TEST SERIES CSIR-UGC-NET/JRF Dec. 2016

BOOKLET SERIES C

Paper Code 05

Test Type: TEST SERIES

PHYSICAL SCIENCES

Duration: 02:00 Hours

Date: 01-12-2016

Maximum Marks: 120

Read the following instructions carefully:

1. Attempt all the questions.
2. This booklet contain **60** Objective Type Questions, each Question carry **2 marks** each.
3. For rough work, blank sheet is attached at the end of test booklet.
4. There will be negative marking @25% for each wrong answer.
5. Darken the appropriate bubbles with HB pencil/Ball Pen to write your answer.
6. The candidates shall be allowed to carry the Question Paper Booklet after completion of the exam.

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THERMODYNAMICS & STATISTICAL PHYSICS + NUCLEAR PHYSICS + ELECTRONICS

1. For the fusion process, the thermodynamic equilibrium corresponds to the state with minimum value of
(a) Helmholtz free energy (b) Gibb's free energy
(c) Entropy (d) Enthalpy

2. A radiation 3D cavity of volume V is in thermal equilibrium at temperature T. If the number of photons inside the cavity is doubled without changing volume of cavity, then
(a) Helmholtz free energy would be doubled
(b) Gibb's free energy would be doubled
(c) specific heat at constant volume becomes half
(d) Helmholtz free energy remains unchanged

3. A diatomic ideal gas is expanded adiabatically from an initial volume V and initial pressure P to a final volume 4V and a final pressure P/3. The work done by the gas is:
(a) $\frac{5}{7}$PV (b) $\frac{5}{6}$PV (c) $\frac{3}{4}$PV (d) $\frac{6}{5}$PV

4. Consider a system of distinguishable particles with energy levels $0, \varepsilon, 2\varepsilon, 3\varepsilon, 4\varepsilon, ...$. For a system with 2 particles and energy 2ε, the entropy of the system is
(a) $k\ln 3$ (b) $2k\ln 2$ (c) $2k\ln 3$ (d) $k\ln 5$

5. A system consists of N very weakly interacting particles at a temperature sufficiently high such that classical statistics are applicable. Each particle has mass m and oscillates in one direction about its equilibrium position. If restoring force is proportional to x^3, the heat capacity at consant volume at temperature T is
(a) $\frac{3}{2}Nk$ (b) $\frac{5}{4}Nk$ (c) $\frac{3}{4}Nk$ (d) $\frac{5}{2}Nk$

6. A system of 6 localized and independent quantum oscillators in contact with a thermal reservoir at temperature T. The energy levels of single oscillator are given by

$$E_n = \hbar\omega_0\left(n + \frac{1}{2}\right), \qquad n = 1, 3, 5, 7..........$$

The average internal energy of the system is
(a) $\frac{1}{2}\hbar\omega_0 + \frac{\hbar\omega_0}{e^{\frac{\hbar\omega_0}{kT}} - 1}$ (b) $3\hbar\omega_0 + \frac{6\hbar\omega_0}{e^{\frac{\hbar\omega_0}{kT}} - 1}$ (c) $\frac{15}{2}\hbar\omega_0 + \frac{10\hbar\omega_0}{e^{\frac{2\hbar\omega_0}{kT}} - 1}$ (d) $9\hbar\omega_0 + \frac{12\hbar\omega_0}{e^{\frac{2\hbar\omega_0}{kT}} - 1}$

7. Consider that the density of states $g(E)$ for super-relativistic gas is defined as

$$g(E) = \begin{cases} 1, & 0 < E < E_D \\ 0, & E > E_D \end{cases}$$

The specific heat at constant volume C_V for gas of bosons and fermions in very low temperature limit ($T \to 0$) varies as
(a) $C_V \,\alpha\, T^3$ for bosons and $C_V \,\alpha\, T$ for fermions
(b) $C_V \,\alpha\, T$ for bosons and for fermions $C_V \,\alpha\, T^3$
(c) $C_V \,\alpha\, T^2$ for bosons and for fermions $C_V \,\alpha\, T$
(d) $C_V \,\alpha\, T$ for bosons and for fermions $C_V \,\alpha\, T$

8. The equation of state for one mole of a gas is given by $\left(P+\frac{a}{TV^2}\right)(V-b)=RT$, where a, b are positive constants of appropriate dimensions and R is universal gas constant, the value of critical temperature of the gas is

