23 - ATOMS, MOLECULES AND NUCLEI

(Answers at the end of all questions)

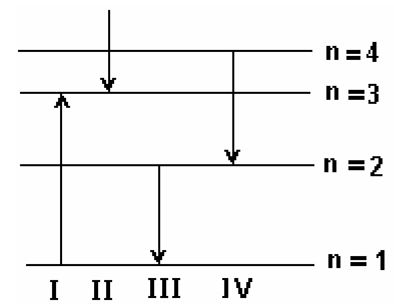
1) If the radius of the $_{13}Al^{27}$ nucleus is estimated to be 3.6 fermi, then the radius of $_{52}Te^{125}$ nucleus will be nearly
(a) 8 fermi (b) 6 fermi (c) 5 fermi (d) 4 fermi [AIEEE 2005]

2) Starting with a sample of pure Cu^{66}, 7/8th of it decays into Zn in 15 minutes. The corresponding half-life is
(a) 15 minutes (b) 10 minutes (c) 7.5 minutes (d) 5 minutes [AIEEE 2005]

3) The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy

(a) IV (b) III (c) II (d) I

[AIEEE 2005]



4) A nuclear transformation is denoted by X (n, α) $_3Li^7$. Which of the following is the nucleus of element X ?
(a) $_5B^{10}$ (b) $_6C^{12}$ (c) $_4Be^{11}$ (d) $_5B^9$ [AIEEE 2005]

5) If the kinetic energy of a free electron doubles, its de-Broglie wavelength changes by the factor
(a) 2 (b) 1 / 2 (c) $\sqrt{2}$ (d) 1 / $\sqrt{2}$ [AIEEE 2005]

6) A nucleus disintegrates into two nuclear parts which have their velocities in the ratio 2 : 1. The ratio of their nuclear sizes will be
(a) $2^{\frac{1}{3}} : 1$ (b) $1 : 3^{\frac{1}{2}}$ (c) $3^{\frac{1}{2}} : 1$ (d) $1 : 2^{\frac{1}{3}}$ [AIEEE 2004]

7) The binding energy per nucleon of deuteron ($_1H^2$) and helium nucleus ($_2He^4$) is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei reacts to form a single helium nucleus, then the energy released is
(a) 13.9 MeV (b) 26.9 MeV (c) 23.6 MeV (d) 19.2 MeV [AIEEE 2004]

8) An α - particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of the closest approach is of the order of
(a) 1 A° (b) 10^{-10} cm (c) 10^{-12} cm (d) 10^{-15} cm [AIEEE 2004]

9) When U^{238} nucleus originally at rest, decays by emitting an alpha particle having speed 'u', the recoil speed of the residual nucleus is
(a) $-\frac{4u}{238}$ (b) $\frac{4u}{238}$ (c) $-\frac{4u}{234}$ (d) $\frac{4u}{234}$ [AIEEE 2003]

10) A nucleus with Z = 92 emits the following in a sequence α, α, α, α, α, β^-, β^-, α, β^+, α. The Z of the resulting nucleus is
(a) 74 (b) 76 (c) 78 (d) 82 [AIEEE 2003]

11) If the radioactive decay constant of radium is 1.07×10^{-4} per year, then the half-life period is approximately equal to
(a) 8900 yrs. (b) 7000 yrs. (c) 6500 yrs. (d) 5000 years [AIEEE 2003]

12) Which of the following cannot be emitted by radioactive substances during their decay ?
(a) electrons (b) protons (c) neutrinos (d) helium nuclei
[AIEEE 2003]

13) Which of the following atoms has the lowest ionization potential ?
(a) ${}_{8}O^{16}$ (b) ${}_{7}N^{14}$ (c) ${}_{55}Cs^{123}$ (d) ${}_{18}Ar^{14}$ [AIEEE 2003]

14) If the binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of Li^{++} is
(a) 122.4 eV (b) 30.6 eV (c) 13.6 eV (d) 3.4 eV [AIEEE 2003]

15) The wavelengths involved in the spectrum of deuterium (${}_{1}D^{2}$) are slightly different from that of hydrogen spectrum, because
(a) size of the two nuclei are different
(b) masses of the two nuclei are different
(c) nuclear forces are different in the two cases
(d) attraction between the electrons and the nucleus is different in two cases
[AIEEE 2003]

