TEST SERIES GATE 2018

BOOKLET SERIES A

Paper Code: PH

Test Type: TEST SERIES

Duration: 3:00 Hours

PHYSICS

Date: 09-01-2018

Maximum Marks: 100

Read the following instructions carefully:

1. Attempt all questions.
2. This question paper consists of **2 sections**, General Aptitude (GA) for **15 marks** and the subject specific GATE paper for **85 marks**. Both these sections are compulsory. The GA section consists of **10** questions. Question numbers 1 to 5 are of 1-mark each, while question numbers 6 to 10 are of 2-mark each.
   The subject specific GATE paper section consists of **55** questions, out of which question numbers 11 to 35 are of 1-mark each, while question numbers 36 to 65 are of 2-mark each.
3. The question paper may consist of questions of **multiple choice type** (MCQ) and **numerical answer type**.
4. Multiple choice type questions will have four choices against (a), (b), (c), (d), out of which only **ONE** is the correct answer.
5. For numerical answer type questions, each question will have a numerical answer and there will not be any choices**.**
6. All questions that are not attempted will result in zero marks. However, wrong answers for multiple choice type questions (MCQ) will result in **NEGATIVE** marks. For all MCQ questions a wrong answer will result in deduction of ⅓ marks for a **1-mark** question and ⅔ marks for a **2-mark** question.
7. There is **NO NEGATIVE MARKING** for questions of **NUMERICAL ANSWER TYPE**.
8. Non-programmable type Calculator is allowed

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CORPORATE OFFICE :
33-35, Mall Road, G.T.B. Nagar,
Opp. G.T.B. Nagar Metro Station
Gate No. 3, Delhi-110 009
T : 011-65462244, 65662255

REGISTERED OFFICE :
28-A/11, Jia Sarai, Near-IIT,
Hauz Khas Metro Station
Delhi-110 016
T : 011-26851008, 26861009

E : info@careerendeavour.com

w : www.careerendeavour.com

Q.1-Q. 5 carry ONE mark each.

1. Choose the most appropriate word from the options given below to complete the following sentence.
Privacy is _____ by laws relating to defamation, under the Indian Penal Code.
(a) secluded (b) derived (c) protected (d) confined

2. The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair:
After : Before ::
(a) First: Second (b) Present : Past
(c) Contemporary : Historic (d) Successor : Predecessor

3. The value of a for which the equation $x^3 + ax + 1 = 0$ and $x^4 + ax^2 + 1 = 0$ have a common root is
(a) 2 (b) –2 (c) 0 (d) 1

4. Find the value of $i + i^2 + i^3 + i^4 + ... + i^{50}$ where $i = \sqrt{-1}$
(a) 1 (b) –1 (c) $i + 1$ (d) $i - 1$

5. If 'TEMPLE' is coded as 'VHQNIA'. How would you code CHURCH?
(a) EKYWI (b) EKYQZD (c) EKYPZD (d) EKYQWD

Q.6-Q. 10 carry TWO marks each.

6. The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair:
Stutter : Speech ::
(a) Blare : Hearing (b) Aroma : Smell
(c) Novacain: Touch (d) Astigmatism : Sight

7. Choose the most appropriate word from the options given below to complete the following sentence.
The age of satellite communication _____ in 1962 with the launching of Early Bird, the first Communication Satellite.
(a) dawned (b) negated (c) ended (d) estimated

8. The value of $\left\{\frac{1}{\log_{xy}(xyz)} + \frac{1}{\log_{yz}(xyz)} + \frac{1}{\log_{zx}(xyz)}\right\}$ is
(a) 0 (b) 1 (c) 2 (d) 3

9. For a back sale, Zara backed 2n more pies than Simran. Simran backed half as many pies as Mani, who baked $\frac{1}{3}n$ pies. No other pies were baked for the sale. What fraction of the total pies for sale did Mani bake?
(a) $\frac{1}{16}$ (b) $\frac{1}{8}$ (c) $\frac{3}{16}$ (d) $\frac{13}{16}$

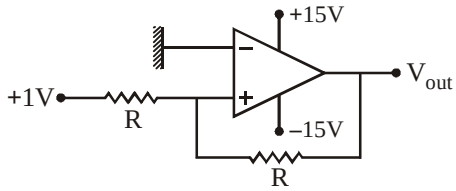
10. Consider the following set of lines : $|x| + |y| = 1$. Area enclosed by them is
(a) 1 (b) 2 (c) 3 (d) 4

Q.11-Q.35 carry one mark each.