(a) $\sqrt{\left(\frac{8a}{27bR}\right)}$ (b) $\frac{8a}{27bR}$ (c) $\frac{3a}{27bR}$ (d) $\sqrt{\left(\frac{a}{27bR}\right)}$

9. Consider a system of N and distinguishable particles (in which particles can move in one dimensional segment $q=0$ and $q=L$) in thermal equilibrium at temperature T. The single particle Hamiltonian is given by

$H=\frac{p^2}{2m}-\alpha\,\ell n\left(\frac{q}{L_0}\right)$, where α is positive constant and L_0 is characteristic length.

The partition function of the system is given by

(a) $L^N\left(\frac{2\pi mkT}{h^2}\right)^{N/2}$ (b) $\left(\frac{2\pi mkT}{h^2}\right)^{N/2}\alpha\ell n\left(\frac{q}{L_0}\right)$

(c) $\left(\left(\frac{2\pi mkT}{h^2}\right)^{1/2}\frac{L_0^{\alpha\beta}}{(\alpha\beta+1)L^{\alpha\beta+1}}\right)^N$ (d) $\left(\left(\frac{2\pi mkT}{h^2}\right)^{1/2}\frac{L^{\alpha\beta+1}}{(\alpha\beta+1)L_0^{\alpha\beta}}\right)^N$

10. The Hamiltonian marix for a quantum mechanical system can be written as

$H=-\frac{gB}{\sqrt{2}}\begin{pmatrix}0&1&0\\1&0&1\\0&1&0\end{pmatrix}$, where $g,B>0$ constants.

The system is in thermal equilibrium at temperature T, the average energy of the system is given by

(a) 0 (b) $\frac{2gB}{3}$ (c) $\frac{-gB\left(e^{\beta gB}-e^{-\beta gB}\right)}{\left(1+e^{\beta gB}+e^{-\beta gB}\right)}$ (d) $\frac{-gB\left(e^{\beta gB}+e^{-\beta gB}\right)}{\left(1+e^{\beta gB}+e^{-\beta gB}\right)}$

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11. The relation between entropy (*S*) and energy (*E*) for a thermodynamic system is given by $S=CV^2\ln E$, where *C* is a constant. The correct relation between pressure (*P*), energy (*E*) and volume (*V*) for the system is

(a) $P=\frac{2E\ln E}{V}$ (b) $P=\frac{2E}{V}$ (c) $P=\frac{E}{2V}$ (d) $P=\frac{2}{3}\frac{E}{V}\ln E$

12. An equation of state for a certain thermodynamic system is found to be $PV^2-aTV=bT$ where *a* and *b* are constants. The isothermal compressibility of the system is given by

(a) $\frac{2PV-aT}{V}$ (b) $\frac{V}{2PV-aT}$ (c) $\frac{1}{aT-PV^2}$ (d) $\frac{V}{PV+aT}$

13. Consider an ideal Fermi gas is confined in one dimensional region of length *L* at *T* = 0. If the density of gas increases to two times of its initial value, then its pressure

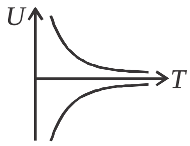
(a) increases to eight times of its initial value (b) increases to $2\sqrt{2}$ times of its initial value

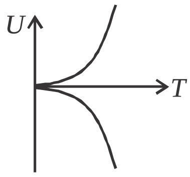
(c) increases to $4\sqrt{2}$ times of its initial value (d) remains unchanged

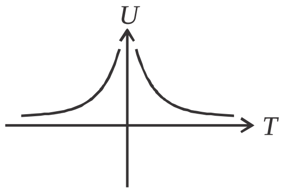
14. The entropy S of an ideal paramagnet in a magnetic field is given approximated by

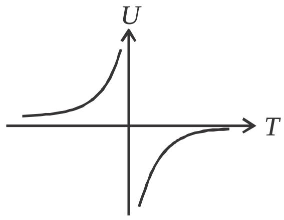
$$S = S_0 - CU^2$$

where, U is the energy of the spin system and C is a constant. For the variation of internal energy with absolute temperature T, which of the following plots is correct?

