half lives 2 half lives = 60 min. $\therefore\ t_{1/2} = 30$ min .

59. (d) $\frac{0.693}{t_{1/2}} = \frac{2.303}{180} \times \log \frac{100}{12.5}$

$t_{1/2} = \frac{0.693 \times 180}{2.303 \times 3 \times 0.3010} = 60 min = 1 hr.$

60. (b) Tritium $({}_1H^3 \rightarrow {}_2He^3 + {}_{-1}e^0)$ is a β-emitter.

61. (d) $t_{1/2} = \ln 2 / \lambda$

62. (b) $t_{1/2} = \frac{0.693}{\lambda} = \frac{0.693}{231 \sec^{-1}} = 3.0 \times 10^{-3}$ sec .

63. (c) The amount of ${}_{53}I^{128}$ left after 50 minutes will be

= 25 minutes $= \frac{100}{25} = \frac{1}{4}$.

64. (a) $N = \frac{25}{100} N_o$(at $t = 2\,hr$)

Thus $t = \frac{2.303}{0.693} \times t_{1/2} \log \frac{N_o}{N}$

65. (b) Radioactive decay is a first order reaction.

66. (d) $t_{1/2}$ is independent of all external factors.

67. (d) Rate of decay of radioactive species is independent of all external factors.

68. (c) $n = \frac{100}{25} = 4, N = \frac{N_o}{2^n} = \frac{100}{2^4} = \frac{100}{16} = 6.25 gm$.

69. (d) ${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{145} + {}_{36}Kr^{88} + 3{}_0^1n$

70. (c) Half-life is independent of initial amount.

71. (d) $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{6.93 \times 10^{-6}} = 0.1 \times 10^6 = 10^5 yrs$.

72. (a) 1 milli curie = $3.7 \times 10^7 dps$

1.5 milli curie = $5.55 \times 10^7 dps$

$\frac{5.55 \times 10^7}{N_o} = \lambda = 1.37 \times 10^{-11}$

73. (c) $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{T}{t_{1/2}}}$; $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{75}{25}}$; $\frac{N}{N_o} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$

74. (a) $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{T}{t_{1/2}}}$; $\frac{N}{200} = \left(\frac{1}{2}\right)^{\frac{24}{4}}$; $\frac{N}{200} = \left(\frac{1}{2}\right)^6$

$N = \frac{200}{64} = 3.125\,g$

75. (a) ${}_xX^y \xrightarrow{2\beta} {}_7N^{14}$

${}_{x=7-2}X^{y=14} = {}_5X^{14}$

Total no. of neutrons =14 − 5 = 9

76. (c) $K = \frac{0.693}{t_{1/2}}$; $K = \frac{0.693}{10} = 0.0693\, yr^{-1}$

77. (b) $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{T}{t_{1/2}}}$; $\left(\frac{1}{16}\right) = \left(\frac{1}{2}\right)^{\frac{192}{t_{1/2}}}$; $\left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^{\frac{192}{t_{1/2}}}$

$t_{1/2} = 48$ min

78. (b) ${}_{92}U^{235} \xrightarrow{-\alpha} (A) \xrightarrow{-\beta} (B) \xrightarrow{-\beta} (C)$

(i) ${}_{92-2}A^{235-4} = {}_{90}A^{231}$

(ii) ${}_{90}A^{231} \xrightarrow{-\beta} {}_{(90+1)}B^{(231)} = {}_{91}B^{231}$

(iii) ${}_{91}B^{231} \xrightarrow{-\beta} {}_{(91+1)}C^{231} = {}_{92}C^{231}$

Isotopes are ${}_{92}U^{235}$ and C

80. (a) $t_{1/2} = \frac{0.693}{K} = \frac{0.693}{2.34} = 0.296\,\text{sec}$

81. (a) $K = \frac{0.693}{T_{1/2}} = \frac{0.693}{5770}$

$\therefore \quad t = \frac{2.303}{K}\log\frac{100}{72} = \frac{2.303 \times 5770}{0.693}\log\frac{100}{72}$

$= 19175.05 \times (\log 100 - \log 72)$

$19175.05 \times 0.143 = 2742.03$ years.