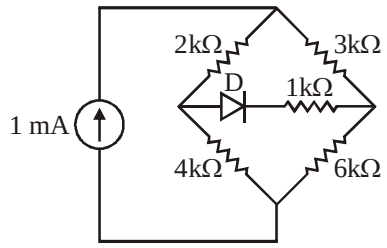
11. The total energy, E of an ideal non-relativistic fermi gas in three dimensional is given by $E \propto \frac{N^{5/9}}{V^{2/3}}$, where N is the number of particles and V is the volume of the gas. The value of $\frac{PV}{E}$ is _____

12. One mole of an ideal gas at 300K expands reversibly and isothermally from a pressure of 1.5×10^3 N/m^2 to 5×10^2 N/m^2. The change in entropy (J/K) of the universe is
(a) –0.21 (b) 19.1 (c) 0.21 (d) 0

13. In the circuit of the figure, V_o is _____V



14. The diode in the circuit given below has V_{ON} = 0.7 V but is ideal otherwise. The current (in mA) in the 4 kΩ resistor is



(a) 0 (b) 0.5 (c) 0.4 (d) 0.6

15. A hydrogen atom in its ground state is collided with an electron of kinetic energy 12.97 eV. The maximum factor by which the radius of the atom would increase is _____

16. Suppose a spin 1/2 particle is in the state $|\phi\rangle = \frac{1}{\sqrt{5}}\begin{bmatrix} 1-i \\ \sqrt{3} \end{bmatrix}$. The expectation value of *z*-component of spin angular momentum of the particle is _____$\hbar$

17. The translational operator $\left(\hat{T}_L\right)$ is defined as $\hat{T}_L f(x) = f(x-L)$, where $f(x)$ in any arbitrary function of position *x* and *L* is any constant. If the position operator is represented by $\hat{x}$, then the value of commutator $\left[\hat{T}_L, \hat{x}\right]$ is

(a) $L\,\hat{x}$ (b) $-L\,\hat{T}_L$ (c) $-L\,\hat{x}$ (d) 0

18. If σ_i represents $(i = x, y, z)$ Pauli's spin operator corresponding to spin-½ particle and $\hat{I}$ is unit operator then $e^{(\sigma_x+\sigma_y)}$ is given by

(a) $e^{\sigma_x}\, e^{\sigma_y}$ (b) $\cosh(1)\hat{I} + \frac{1}{2}(\sigma_x + \sigma_y)\sinh(1)$

(c) $\cosh(2)\hat{I} + (\sigma_x + \sigma_y)\sinh(2)$ (d) $\cosh\left(\sqrt{2}\right)\hat{I} + \frac{1}{\sqrt{2}}\sinh\left(\sqrt{2}\right)(\sigma_x + \sigma_y)$

19. According to single particle nuclear shell model, the spin parity of first excited state of $^{7}_{4}\mathrm{Be}$ is

(a) $\frac{1}{2}^{+}$ (b) $\frac{3}{2}^{-}$ (c) $\frac{1}{2}^{-}$ (d) $\frac{3}{2}^{+}$

20. The threshold kinetic energy to produce π meson from the reaction, $p + p \rightarrow p + p + \pi^0$ is _____MeV. $\left(m_p = 938\ MeV/c^2, m_{\pi^0} = 135\ MeV/c^2\right)$

21. Consider the following functinos:

$$f_1(x)=\begin{cases}+1 & 0<x<\pi\\ -1 & -\pi<x<0\end{cases};\quad f_1(x+2\pi)=f_1(x)$$

$$f_2(x)=\begin{cases}+x & 0<x<\pi\\ -x & -\pi<x<0\end{cases};\quad f_2(x+2\pi)=f_2(x)$$