(a) 

(b) 

(c) 

(d) 

15. The entropy S of a system of N particles at temperature T is given by $S = a\left(NVU\right)^{1/3}$, where U and V are internal energy and volume of the system respectively and a is constant. If temperature changes to $4T$ then specific heat of the system at constant volume becomes

(a) four times (b) two times (c) eight times (d) half

16. Consider a quantum mechanical rigid rotator with Hamiltonian $H = \frac{L^2}{2I}$, where L is the magnitude of orbital angular momentum, is in thermal equilibrium at temperature T. The average energy of the rotator if it assumes only two values of angular momentum quantum number $\ell = 0$ and $\ell = 1$, is

(a) $\dfrac{\hbar^2}{2I\left[1+e^{-\frac{\hbar^2}{2IkT}}\right]}$ (b) $\dfrac{\left[1+\frac{3\hbar^2}{I}e^{-\frac{\hbar^2}{IkT}}\right]}{\left[1+3e^{-\frac{\hbar^2}{2IkT}}\right]}$ (c) $\dfrac{\hbar^2}{I\left[2+e^{+\frac{\hbar^2}{IkT}}\right]}$ (d) $\dfrac{\frac{3\hbar^2}{I}}{\left[3+e^{\frac{\hbar^2}{IkT}}\right]}$

17. Consider a system of N non-interacting and distinguishable particles with single particle states of energies $\varepsilon_{1,}\ \varepsilon_{2,}\ \varepsilon_{3,}\ldots\ldots\ \varepsilon_j$ with corresponding degeneracies $g_{1,}\ g_{2,}\ g_{3,}\ldots\ldots\ g_j$. The value of the single particle partition function in the limit $T \to \infty$ will be

(a) 1 (b) g_j (c) $\sum_j g_j$ (d) $\left(g_j\right)^N$

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18. The average energy per particle for a Fermi gas at $T = 0$, in terms of Fermi energy ε_F, if density of states is proportional $\varepsilon^{-1/2}$ is given by

(a) $\frac{3}{5}\varepsilon_F$ (b) $\frac{1}{2}\varepsilon_F$ (c) $\frac{3}{4}\varepsilon_F$ (d) $\frac{1}{3}\varepsilon_F$

19. Consider a system of two particles A and B. Each particle can occupy one of three possible quantum states $|1\rangle$, $|2\rangle$ and $|3\rangle$. The ratio of the probability that the two particles are in the same state to the probability that the two particles are in different states is calculated for fermions and classical (Maxwell-Boltzmann) particles. They are respectively

(a) 1 and 0 (b) ½ and 1 (c) 1 and ½ (d) 0 and ½

20. In the first –order phase transition which is/are continuous?

(a) Volume (b) Chemical potential (c) Entropy (d) all

21. A π^+ meson at rest decays into a μ^+ meson and a neutrino in 2.5×10^{-8} sec. Assuming that π^+ meson has kinetic energy equal to its rest energy, the distance would the meson travel before decaying as seen by an observer at rest is

(a) 11 m (b) 1.1 km (c) 13 m (d) 1.3 km

22. A particle ρ of mass 770 MeV/c^2 decays into two pions each of rest mass 140 MeV/c^2. The momentum of each pion is about

(a) 359 MeV/c (b) 455 MeV/c (c) 490 MeV/c (d) 630 MeV/c

23. A neutron beam is incident on a stationary target of F^{19} atoms. The reaction of F^{19} (n, p) O^{19} has a Q-value of –3.9 MeV. The lowest neutron energy which will make this reaction possible is

(a) 3.9 MeV (b) 4.5 MeV (c) 4.1 MeV (d) 3.5 MeV

24. According to single particle shell model, the nuclear spin and parity of ${}_{49}In^{109}$ is

(a) $\frac{9}{2}$ and odd (b) $\frac{7}{2}$ and even (c) $\frac{9}{2}$ and even (d) $\frac{7}{2}$ and odd

25. The quadrupole moment of ${}_{6}C^{13}$ nucleus is

(a) – 0.18 barn (b) zero barn (c) + 0.033 barn (d) + 0.18 barn

26. A particular type of nucleus with decay constant λ is produced at a steady rate of P nuclei per second. The number of nuclei N(t) present at t second after the production starts is