82. (a) For 25% decay

$K = \frac{2.303}{20}\log\frac{100}{75} = \frac{2.303}{20} \times 0.1249 = 0..1438$

For 75% decay,

$t = \frac{2.303}{0.01438}\log\frac{100}{25} = 96.4$ minute.

83. (b) $N = N_0\left(\frac{1}{2}\right)^n \Rightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

or $\frac{1}{64} = \left(\frac{1}{2}\right)^n \Rightarrow \left(\frac{1}{2}\right)^6 = \left(\frac{1}{2}\right)^n \Rightarrow n = 6$

$T = t_{1/2} \times n = 2 \times 6 = 12$ hours.

After 12 hours, sample became non-hazardous.

84. (c) Half-life of same substance remains same.

Artificial transmutation

1. (b) $C - 14$ dating method is used in estimate the age of most ancient geological formation.
2. (c) Joining up of two lighter nuclei is fusion.
5. (c) Equate atomic no. and mass no.
6. (a) For studies on carbon dating, W. F. Libby was awarded a Nobel prize.
7. (a) Spallation reactions are similar to fission reactions. They brought about by high energy bombarding particles or photons.
9. (d) Uranium or Plutonium are atomic fuel.
11. (a) It is the required technique.
12. (c) $N_t = N_o\left(\frac{1}{2}\right)^n = 32 \times \left(\frac{1}{2}\right)^{49.2/12.3} = 32 \times \left(\frac{1}{2}\right)^4 = 2$.
14. (b) In hydrogen bomb, the following reaction is occur,

$${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0^1n + \text{energy}.$$

15. (a) Heavy water is D_2O.
16. (d) Einstein's law is $E = mc^2$.
17. (d)
18. (b) 11460 years = 2 half lives

Activity left = 25% = 0.25.

19. (a) The control rods used in nuclear reactor are made up of Cd – 113 or B -10. They can absorb neutrons.
20. (c) The radioactive isotope ${}_6C^{14}$ is produced in the atmosphere by the action of cosmic ray neutrons on ${}_7N^{14}$
22. (a) Heavy water (D_2O) is used as a moderator in a nuclear reactor. It slows down the speed of neutrons. It also acts as a coolant.
23. (c) Uranium or Plutonium are atomic fuel.
24. (b) atom bomb is based on the principal of nuclear fission.
25. (d) Hahn and Strassmann discovered the phenomenon of nuclear fission in 1939.
26. (c) Rate of disintegration is not affected by environmental conditions.
27. (b) It is believed that when an α or β-particle is emitted, the nucleus becomes excited *i.e.* has higher energy and emits the excess energy in the from of radiation which form γ -rays.
28. (a) Packing fraction $= \frac{\text{Isotopic mass} - \text{Mass number}}{\text{Mass number}} \times 10^4$
30. (a) C^{14} is a natural radioactive isotope of C^{12}.
31. (d) $t_{1/2} = 10 yrs, t = 20 yrs.$

$\therefore n = \frac{t}{t_{1/2}} = \frac{20}{10} = 2$

$N = \frac{N_o}{2^2} = \frac{1}{4}N_o = \frac{1}{4} \times 100\%\,\text{of}\, N_o = 25$.

32. (b) Due to evolution of nuclear energy as a result of mass decay.
33. (d) Heavy water (D_2O) is used as a moderator in nuclear reactor.
34. (c) It is a transformation of chlorine.
35. (b) 48 *gm* of radioactive sodium will need 32 hours to become 3.0 *gm*.
36. (a) Mass decay occurs.
37. (b) In hydrogen bomb, the following reaction is occur,

$${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0^1n + \text{energy}.$$

38. (c) A reason for the C-14 dating technique.
39. (d) $t = \frac{2.303}{k}\log\frac{a}{0.99a}, (a - x) = \frac{99}{100} = 0.99a$

But $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{10.6} = 0.0653$ *year*

$t = \frac{2.303}{0.0653}\log\frac{1}{0.99} = 70.4 yrs.$

41. (d) D_2O is heavy water.
42. (b) D_2O is used as moderator in nuclear reactor.
45. (b) Liquid sodium use in nuclear reactors as heat exchanger or coolant.
46. (c) Due to heavy mass α-particles can not easily pass through solid matter so they are less effective for artificial transmutation.
47. (b) Given $N_o = 1, N_t = 0.70$ and $t_{1/2} = 5760$ *yrs.*

$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{5760}$.