In the fourier series expansion of the two functions, fourier co-efficient b_n will be zero for

(a) both $f_1(x)$ and $f_2(x)$ (b) only $f_2(x)$

(c) only $f_1(x)$ (d) neither $f_1(x)$ nor $f_2(x)$

22. Fourier transform of $f(t)$ is given by $F[f(t)]=\int_{-\infty}^{+\infty} f(t)e^{-i\omega t}dt=F(\omega)$. If $f(t)=\begin{cases}e^{at} & t<0\\ e^{-at} & t>0\end{cases}$ and its fourier transform $F(\omega)$ is given by $\frac{na}{a^2+\omega^2}$, then the value of n is _____(answer should be integer)

23. An unpolarized light propagating along z-direction, scattered from clouds of charge particles (whose dimension is of the order of wavelength of light). The observer who is standing on the x-axis he will receive the state of polarization of the light is

(a) y-polarized light (b) x-polarized light (c) z-polarized light (d) circular polarized light

24. The electric potential inside a solid sphere of radius R at a distance r from the centre is $\phi(r)=(ar^3+b)$. If electric field at $r=2R$ is βaR^2 then value of β is _____(upto second decimal places)

25. The hyperfine structure arises due to:

(a) interaction between nuclear spin angular momentum & internal magnetic field produced by the surrounding electrons in the atom only.

(b) is due to the presence of different of isotopic species in the element under consideration only.

(c) the interaction between nuclear spin angular momentum & internal magnetic field produced by the surrounding electrons in the atom & due to isotope effect both

(d) spin-orbit interaction of electron & relativistic correction both

26. The rotational spectra of rigid diatomic molecule contains spectral lines separated by a distance 0.6cm^{-1}. The moment of inertia of the molecule will be

(a) 9.3×10^{-34} kg-m^2 (b) 6.3×10^{-34} kg-m^2 (c) 9.3×10^{-46} kg-m^2 (d) 6.3×10^{-46} kg-m^2

27. A beam of neutral atoms passes through a Stern-Gerlach apparatus. Five equally spaced lines are observed, the total angular momentum of the atom is $\sqrt{n}\hbar$, value of n is _____(answer should be integer)

28. The Lagrangian of a (three springs and two masses) system is given by

$$L=\frac{1}{2}m_1\dot{x}_1^2+\frac{1}{2}m_2\dot{x}_2^2-\frac{1}{2}k_1x_1^2-\frac{1}{2}k_2(x_2-x_1)^2-\frac{1}{2}k_3x_2^2$$

Where $m_1=2m, m_2=m, k_1=4k, k_2=k$ and $k_3=2k$. The eigen frequencies of small oscillations are

(a) $\sqrt{\frac{2k}{m}},\sqrt{\frac{k}{m}}$ (b) $\sqrt{\frac{2k}{m}},\sqrt{\frac{7k}{2m}}$ (c) $\sqrt{\frac{3k}{2m}},\sqrt{\frac{2k}{5m}}$ (d) $\sqrt{\frac{3k}{m}},\sqrt{\frac{5k}{2m}}$

29. The following transformation $Q=Aq+Bp, P=Cq+Dp$ is canonical under the condition

(a) $AD=1+BC$ (b) $AB=1+CD$ (c) $AC=1+BD$ (d) $AD=1-BC$

30. Two masses $m_1=100$ g and $m_2=200$ g slide freely in a horizontal frictionless track and are connected by a spring whose force constant is $k=0.5$ N/m. The frequency of oscillatory motion for this system is _____ Hz. (up to two decimal places)

31. A particle of mass m and velocity u collides elastically with a particle of mass $2m$ at rest. The maximum potential energy stored in the system during the collision is βmu^2. The value of β is _____ (up to two decimal places).

32. A particle of mass m is subject to a force $f(t) = me^{-2t}$ N. The initial position and speed are 0. The distance covered by particle after time $t = 2$s is _____ m. (up to three decimal place) (given data: $e^{-4} \simeq 0.0183$)

33. The Hall coefficient R_H of sodium depends on
(a) The effective charge carrier mass and carrier density
(b) The charge carrier density and relaxation time
(c) The charge carrier density only
(d) The effective charge carrier mass.