16) In the nuclear fusion reaction, ${}_{1}H^{2} + {}_{1}H^{3} \rightarrow {}_{2}He^{4} + n$, given that the repulsive potential energy between the two nuclei is $\sim 7.7 \times 10^{-14}$ J, the temperature at which the gases must be heated to initiate the reaction is nearly [Boltzmann's constant $k = 1.38 \times 10^{-23}$ J / K]
(a) 10^{9} K (b) 10^{7} K (c) 10^{5} K (d) 10^{3} K
[AIEEE 2003]

17) If the second Bohr's radius of hydrogen atom is $4a_0$, then the radius of the fifth Bohr's orbit in hydrogen atom is
(a) $5a_0$ (b) $10a_0$ (c) $20a_0$ (d) $25a_0$ [AIEEE 2002]

18) An electron changes its position from n = 2 to the orbit n = 4 of an atom. The wavelength of the emitted radiations is (R = Rydberg's constant)
(a) $\frac{16}{R}$ (b) $\frac{16}{3R}$ (c) $\frac{16}{5R}$ (d) $\frac{16}{7R}$ [AIEEE 2002]

19) Hubble's law is based on the
(a) Wein's law (b) Stefan's law (c) Doppler's effect (d) Law of gravitation
[AIEEE 2002]

20) A radioactive sample at any instant has its disintegration rate of 5000 disintegrations per minute. After 5 minutes, the rate is 1250 disintegrations per minute. The decay constant per minute is
(a) 0.8 In 2 (b) 0.4 In 2 (c) 0.2 In 2 (d) 0.1 In 2 [AIEEE 2002]

21) If the wavelength K_α of Z = 11 atom is λ, then the atomic number of atom whose K_α radiation wavelength is 4λ will be
(a) 44 (b) 11 (c) 6 (d) 5 [IIT 2005]

22) If the star can convert all the He nuclei completely into oxygen nuclei, the energy released per oxygen nucleus is (Mass of He nucleus is 4.0026 amu and mass of oxygen nucleus is 15.9994 amu)
(a) 7.6 MeV (b) 56.12 MeV (c) 10.24 MeV (d) 23.9 MeV [IIT 2005]

23) A photon of energy 10.2 eV collides inelastically with stationary hydrogen atom in its ground state and after a few micro-second, another photon of energy 15 eV collides with the hydrogen atom inelastically. Then a detector detects
(a) one 10.2 eV photon and one 1.4 eV electron
(b) one 3.4 eV photon and one 1.4 eV electron
(c) two photons of 10.2 eV energy (d) two electrons of 1.4 eV energy [IIT 2005]

24) After 280 days, the activity of a radioactive sample is 6000 dps. The activity reduces to 3000 dps after another 140 days. The initial activity of the sample in dps is
(a) 6000 (b) 9000 (c) 3000 (d) 24000 [IIT 2004]

25) The electric potential between a proton and an electron is given by $V = V_0 \ln (r / r_0)$, where r_0 is a constant. Assuming Bohr's model to be applicable, write variation of r_n with n, n being the principal quantum number.
(a) $r_n \propto n$ (b) $r_n \propto 1 / n$ (c) $r_n \propto n^2$ (d) $r_n \propto 1 / n^2$ [IIT 2003]

26) For uranium nucleus, how does its mass vary with volume ?
(a) $m \propto V$ (b) $m \propto 1 / V$ (c) $m \propto \sqrt{V}$ (d) $m \propto V^2$ [IIT 2003]

27) If the atom ${}_{100}Fm^{257}$ follows the Bohr model and the radius of ${}_{100}Fm^{257}$ is n times the Bohr radius, then find n.
(a) 100 (b) 200 (c) 4 (d) 1 / 4 [IIT 2003]

28) 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.
(a) 4.4 MeV (b) 5.4 MeV (c) 5.6 MeV (d) 6.5 MeV [IIT 2003]

29) A hydrogen atom and a Li^{++} ion are both in the second excited state. If l_H and l_{Li} are their respective angular momenta and E_H and E_{Li} are their respective energies, then
(a) $l_H > l_{Li}$ and $|E_H| > |E_{Li}|$ (b) $l_H = l_{Li}$ and $|E_H| < |E_{Li}|$
(c) $l_H = l_{Li}$ and $|E_H| > |E_{Li}|$ (d) $l_H < l_{Li}$ and $|E_H| < |E_{Li}|$ [IIT 2002]