We also know, $k = \frac{2.303}{t}\log\frac{N_0}{N_t}.\frac{0.693}{5760}$

or $t = \frac{2.303\times 5760\times 0.155}{0.693} = 2966 yrs.$

48. (b) The splitting of a heavier atom like that of *U*-235 into a number of fragments of much smaller mass by suitable bombardment with sub-atomic particles with liberation of huge amount of energy is called nuclear fission.

49. (c) $_{13}Al^{28} + {}_2He^4 \rightarrow {}_{15}P^{31} + {}_0n^1$

50. (c) Rate of radioactivity is independent of all external factors.

51. (d) I^{131} is used for goitre therapy, *i.e.* iodine deficiency.

52. (c) *C*-14 is found in nature abundantly and in definite ratio.

53. (a) Astatine (At) is resembles in properties with iodine.

56. (d) Equate mass number and atomic number.

57. (b,d) D_2O is used as moderator in nuclear reactor.

58. (a) The rate of disintegration is expressed in terms of the number of disintegrations per second.

59. (b) $_6C^{14}$ is used in dating archeological findings.

60. (a) $n = \frac{40}{20} = 2$

$\therefore$ Amount left $\frac{N_0}{2^n} = \frac{100}{2^2} = 25 gm$

61. (d) The definition of nuclear fission.

62. (a) The huge amount of energy released during atomic fission is due to loss of mass.

63. (a) Mass defect is the measure of binding energy of a nucleus.

65. (d) Irene curie and Juliot studied the artificial radioactivity.

66. (d) $N = \frac{N_o}{2^n}$ and $n = \frac{560}{140} = 4;\ N = \frac{1}{2^4} = \frac{1}{16} gm.$

67. (d) G.M counter is used to determine rate of decay.

68. (b) *Cd* and boron rods are control rods used in reactors.

69. (b) Graphite is used as moderator to slow down the speed of neutrons in atomic reactors.

70. (d) Isotope C^{12} is the modern basis of atomic weight.

71. (a) $_6C^{14}$ is used to determine the mechanism of photosynthesis.

74. (a) $_{28}Ni^{60} + {}_0n^1 \longrightarrow {}_{28}Ni^{61} \longrightarrow {}_{27}Co^{60} + {}_1p^1$

76. (b) $_6C^{14}$ used for dating process.

79. (a) $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{T}{t_{1/2}}} \Rightarrow \frac{13}{100} = \left(\frac{1}{2}\right)^{\frac{T}{5770}}$

Taking log $\Rightarrow \log\frac{13}{100} = \frac{T}{5770}\log 1/2 \Rightarrow 16989 yrs$

Isotopes-Isotones and Nuclear isomers

1. (b) The definition of Isotopes.

2. (a) Isotopes of hydrogen is $_1H^1, {}_1H^2, {}_1H^3$ known as protium, deuterium and tritium respectively.

3. (d) $_8O^{18}$ isotope of oxygen have 10 neutrons and 8 protons.

4. (a) Atoms of different elements having different atomic no. but same mass no. are called isobars.

5. (c) Isotopes have same atomic number but different mass number.

6. (c) $_ZA^m \rightarrow {}_ZB^{m-4} + {}_2He^4 + 2{}_{-1}e^0$

7. (c) Co^{60} is used in radiotherapy of cancer.

8. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

9. (b) $_7N^{14} + {}_2He^4 \rightarrow {}_8O^{17} + {}_1H^1$

10. (d) $_1H^3 \rightarrow {}_2He^3 + {}_{-1}e^0$

$_1H^3$ and $_2He^3$ are isobars (same mass no.)

11. (a) The isotopes having an excessive *n*/*p* ratio exhibit e^--emission.

12. (b) $_6C^{14}$ is an isotope of carbon $({}_6C^{12})$.

14. (a) Isotopes differ in number of neutrons but have same number of protons.