34. The ratio of nearest neighbour distance of SC crystal to FCC is _____

35. The band gap in a BCS superconductor is measured to be 3 meV at 0K. The critical temperatuer (T_C) of the superconductor is:
(a) 5K (b) 10K (c) 2K (d) 15K

Q.36-Q.65 carry TWO marks each.

36. The equation of state for adiabatic process performed on an ideal gas consisting of non-relativistic rigid triangular molecule in terms of pressure (P) and volume (V) is given by $PV^{\gamma} = \text{constant}$, the value of γ is _____

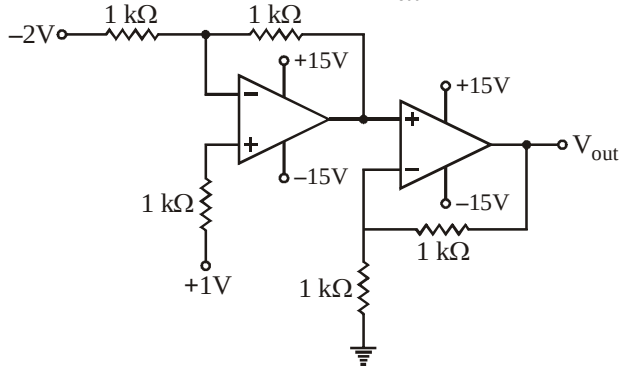
37. The entropy (S) of a thermodynamics system is give in terms of its internal energy (U) and volume (V) by $S = cU^{3/4}V^{1/4}$, where c is constant.
The equation of state of the system is given by
(a) $3PV = 2U$ (b) $4PV = 3U$ (c) $3PV = U$ (d) $3PV = 4U$

38. Consider a system of 2 spin-zero indistinguishable particles, each of which can occupy any of four lowest energy states of one-dimensional infinite potential well. The number of microstates allowed to the system is
(a) 16 (b) 10 (c) 8 (d) 6

39. Consider a thermodynamic system which can occupy any of three energy levels (1, 2, 3) with energy $\in_1, \in_2$ and $\in_3$ with corresponding probabilities $p_1 = 0.9$, $p_2 = 0.09$ and $p_3 = 0.01$ at $T = 300$K. The energy of level 2 relative to level 1 is _____eV.

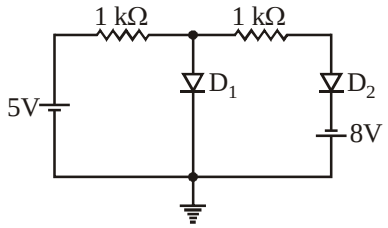
40. The partition function (Z) of a hypothetical thermodynamic system is given by $Z = e^{aVT^4}$
where a is constant, absolute temperature T and volume V. If the entropy (S) of the system in terms of internal energy (U) can be written as $S = \alpha \frac{U}{T}$, then the value of α is _____.

41. In the circuit shown below the op-amp are ideal. Then V_{out} in volts is _____



42. A diode whose terminal characteristic are related as $I_D = I_s e^{\left(\frac{V}{V_T}\right)}$, where I_s is the reverse saturation current and V_T is the thermal voltage (= 25 mV) is biased at $I_D = 2$ mA. Its dynamic resistance is
(a) 25 ohms (b) 12.5 ohms (c) 50 ohms (d) 100 ohms

43. Assuming that the diodes are ideal in figure, the current in D_1 is



(a) 8 mA (b) 5 mA (c) 0 mA (d) –3 mA

44. The de-Broglie wavelength of a particle having a mass 900 MeV/c^2 and kinetic energy 2 MeV, is equal to _____ $\times 10^{-14} m$.