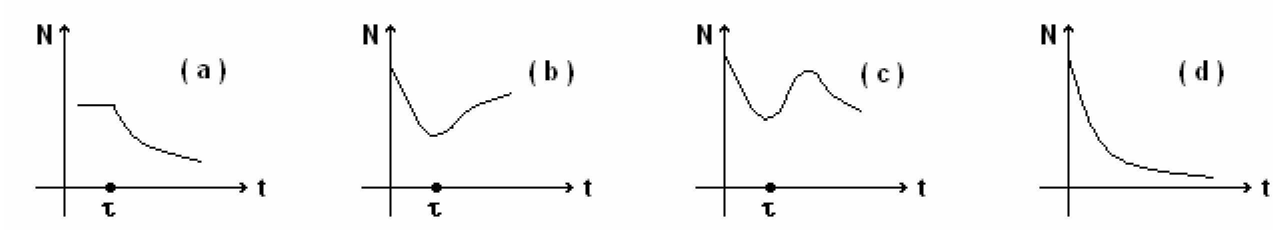
30) The half-life of ^{215}At is 100 μs. The time taken for the radioactivity of a sample of ^{215}At to decay to $1 / 16^{th}$ of its initial value is
(a) 400 μs (b) 6.3 μs (c) 40 μs (d) 300 μs [IIT 2002]

31) Which of the following processes represents a γ - decay ?
(a) ${}^AX_Z + \gamma \rightarrow {}^AX_{Z-1} + a + b$ (b) ${}^AX_Z + {}^1n_0 \rightarrow {}^{A-3}X_{Z-2} + c$
(c) ${}^AX_Z \rightarrow {}^AX_Z + f$ (d) ${}^AX_Z + e_{-1} \rightarrow {}^AX_{Z-1} + c$
[IIT 2002]

32) The electron emitted in beta radiation originate from
(a) inner orbits of atoms (b) free electrons existing in nuclei
(c) decay of a neutron in a nucleus (d) proton escaping from the nucleus
[IIT 2001]

(Answers at the end of all questions)

33) A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life 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 the total number of radioactive nuclei as a function of time. Which of the following figures best represents the form of this plot ? [IIT 2001]



34) The transition from the state n = 4 to n = 3 in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition

(a) $2 \rightarrow 1$ (b) $3 \rightarrow 2$ (c) $4 \rightarrow 2$ (d) $5 \rightarrow 4$ [IIT 2001]

35) Electrons with energy 80 keV are incident on the tungsten target of an X-ray tube. K-shell electrons of tungsten have - 72.5 keV energy. X-rays emitted by the tube contain only

(a) a continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of ~ 155 A°

(b) a continuous X-ray spectrum (Bremsstrahlung) with all wavelengths.

(c) the characteristic X-ray spectrum of tungsten

(d) a continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of ~ 155 A° and the characteristic X-ray spectrum of tungsten [IIT 2000]

36) Imagine an atom made up of proton and a hypothetical particle of double the mass of the electron but having the same charge as the electron. Apply the Bohr atom model and consider all possible transitions of this hypothetical particle to the first excited level. The longest wavelength photon that will be emitted has wavelength λ (given in terms of the Rydberg constant R for the hydrogen atom) equal to

(a) 9 / (5R) (b) 36 / (5R) (c) 18 / (5R) (d) 4 / R [IIT 2000]

37) Binding energy per nucleon Vs mass number curve for nuclei is shown in figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is:

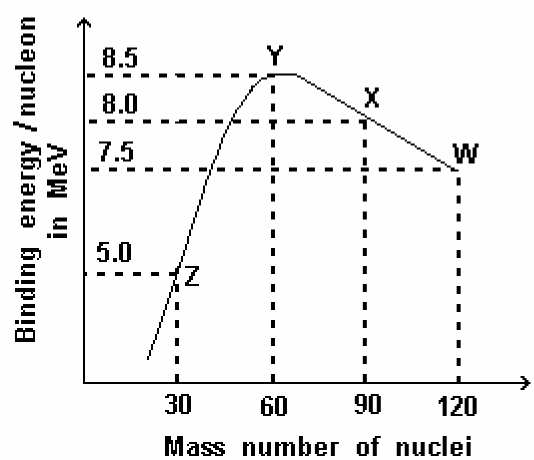
(a) $Y \rightarrow 2Z$

(b) $W \rightarrow X + Z$

(c) $W \rightarrow 2Y$

(d) $X \rightarrow Y + Z$

[IIT 1999]



38) 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
(a) $1 / 10\lambda$ (b) $1 / 10\lambda$ (c) $11 / 10\lambda$ (d) $1 / 9\lambda$ [IIT 2000]

39) The electron in a hydrogen atom makes a transition from an excited state to the ground state. Which of the following statements is true ?
(a) Its kinetic energy increases and its potential and total energy decreases.
(b) Its kinetic energy decreases, potential energy increases and its total energy remains the same.
(c) Its kinetic and total energy decreases and its potential energy increases.
(d) Its kinetic, potential and total energy decreases. [IIT 2000]