15. (a) $_ZA^m \rightarrow {}_ZB^{m-4} + {}_2He^4 + 2{}_{-1}e^o$

16. (c) Atoms of different elements having different atomic no. but same mass no. are called isobars.

17. (b) Isotopes differ in number of neutrons but have same number of protons.

18. (c) $_ZA^m \rightarrow {}_ZB^{m-4} + {}_2He^4 + 2{}_{-1}e^o$

19. (c) $\frac{n}{p}$ is minimum for this isotope.

20. (a) In chlorine gas ratio of Cl^{35} and Cl^{37} is 3 : 1.

21. (d) Isotones have the same number of neutrons but different number of nucleons $(n + p)$. *e.g.*, $^{39}_{18}Ar, {}^{40}_{19}K$.

22. (d) Isobars have different no. of protons and neutrons.

23. (a) Atoms of different elements having different atomic no. but same mass no. are called isobars.

24. (c) Isotopes differ in mass no. and hence in the number of neutrons.

25. (c) Isotones are the species which have same number of neutrons and different number of nucleons (*p* + *n*).

26. (d) In ^3_1H their are 1 proton and 2 neutrons.

27. (c) Isotopes differ in mass number, and hence in the number of neutrons.

28. (b) In isotones have same number of neutrons.

29. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

30. (b) Two isotopes of bromine are $_{35}Br^{79}$, $_{35}Br^{81}$

No. of neutrons in $_{35}Br^{79}$ = $79 - 35 = 44$

No. of neutrons in $_{35}Br^{81}$ = $81 - 35 = 46$.

31. (c,d) Isotopes have same atomic number but different mass number and same chemical properties.

33. (a) Isotopes have same atomic number but different mass number.

34. (c) $_{92}U^{235} \rightarrow {}_{82}Pb^{207} + x\ {}_2He^4 + y\ {}_{-1}\beta^0$

no. of α-particles = $\frac{235 - 207}{4} = \frac{28}{4} = 7\alpha$

no. of β-particles = $92 - 82 - 2\times 7 = 4\beta$.

35. (c) $_ZA^m + 2\ {}_0n^1 \rightarrow {}_ZA^{m+2}$, an isotope of *A*.

36. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

37. (a) $_AX^M \xrightarrow{-\alpha} {}_{A-2}Y^{M-4}$

38. (a) Isotopes have same atomic number but different mass number.

39. (a) In isotope $_{32}X^{65}$, 32 is atomic number and 65 is atomic weight.

40. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

41. (c) Atoms of different elements having different atomic no. but same mass no. are called isobars.

43. (a) Mass no. will remain same as proton is replaced by neutron.

44. (d) Isotopes differ in number of neutrons but have same number of protons.

45. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

46. (a) ${}_{11}Na^{24} \rightarrow {}_{12}Mg^{24} + {}_{-1}e^{0}$ (β-particle comes out).

47. (d) Isotopes differ in number of neutrons but have same number of protons.

48. (d) Atoms of different elements having different atomic no. but same mass no. are called isobars.

49. (a) ${}_{1}H^{3} \rightarrow {}_{2}He^{3} + {}_{-1}e^{o}$

50. (a) Isotopes of same elements have the same number of protons but different number of neutrons.

51. (b) $35.5 = \frac{x \times 37 + (100 - x)35}{100} \Rightarrow 35.5 = \frac{3500 - 2x}{100}$

$2x = 50 \Rightarrow x = 25 \Rightarrow$ Ratio 75 : 25 = 3 : 1

52. (d) An ordinary oxygen contains a mixture of *O*-16 (99.8%), *O*-17(0.037%), *O*-18(0.204%) isotopes.

54. (c) They are isosters *i.e,* Number of atoms = same

Number of e^- = same ;Physical properties = same

55. (ac) Isotopes have same atomic number but different mass number.

57. (bd) Both have 34 neutrons; Isotones have same number of neutrons.

Critical Thinking Questions

1. (a) ${}^{23}_{11}Na \rightarrow \frac{n}{p}$ ratio $= 12/11$

${}^{24}_{11}Na \rightarrow \frac{n}{p}$ ratio $= 23/11$

so decrease in $\frac{n}{p}$ ratio gives out β-particle

$n \rightarrow p + e(\beta^-)$.