45. The spin-orbit interaction in an sodium atom is given by $H = 2\vec{L}.\vec{S}$, where $\vec{L}$ and $\vec{S}$ denote the orbital and spin angular momenta respectively, of the electron. The splitting between the levels $^2P_{3/2}$ and $^2P_{1/2}$ (due to spin-orbit interaction) is (Take $\hbar^2 = 1$)_____ units (Your answer should be **an integer**)

46. State of a particle in an infinite potential well is given to be $\psi(x) = A\sin\left(\frac{2\pi x}{L}\right)\cos\left(\frac{\pi x}{L}\right)$ where $0 \le x \le L$

Which of the following values will the energy measurement give?
(a) $\frac{\pi^2\hbar^2}{2mL^2}, \frac{9\pi^2\hbar^2}{2mL^2}$ (b) $\frac{2\pi^2\hbar^2}{mL^2}, \frac{9\pi^2\hbar^2}{2mL^2}$ (c) $\frac{\pi^2\hbar^2}{mL^2}, \frac{2\pi^2\hbar^2}{mL^2}$ (d) $\frac{8\pi^2\hbar^2}{mL^2}, \frac{2\pi^2\hbar^2}{mL^2}$

47. In the scattering experiment, the potential is spherically symmetric and the particle are scattered such energy that only *s*-waves and *p*-waves are needed to be considered. Suppose the differential cross section can be written as

$$\frac{d\sigma(\theta)}{d\Omega} = A + B\cos\theta + C\cos^2\theta$$

The value of the total cross section can be expressed as
(a) $4\pi\left(A + \frac{C}{3}\right)$ (b) $4\pi\left(A - \frac{C}{3}\right)$ (c) $4\pi\left(A - \frac{C}{2}\right)$ (d) $4\pi\left(A + \frac{C}{2}\right)$

48. The quark content of k^- and Σ^+ are respectively
(a) $s\bar{u}$ and uud (b) $d\bar{u}$ and uud (c) $d\bar{u}$ and uus (d) $s\bar{u}$ and uus

49. Match the following reactions on the left with the associated interactions on the right

(1) $\pi^- + p \to \Lambda^0 + k^0$	(A) strong
(2) $P + \gamma \to P + \pi^0$	(B) electromagnetic
(3) $\Xi^- \to \Lambda^0 + \pi^-$	(C) weak
(4) $\Lambda^0 \to \Sigma^+ + \pi^-$	(D) forbidden

(a) 1-A, 2-B, 3-C, 4-C (b) 1-A, 2-B, 3-D, 4-D
(c) 1-A, 2-B, 3-C, 4-D (d) 1-D, 2-D, 3-C, 4-C

50. Consider the following matrix:

$$A=\begin{bmatrix}0 & 1\\ 1 & 0\end{bmatrix}$$

The matrix $\exp(i\phi A)$ can be written as

(a) $\begin{bmatrix}\cos\phi & i\sin\phi\\ -i\sin\phi & \cos\phi\end{bmatrix}$ (b) $\begin{bmatrix}0 & e^{i\phi}\\ e^{i\phi} & 0\end{bmatrix}$

(c) $\begin{bmatrix}\cos\phi & i\sin\phi\\ i\sin\phi & \cos\phi\end{bmatrix}$ (d) $\begin{bmatrix}1 & e^{i\phi}\\ e^{i\phi} & 1\end{bmatrix}$

51. If V is the volume of the region bounded by surface 'S' and $r^2=x^2+y^2+z^2$, then the value of $\iint_S(\nabla r^2)\cdot\hat{n}\,dS$ is equal to (Here $\hat{n}$ is unit normal perpendicular and outward to surface) _____ $\times V$.

52. Value of the integral $I=\int_0^{2\pi}e^{\cos\theta}\cos(\sin\theta)\,d\theta$ is equal to _____ $\times\pi$.

53. The equation of the curve satisfying

$$\sin y\frac{dy}{dx}=\cos y(1-x\cos y)$$

and passing through the origin will

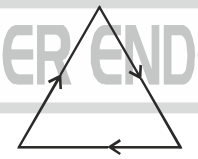
(a) $\sec y=x-1$ (b) $\sec y=x+1$

(c) $\sec y=x+1+2e^{-x}$ (d) $\sec y=x-1+2e^{-x}$

54. A sphere of radius R has uniform volume charge density. The electric field at the surface of sphere is E_s. The electrical potential at the centre of sphere will be