(a) $\frac{P}{\lambda}(1+e^{-\lambda t})$ (b) $P(1+e^{-\lambda t})$ (c) $\frac{P}{\lambda}(1-e^{-\lambda t})$ (d) $P(1-e^{-\lambda t})$

27. If we assume that the charge +Ze of a nucleus is spread over a sphere of radius R, the fastest α-particles (charge 2^e, mass 4 m_p) which can suffer 180° scattering will have the speed equal to

(a) $\sqrt{\frac{Ze^2}{4\pi\varepsilon_0 m_p R}}$ (b) $\sqrt{\frac{Ze^2}{2\pi\varepsilon_0 m_p R}}$ (c) $\sqrt{\frac{Ze^2}{\pi\varepsilon_0 m_p R}}$ (d) $\sqrt{\frac{2Ze^2}{\pi\varepsilon_0 m_p R}}$

28. In β-decay process ${}^{35}_{16}S \to {}^{35}_{17}Cl + \beta^- + \bar{\nu}_e$, the transition is

(a) allowed by Fermi and but not by Gamow-Teller selection rule
(b) allowed both by Fermi and Gamow-Teller selection rule
(c) not allowed by Fermi but allowed by Gamow-Teller selection rule
(d) not allowed both by Fermi and Gamow-Teller selection rule

29. Consider the following processes

(i) $\pi^+ + n \to K^0 + K^+$ (ii) $\pi^+ + n \to \wedge^0 + K^+$

(iii) $\pi^+ + n \to \overline{K^0} + \Sigma^0$ (iv) $\pi^+ + \pi^- \to \bar{n} + p$

Which of the above is/are allowed?

(a) (i) and (ii) (b) only (ii) (c) (ii) and (iv) (d) (i), (ii) and (iii)

30. The dominant interactions underlying the following processes.

(I) $K^- + p \longrightarrow \Omega^- + K^+ + K^0$ (II) $\Sigma^0 \to \wedge^0 + \gamma$ (III) $\pi^+ \to \mu^+ + \nu_\mu$

(a) (I) strong, (II) weak, (III) EM (b) (I) strong, (II) EM, (III) weak
(c) (I) weak, (II) EM, (III) strong (d) (I) weak, (II) EM, (III) weak

31. The expected types of gamma ray transitions between the $g_{9/2} \to p_{1/2}$ transition.

(a) M_5 and E_4 (b) M_4 and E_5
(c) E_3, M_4, E_5 and M_6 (d) M_3, E_4, M_5 and E_6

32. Choose the incorrect statement from the following:

(a) By capturing an electron $^{54}_{25}Mn_{29}$ transforms into $^{54}_{24}Cr_{30}$ releasing a neutrino.

(b) A nucleus of medium mass with excess of neutron may decay with the emission of positron.

(c) The decay chain of the nucleus $^{238}_{92}U$ involves eight α-decay and six β- decays. The final nucleus at the end of the process will have $A = 206, Z = 82$.

(d) The plot of log A versus time t (where A is activity) is always a straight line for only one kind of radioactive nuclei having same half-life.

33. The α-particles emitted when U^{238} decays has a kinetic energy of 4.2 MeV. The disintegration energy of this reaction is

(a) 4.20 MeV (b) 5.27 MeV (c) 4.27 MeV (d) 5.20 MeV

34. The ratio of the mass of ^{208}Pb to the mass of ^{238}U in a certain rock specimen is found to be x. Assuming that the rock originally contained no lead, its age is

(a) $\frac{1}{\lambda}\log_e(x-1)$ (b) $\frac{1}{\lambda}\log_e(x+1)$ (c) $\frac{1}{\lambda}\log_e x$ (d) $\frac{1.44}{\lambda}\log_e(x+1)$

35. Choose the incorrect statement from the following

(a) The last stable end product of 4n series is $_{82}Pb^{206}$

(b) 4n + 2 series is called uranium series

(c) The last stable end product of 4n + 3 series is $_{82}Pb^{207}$

(d) The parent nucleus of 4n + 1 series is $_{93}Np^{237}$

36. The ground state magnetic moment of $^{33}_{16}S$ is

(a) $-1.15\ \mu_N$ (b) $-1.91\ \mu_N$ (c) $1.15\ \mu_N$ (d) $1.91\ \mu_N$

37. The following interactions proceed through the strong, electromagnetic (EM) or weak interactions.

(i) $\pi^0 \rightarrow \gamma + \gamma$ (ii) $\mu^- \rightarrow e^- + \nu_\mu + \bar{\nu}_e$ (iii) $\Delta^{++} \rightarrow p + \pi^+$