2. (b) Oxygen have 90% O^{16} and 10% O^{18}

Atomic mass = $\left[\frac{90}{100} \times 16 + \frac{10}{100} \times 18\right]$

$= \frac{1440 + 180}{100} = \frac{1620}{100} = 16.2$.

3. (c) It is a neutron induced fission reaction.

4. (a) Mass defect = mass of sulphur – mass of chlorine

$= 34.96903 - 34.96885 = 0.00018\,g$

Binding energy =mass defect × 931

$= 0.00018 \times 931$

$= 0.1675\,MeV$

5. (a) The problem refers that rate is constant.

6. (a) $1C$ = Activity of $1g$ of $Ra^{226} = 3.7 \times 10^{10}\,dps$

Activity of $1\mu g$ of $Ra^{226} = 3.7 \times 10^{4}\,dps$

So, the no. of α-particles are emitted per second by $1\mu g$ of Ra is $3.7 \times 10^4\,dps \approx 3.62 \times 10^4$ / sec

7. (a) 2.92×10^4 α-particles will be emitted per second.

8. (b) $\frac{dx_1}{dt} = \lambda N_1,\ 1 \times 10^5 = \lambda N_1$

$\frac{dx_2}{dt} = \lambda N_2, 3.7 \times 10^{10} = \lambda N_2$

$\frac{N_1}{N_2} = \frac{1 \times 10^5}{3.7 \times 10^{10}} = \frac{1 \times 10^{-5}}{3.7} = 0.27 \times 10^{-5}$.

9. (d) ${}_{92}U^{235} + {}_{o}n^{1} \rightarrow {}_{54}X_e^{139} + {}_{38}Sr^{94} + 3\,{}_{o}n^{1}$

10. (a) $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{3hr.} = 0.231$ *per hrs.*

11. (b) $t_{1/2}$ of *C*–14 = 5760 year, $\lambda = \frac{0.693}{5760}$,

Now $t = \frac{2.303}{\lambda} \log \frac{{}^{14}C\,\text{original}}{{}^{14}C\,\text{after time } t}$

$= \frac{2.303 \times 5760}{0.693} \log \frac{100}{12.5} = \frac{2.303 \times 5760 \times 0.9030}{0.693}$

= 17281= 172.81 × 10^2 *years.*

12. (c) According to radioactive equilibrium $\lambda_A N_A = \lambda_B N_B$

or $\frac{0.693 \times N_A}{t_{1/2}(A)} = \frac{0.693 \times N_B}{t_{1/2}(B)} \left[\lambda = \frac{0.693}{t_{1/2}}\right]$

Where $t_{1/2}(A)$ and $t_{1/2}(B)$ are half periods of *A* and *B* respectively

$\therefore \frac{N_A}{t_{1/2}(A)} = \frac{N_B}{t_{1/2}(B)}$ or $\frac{N_A}{N_B} = \frac{t_{1/2}(A)}{t_{1/2}(B)}$

∴ At equilibrium *A* and *B* are present in the ratio of their half lives $\frac{1}{2.8 \times 10^6} = \frac{1620}{\text{Half life of uranium}}$

∴ Half-life of uranium

$= 2.8 \times 10^6 \times 1620 = 4.53 \times 10^9$ *years.*

13. (c) Average life period = $1.44 \times t_{1/2}$

$1.44 \times 1580 = 2275.2 = 2.275 \times 10^3 yrs.$

14. (a) $N_o = 8gms$, *N* = 0.5*g* and *t* = 1 *hr.* = 60 *min.* find $t_{1/2}$ by $t = \frac{2.303 \times t_{1/2}}{0.693} \log \frac{N_o}{N}$.