40) Order of magnitude of density of uranium nucleus is ($m_p = 1.67 \times 10^{-27}$ kg)
(a) 10^{20} kg / m^3 (b) 0^{17} kg / m^3 (c) 10^{14} kg / m^3 (d) 10^{110} kg / m^3 [IIT 1999]

41) ^{22}Ne nucleus, after absorbing energy, decays into two α-particles and an unknown nucleus. The unknown nucleus is
(a) nitrogen (b) carbon (c) boron (d) oxygen [IIT 1999]

42) The half-life period of a rdaioactive 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
(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 ate than X
(d) X will decay at a faster rate than Y [IIT 1999]

43) Which of the following 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 [IIT 1999]

44) Let m_p be the mass of proton, m_n the mass of neutron, M_1 the mass of $^{20}_{10}$Ne nucleus and M_2 the mass of $^{40}_{20}$Ca nucleus. Then
(a) $M_2 = 2M_1$ (b) $M_2 > 2M_1$ (c) $M_2 < 2M_1$ (d) $M_1 < 10 (m_n + m_p)$ [IIT 1998]

45) The electron in a hydrogen atom makes a transition $n_1 \rightarrow n_2$ where n_1 and n_2 are the principal quantum numbers of two states. Assume the Bohr model to be valid. The time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_1 are
(a) $n_1 = 4$, $n_2 = 2$ b) $n_1 = 8$, $n_2 = 2$ (c) $n_1 = 8$, $n_2 = 1$ (d) $n_1 = 6$, $n_2 = 3$ [IIT 1998]

46) 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
(c) all nuclei will decay before t = 16 days
(d) a given nucleus may decay at any time after t = 0 [IIT 1998]

47) As per Bohr model, the minimum energy (in eV) required to remove an electron from the ground state of doubly ionized Li atom (Z = 3) is
(a) 1.51 (b) 13.6 (c) 40.8 (d) 122.4 [IIT 1997]

48) The K_α X-ray emission line of tungsten occurs at λ = 0.021 nm. The energy difference in K and L levels in this atom is about
(a) 0.51 MeV (b) 1.2 MeV (c) 59 keV (d) 13.6 eV [IIT 1997]

49) Masses of two isobars $_{29}Cu^{64}$ and $_{30}Zn^{64}$ are 63.9298 u and 63.9292 u respectively. It can be concluded from this data that
(a) both the isobars are stable
(b) Zn^{64} is radioactive, decaying to Cu^{64} through β-decay
(c) Cu^{64} is radioactive, decaying to Zn^{64} though γ-decay
(d) Cu^{64} is radioactive, decaying to Zn^{64} though β-decay [IIT 1997]

50) Which of the following statement (s) is (are) correct ?

(a) The rest mass of a stable nucleus is less than the sum of the rest masses of its separated nucleons.
(b) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons.
(c) In nuclear fusion, energy is released by fusing two nuclei of medium mass (approximately 100 amu).
(d) In nuclear fission, energy is released by fragmentation of a very heavy nucleons.
[IIT 1994]

51) 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 [IIT 1994]

52) Consider α particles, β particles and γ-rays, each having an energy of 0.5 MeV. In increasing order of penetrating powers, the radiations are
(a) α, β, γ (b) α, γ, β (c) β, γ, α (d) γ, β, α [IIT 1994]

53) A star initially has 10^{40} deuterons. It produces energy via the following processes:
$_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + p$ and $_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + n$
The masses of the nuclei are as follows:
M (H^2) = 2.014 amu, M (p) = 1.007 amu, M (n) = 1.008 amu, M (He^4) = 4.001 amu
If the average power radiated by the star is 10^{16} W, the deuteron supply of the star is exhausted in a time of the order of
(a) 10^{16} sec (b) 10^{8} sec (c) 10^{12} sec (d) 10^{20} sec [IIT 1993]

54) The decay constant of a radioactive sample is λ. The half-life and the mean-life of the sample are respectively given by
(a) $1/\lambda$ and $\ln 2/\lambda$ (b) $\ln 2/\lambda$ and $1/\lambda$
(c) $\lambda/\ln 2$ and $1/\lambda$ (d) $\lambda/\ln 2$ and 2λ [IIT 1989]

55) The potential difference applied to an X-ray tube is increased. As a result, in the emitted radiation

(a) the intensity increases
(b) the minimum wavelength increases
(c) the intensity remains unchanged
(d) the minimum wavelength decreases