The correct order of interactions is

(a) (i) strong, (ii) weak, (iii) EM

(b) (i) EM, (ii) strong (iii) weak

(c) (i) EM, (ii) weak, (iii) strong

(d) (i) strong, (ii) EM, (iii) weak

38. Which one of the following reaction is forbidden ?

(a) $\pi^+ + n \longrightarrow \Lambda^0 + K^+$ (b) $\pi^0 + n \longrightarrow \bar{K}^0 + \Sigma^0$

(c) $\Lambda^0 \longrightarrow p + \pi^-$ (d) $\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$

39. By using semi-empirical mass formula, the most stable isobar corresponding to mass number A = 97 is

(a) 40 (b) 42 (c) 45 (d) 50

40. Choose the incorrect statement from the following

(a) The mean momentum of a nucleon in a nucleus with mass number (A) varies as $A^{-1/3}$.

(b) The radius of a nucleus with mass number (A) varies as $A^{1/3}$.

(c) The kinetic energy of a nucleon in a nucleus with mass number (A) varies as $A^{-1/3}$.

(d) The volume of a nucleus in a atom is proportional to the mass number (A).

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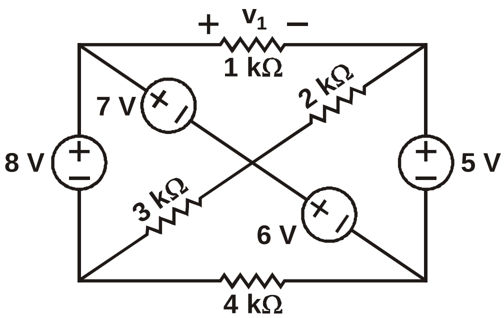
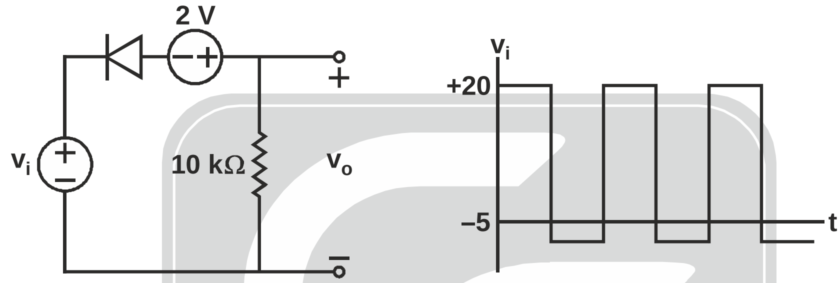
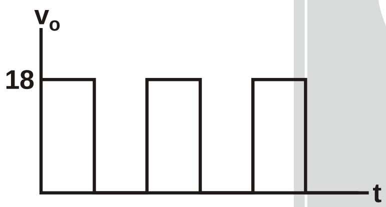
41. In the circuit of figure the voltage $v_1 = ?$

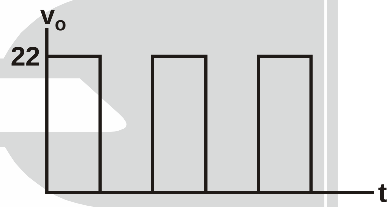


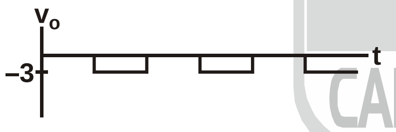
(a) –11 V (b) 5 V (c) 8 V (d) 18 V

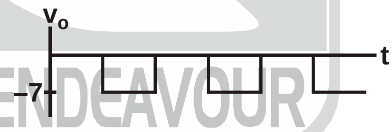
42. Consider the given a circuit and a waveform for the input voltage. The diode in circuit has cutin voltage $V_\gamma = 0$. The waveform of output voltage v_0 is



(a)


(b)


(c)


(d)