15. (b) $k = \frac{0.693}{0.75\text{hr}} = \frac{2.303}{\text{t}} \log \frac{a}{a - 0.999a}$

$= \frac{2.303}{t} \log 10^3 = 7.5\,hrs.$

16. (c) *T* = 50 days, $t_{1/2}$ = ?, $N_o = 1, N = \frac{1}{32}$,

$N = N_o \times \left(\frac{1}{2}\right)^n$ or $\frac{1}{32} = 1 \times \left(\frac{1}{2}\right)^n$,

or $\left(\frac{1}{2}\right)^5 = \left(\frac{1}{2}\right)^n$ or *n* = 5

$T = t_{1/2} \times 2$, or $t_{1/2} = \frac{50}{5} = 10$ *days.*

17. (d) $K = \frac{2.303}{40}\log\frac{a}{a-0.875a} = \frac{2.303}{40}\log 8$

$= 0.05199\,\text{min}^{-1}$ $t_{1/2}$ = 0.693/0.05199

= 13.33 *min.* = 13 *min* 20 *sec.*

18. (d) $t_{1/2} = 10\,\text{days}, N = 125$

Calculate as, $t = \frac{2.303 \times t_{1/2}}{0.693}\log\frac{N_o}{125}$.

19. (a) $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{6.31\times10^{-4}} = 0.1098\times10^4 = 1098 yrs$.

20. (c) $T = t_{1/2}\times n$, $\therefore 3000 = 1500\times \text{n}$ $\therefore n = 2$

$\therefore$ Amount left $= \frac{1}{2^2} = \frac{1}{4} = 0.25g$.

21. (a) $N_t = N_o\left(\frac{1}{2}\right)^n$, $N_t = 256\left(\frac{1}{2}\right)^{18/3} = 256\left(\frac{1}{2}\right)^6 = 4$.

22. (b) Quantity of radioactive element decayed $= \frac{15}{16}$

Quantity left = $1 - \frac{15}{16} = \frac{1}{16}$

$\frac{1}{16} = 1\times\left(\frac{1}{2}\right)^n$ or $\left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^n$

one half-life = $\frac{40}{4} = 10$ *days.*

23. (c) $N_t = N_o\left(\frac{1}{2}\right)^n = 48\times10^{19}\left(\frac{1}{2}\right)^{26/6.5}$

$= 48\times10^{19}\left(\frac{1}{2}\right)^4 = 3\times10^{19}$.

24. (c) $\frac{0.693}{9} = \frac{2.303}{t}\log\frac{1}{1-0.2}$

25. (b) $\frac{0.693}{140} = \frac{2.303}{t}\log\frac{16}{16-15} = 560\,\text{days}$

26. (b) $n = \frac{20}{4} = 5, \frac{N_t}{N_o} = \left(\frac{1}{2}\right)^5 = \frac{1}{32}$, $\therefore$ decayed

$= \left(1-\frac{1}{32}\right)\times100 = \frac{31}{32}\times100 = 96.87$.

27. (b) $r_{\text{nucleus}} = 1.3\times10^{-13}\times(A)^{1/3}$, where A is mass number

$r_{U^{238}} = 1.3\times10^{-13}\times(238)^{1/3} = 8.06\times10^{-13}cm$.

$r_{He^4} = 1.3\times10^{-13}\times(4)^{1/3} = 2.06\times10^{-13}cm$.

$\therefore$ Total distance in between uranium and α nuclei

= 8.06× 10^{-13} + 2.06 × 10^{-13} = 10.12 × 10^{-13} *cm*

Now repulsion energy =

$\frac{Q_1Q_2}{r} = \frac{92\times4.8\times10^{-10}\times2\times4.8\times10^{-10}}{10.12\times10^{-13}}erg$

$= 418.9\times10^{-7}erg$ = $418.9\times10^{-7}\times6.242\times10^{11}eV$

= $26.147738\times10^4 eV$.

28. (a) $N_t = N_o\left(\frac{1}{2}\right)^2$ [$\therefore t_{1/2}$ = 22 years, T = 11 years, N_o =2, N_t =?]

$T = t_{1/2}\times n$, 11= 2 × n or $n = \frac{11}{22} = \frac{1}{2}$

$\therefore N_t = 2gm\times\left(\frac{1}{2}\right)^{1/2} = 1.414gm$.