[IIT 1988]

56) A freshly prepared radioactive source of half life 2 hr 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 hr (b) 12 hr (c) 24 hr (d) 128 hr [IIT 1988]

57) 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 emitting an electron
(d) a part of the binding energy of the nucleus is converted into an electron

[IIT 1987]

58) Four physical quantities are listed in Column I. Their values are listed in Column II in random order:

Column I	Column II
(i) Thermal energy of air molecules at room temperature	(e) 0.02 eV
(ii) Binding energy of heavy nuclei per nucleon	(f) 2 eV
(iii) X-ray photon energy	(g) 1 KeV
(iv) Photon energy of visible light	(h) 7 MeV

The correct matching of column I and II is given by

(a) i - e, ii - h, iii - g, iv - f
(b) i - e, ii - g, iii - f, iv – h
(c) i - f, ii - e, iii - g, iv - h
(d) i - f, ii - h, iii - e, iv - g

[IIT 1987]

59) During a nuclear fusion reaction

(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

[IIT 1986]

60) 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

[IIT 1986]

61) The X-ray beam coming from an X-ray tube will be

(a) monochromatic
(b) having all wavelengths smaller than a certain maximum wavelength
(c) having all wavelengths larger than a certain minimum wavelength
(d) having all wavelengths lying between a minimum and a maximum wavelength

[IIT 1985]

62) If elements with principal quantum number $n > 4$ were not allowed in nature, the number of possible elements would be

(a) 60 (b) 32 (c) 4 (d) 64 [IIT 1983]

(Answers at the end of all questions)

63) From the following equations pick out the possible nuclear fusion reactions

(a) ${}_{5}C^{13} + {}_{1}H^{1} \rightarrow {}_{6}C^{14} + 4.3\ \text{MeV}$

(b) ${}_{6}C^{12} + {}_{1}H^{1} \rightarrow {}_{7}N^{13} + 2\ \text{MeV}$

(c) ${}_{7}N^{14} + {}_{1}H^{1} \rightarrow {}_{8}O^{15} + 7.3\ \text{MeV}$

(d) ${}_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{34}Xe^{140} + {}_{38}Sr^{94} + 2\,{}_{0}n^{1} + \nu + 200\ \text{MeV}$

[IIT 1984]

64) In the Bohr model of the hydrogen atom

(a) the radius of the nth orbit is proportional to n^2

(b) the total energy of the electron in the nth orbit is inversely proportional to n

(c) the angular momentum of the electron in an orbit is an integral multiple of $h / 2\pi$

(d) the magnitude of the potential energy of the electron in any orbit is greater than its kinetic energy

[IIT 1984]

65) Beta rays emitted by a radioactive material are

(a) electromagnetic radiations

(b) the electrons orbiting around the nucleus

(c) charged particles emitted by the nucleus

(d) neutral particles [IIT 1983]

66) Consider the spectral line resulting from the transition $n = 2 \rightarrow n = 1$ in the atoms and ions given below. The shortest wavelength is produced by

(a) Hydrogen atom (b) Singly ionized Helium

(c) Deuterium atom (d) Doubly ionized Lithium [IIT 1983]

67) The equation $4\,{}_{1}^{1}H^{+} \rightarrow {}_{2}^{4}He^{++} + 2e + 26\ \text{MeV}$ represents

(a) β - decay (b) γ - decay (c) fusion (d) fission [IIT 1983]

68) The shortest wavelength of X-rays emitted from an X-ray tube depends on

(a) the current in the tube (b) the voltage applied to the tube

(c) the nature of the gas in the tube

(d) the atomic number of the target material [IIT 1982]

69) An alpha particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of

(a) 1 A° (b) 10^{-10} cm (c) 10^{-12} cm (d) 10^{-15} cm [IIT 1981]

70) The half-life of radioactive radon is 3.8 days. The time at the end of which 1 / 20th of the radon sample will remain undecayed is (given $\log_{10} e = 0.4343$)

(a) 3.8 days (b) 16.5 days (c) 33 days (d) 76 days [IIT 1981]

Answers

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
b	d	b	a	d	d	c	c	c	c	c	b	c	b	b	a	d	b	c	b

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
c	c	a	d	a	a	d	b	b	a	c	c	d	d	d	c	c	d	a	b

41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
b	c	a	c,d	a,d	d	d	c	d	a,d	b	a	c	b	d	b	c

58	59	60	61	62	63	64	65	66	67	68	69	70
a	d	c,d	d	a	b,c	a,c,d	c	d	c	b	c	b