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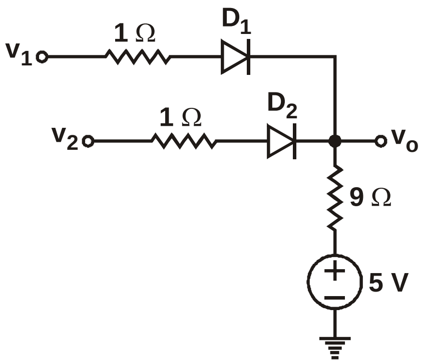
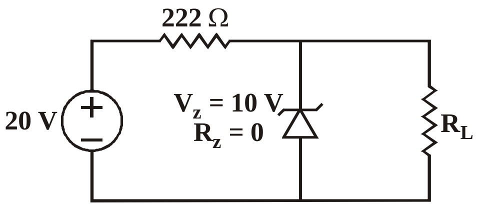
43. Consider the circuit shown below. Assume diodes are ideal.



If $v_1 = v_2 = 10$ V, then output voltage v_o is

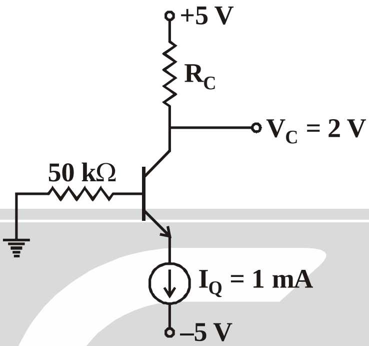
(a) 0 V (b) 9.737 V (c) 9 V (d) 9.5 V

44. In the voltage regulator circuit shown below the power rating of Zener diode is 400 mW. The value of R_L that will establish maximum power in Zener diode is



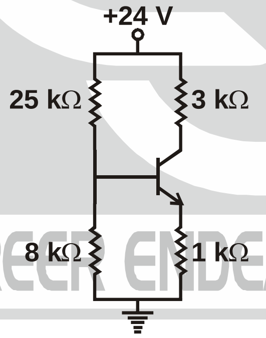
(a) 5 kΩ (b) 2 kΩ (c) 10 kΩ (d) 8 kΩ

45. The common-emitter current gain of the transistor is $\beta = 75$. The voltage V_{BE} in ON state is 0.7 V. The value of I_C and R_C is



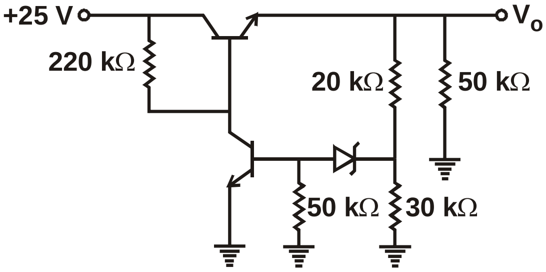
(a) 0.987 mA, 3.04 kΩ (b) 1.013 mA, 2.96 kΩ
(c) 0.946 mA, 4.18 kΩ (d) 1.057 mA, 3.96 kΩ

46. For the circuit shown below, let $\beta = 75$. The Q-point (I_{CQ}, V_{CEQ}) is



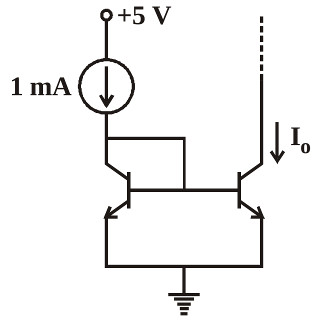
(a) (4.68 mA, 16.46 V) (b) (3.12 mA, 1.86 V)
(c) (3.12 mA, 8.46 V) (d) (4.68 mA, 5.22 V)

47. In the series voltage regulator circuit shown below $V_{BE} = 0.7$ V, $\beta = 50$, $V_Z = 8.3$ V. The output voltage V_o is



(a) 25 V (b) 25.7 V (c) 15 V (d) 15.7 V

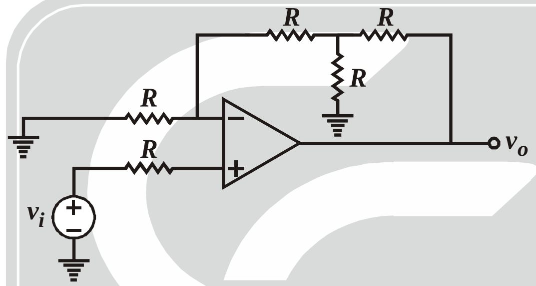
48. In the current mirror circuit shown below the transistor parameters are $V_{BE} = 0.7$ V, $\beta = 50$ and the Early voltage is infinite. Assume transistor are matched.