29. (c) $t = \frac{2.303}{0.693}\times5000\times\log\frac{15}{5}$

$= \frac{2.303}{0.693}\times5000\times\log3 = 7927 = 7.92\times10^3 yrs.$

30. (c) 1*g U*-235 $= \frac{6.023\times10^{23}}{235}$ *atoms*

$\therefore$ energy released $= 3.2\times10^{-11}\times\frac{6.023\times10^{23}}{235}J = 8.21\times10^{10}J$

$= 8.2\times10^7 kJ$.

31. (a) Isotones have same number of neutrons.

32. (b) Average atomic weight of element $= \frac{85\times3+87\times1}{3+1} = 85.5$

Assertion & Reason

1. (c) Atomic number defines identity of an atom because each atom has a definite number of protons in its nucleus.

3. (d) The activity of $1g$ of pure $U-235$ and that in U_3O_8 is same. Activity does not depend upon the state of combination.

5. (b) In some nuclides, the nucleus may capture an electron from the K -shell and the vacancy created is filled by electrons from higher levels giving rise to characteristic X -rays. This process is known as K -electron capture or simply K -capture.

6. (c) Radioactivity of an element is independent of its physical state its chemical environment or temperature, suggesting that it is a property of nucleus i.e., nuclear phenomenon.

7. (d) At onetime, it was believed that actinium series starts with $Ac-227$ but now it is well known that it starts with $U-235$ and $Ac-227$ is one of the main products.

9. (a) ${}_{92}U^{238} + {}_0n^1 \longrightarrow {}_{92}U^{239} \xrightarrow{-\beta} {}_{93}Np^{239} \xrightarrow{-\beta} {}_{94}Pu^{239}$

In breeder reactors, the neutrons produced from fission of $U-235$ are partly used to carry on the fission of $U-235$ and partly used to produce some other fissionable material.

10. (a) The activation energies for fusion reactions are very high. They require very high temperature $(>10^6)$ to over come electrostatic repulsion between the nuclei.

12. (c) Loss of α or β -particle is to change N/P ratio so that it lies with in the stability belt. Loss of α -particle increases N/P ratio while loss of β -particle decreases N/P ratio.

13. (b) It is correct that photochemical smog is produced by nitrogen oxide and it is also fact that vehicular pollution is a major source of nitrogen oxide but it is not correct explanation.

14. (d) Binding energy per nucleon of ${}_3Li^7$ (5.38 *MeV*) is lesser than ${}_2He^4$ (7.08 *MeV*) as helium is found to be more stable than Li. As the atomic mass number increases, the binding energy

per nucleon decreases. As the atomic number and the atomic mass number increase, the repulsive electrostatic forces with in the nucleus increase due to the greater number of protons in the heavy elements. To over come this increased repulsion, the proportion of neutrons in the nucleus must increase to maintain stability. This increase in the neutron to proton ratio only partially compensates for the growing proton – proton repulsive force in the heavier, naturally occurring elements.

Because the repulsive forces are increasing less energy must be supplied, on the average, to remove a nucleon from the nucleus. The BE/A has decreased. The BE/A of a nucleus is an indication of its degree of stability. Generally, the more stable nuclides have higher BE/A than the less stable ones. The increase in BE/A as the atomic mass number decreases from 260 to 60 is the primary reason for the energy liberation in the fission process. The increase in the BE/A as the atomic mass number increases from 1 to 60 is the reason for the energy liberation in the fusion process, which is the opposite reaction of fission.

15. (b) It is correct that during nuclear fission energy is always released and it is also true that nuclear fission is a chain prouss.

16. (e) Neutrons are more effective than protons of equal energy in causing artificial disintegration of atoms. neutrons are neutral they penetrate the nucleus and do not exert any repulsive force like positive charged protons.

17. (b) It is true that abeam of electrons deflects more than a beam of α-particles in am electric field. It is also true that electrons have –ve while α-particles have +ve charge. Here both are true but reason is not a correct explanation.

18. (d) ${}_{11}Na^{22} \longrightarrow {}_{12}Mg^{22} + {}_{-1}\beta^{0}$.

Thus this change involves a β-particle emission and not a positron. Also, proton emission convert proton into neutron as : ${}_{1}P^{1} \longrightarrow {}_{0}n^{1} + {}_{+1}\beta^{0}$