The output current I_o is

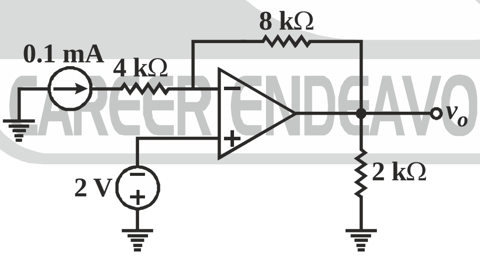
(a) 1.04 mA (b) 1.68 mA (c) 962 μA (d) 432 μA

49. For the circuit shown below the value of $A_v = \dfrac{v_o}{v_i}$ is



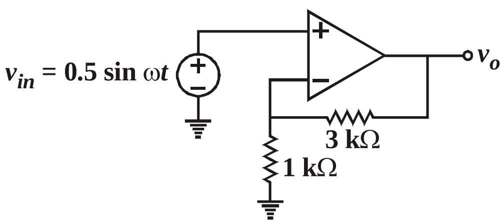
(a) 5 (b) –5 (c) 6 (d) –6

50. For the circuit shown below the value of v_o is



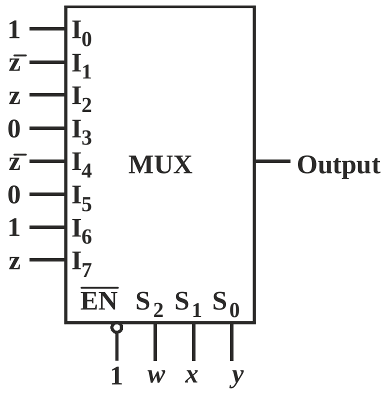
(a) –30 V (b) 18 V (c) –18 V (d) 28 V

51. The op-amp shown in figure, has a slew rate of 1V/ns, what is the highest input frequency for which no slewing occurs



(a) 153.8 MHz (b) 63.7 MHz (c) 79.6 MHz (d) 127.4 MHz

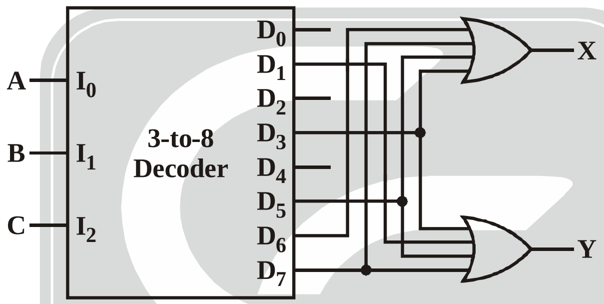
52. The 8-to-1 multiplexer shown below realize the following Boolean expression



(a) $w\bar{x}z + \bar{w}\,\bar{x}\,\bar{z} + wyz + x\,\bar{y}\,\bar{z}$ (b) $wxz + \bar{w}yz + wy\bar{z} + \bar{w}\,\bar{x}\,\bar{y}$

(c) $\bar{w}\,\bar{x}\,\bar{z} + w\,\bar{y}\,\bar{z} + \bar{w}\,\bar{y}\,z + wxz$ (d) MUX is not enable

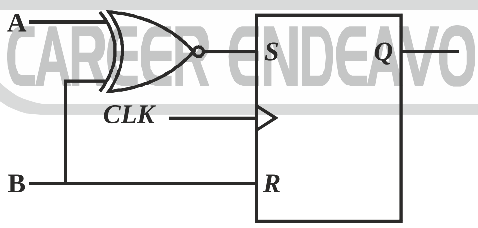
53. The building block shown below is a active high output decoder.



The output X is

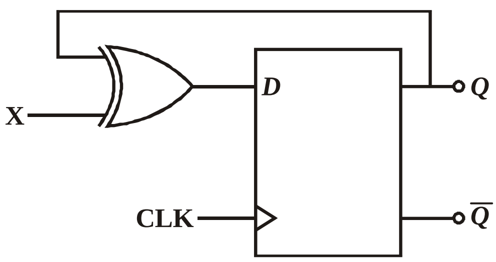
(a) AB + BC + CA (b) A + B + C (c) ABC (d) None of these

54. An AB flip-flop is constructed from an SR flip-flop as shown below. The expression for next state Q^+ is



(a) $\bar{A}\,\bar{B} + A\,Q$ (b) $\bar{A}\,\bar{B} + \bar{B}\,Q$ (c) Both A and B (d) None of these

55. The digital circuit shown in the figure works as



(a) JK flip-flop (b) Clocked RS flip-flop

(c) T-flip-flop (d) Ring counter

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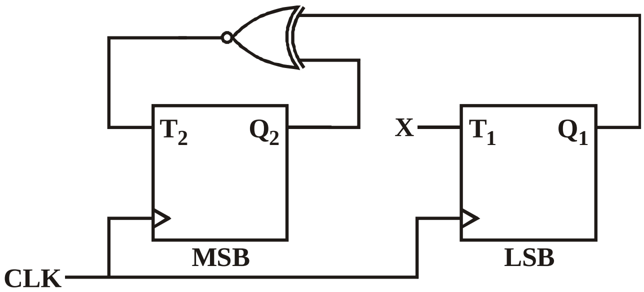
56. How many flip-flops will be complemented in a 10-bit binary ripple counter to reach the next count after the count 1001100111

(a) 4 (b) 5 (c) 6 (d) 9

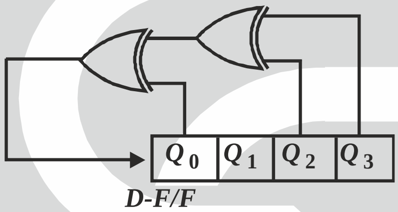
57. Consider the partial implementation of a 2-bit counter using T flip-flop following the sequence 0-2-3-1-0 as shown below.



To complete the circuit the input X should be

(a) $\bar{Q}_2$ (b) $Q_2 + Q_1$ (c) $\overline{(Q_1 \oplus Q_2)}$ (d) $Q_1 \oplus Q_2$

58. A 4-bit right shift register is initialized to value 1000 for (Q_3, Q_2, Q_1, Q_0). The D input is derived from Q_0, Q_2 and Q_3 through two XOR gates as shown in figure. The pattern 1000 will appear at



(a) 3rd pulse (b) 7th pulse (c) 6th pulse (d) 4th pulse

59. A 4-bit ripple counter and a 4-bit synchronous counter are made by flips flops having a propagation delay of 10 ns each. If the worst case delay in the ripple counter and the synchronous counter be R and S respectively, then

(a) R = 10 ns, S = 40 ns (b) R = 40 ns, S = 10 ns
(c) R = 10 ns, S = 30 ns (d) R = 30 ns, S = 10 ns

60. 12 MHz clock frequency is applied to a cascaded counter of modulus-3 counter, modulus-4 counter and modulus-5 counter. What are the lowest output frequency and the overall modulus, respectively?

(a) 200 kHz, 60 (b) 1 MHz, 60 (c) 3 MHz, 12 (d) 4 MHz, 12

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Space for rough work

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PHYSICAL SCIENCES

TEST SERIES-III

Date : 01-12-2016

THERMODYNAMICS & STATISTICAL PHYSICS + NUCLEAR PHYSICS + ELECTRONICS

ANSWER KEY

1. (b)	2. (d)	3. (b)	4. (a)	5. (c)	6. (d)	7. (d)
8. (a)	9. (d)	10. (c)	11. (a)	12. (b)	13. (a)	14. (d)
15. (b)	16. (d)	17. (c)	18. (d)	19. (d)	20. (b)	21. (c)
22. (a)	23. (c)	24. (c)	25. (b)	26. (c)	27. (a)	28. (b)
29. (b)	30. (b)	31. (b)	32. (b)	33. (c)	34. (b)	35. (a)
36. (c)	37. (c)	38. (b)	39. (b)	40. (c)	41. (c)	42. (c)
43. (b)	44. (b)	45. (a)	46. (d)	47. (c)	48. (c)	49. (a)
50. (a)	51. (c)	52. (d)	53. (a)	54. (c)	55. (c)	56. (a)
57. (d)	58. (c)	59. (b)	60. (a)			

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