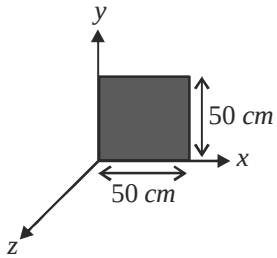
(a) $\frac{E_sR}{2}$ (b) $-\frac{E_sR}{2}$ (c) $\frac{3}{2}E_sR$ (d) $-\frac{3}{2}E_sR$

55. A current I flows in a triangular loop of each side a, magnetic field at centroide of the triangle is



(a) $\frac{3\mu_0 I}{2\pi a}$ (b) $\frac{3\mu_0 I}{\pi a}$ (c) $\frac{3\sqrt{3}\mu_0 I}{2\pi a}$ (d) $\frac{9\mu_0 I}{2\pi a}$

56. A plane electromagnetic wave $\vec{E}=\hat{j}E_0\cos(\omega t-kx)$ propagating in space. If $E_0=5\times10^{-4}\,V/m$ and $\omega=10\pi\times10^6\,rad/\sec$, the amplitude of emf induced in the loop as shown figure is _____mVolt. (answer upto three decimal places)



57. He-Ne laser emmits light of wavelength 6328Å with spectral width $\Delta\lambda = 10^{-7}\,\text{Å}$. Its coherence time and coherence length are
(a) 133 μs and 40 m (b) 133 μs and 40 km (c) 133 μs and 40 m (d) 133 ms and 40 km

58. If the doublet splitting of the first excited state $2^2D_{5/2} - 2^2D_{3/2}$ of H atom is 0.23 cm^{-1}, then the corresponding separation of He^+ is _____ cm^{-1}.

59. The degeneracy of the spectral term ^3D is
(a) 15 (b) 20 (c) 25 (d) 10

60. Suppose a charge Q is distributed within a sphere of radius R in such a way that the charge density $\rho(r)$ at a distance r from the centre of the sphere is

$$\rho(r) = \begin{cases} \dfrac{3Q}{\pi R^n}(R-r) & \text{for } 0 < r < R \\ 0 & \text{for } r > R \end{cases}$$

The value of n is _____(answer is an integer)

61. The Lagrangian for a disk rolling down an inclined plane is

$$L = \frac{1}{2}m\dot{y}^2 + \frac{1}{4}mR^2\dot{\theta}^2 + mg(y-l)\sin\alpha$$

Where m, R, l, g, α are constants. The Hamiltonian for this system is

(a) $\dfrac{p_y^2}{m} + \dfrac{p_\theta^2}{2mR^2} + mg(y-l)\sin\alpha$ (b) $\dfrac{p_y^2}{2m} + \dfrac{p_\theta^2}{mR^2} - mg(y-l)\sin\alpha$

(c) $\dfrac{p_y^2}{m} + \dfrac{p_\theta^2}{2mR^2} - mg(y-l)\sin\alpha$ (d) $\dfrac{p_y^2}{2m} + \dfrac{p_\theta^2}{mR^2} + mg(y-l)\sin\alpha$

62. A particle moves under a potential $V(r) = -\dfrac{e^2}{r}$, where e is a positive constant. Then

(a) Only E is conserved (b) Only L is conserved
(c) Both E and L are conserved (d) Neither E nor L is conserved

63. An event occurs in S at $x = 9 \times 10^8$ m and in S' at $x' = 3\times10^8$ m, $t' = 4$ s. The relative velocity of the systems (in units of c) is _____ c. (up to one decimal place)

64. The excitation of a three dimensional solid are bosonic in nature with their frequency and wavenumber are related by $\omega \propto k^2$ in large wavelength limit. If the chemical potential is zero. The behaviour of specific heat of the system at low temperature is proportional to
(a) T^3 (b) T (c) $T^{1/2}$ (d) $T^{3/2}$

65. A gold crystal has a FCC lattice with one gold atom per lattice point and a lattice constant of 4.08Å. Every gold atom has one valence electron. The fermi energy of the gold crystal is _____eV. (answer upto two decimal places)

Space for rough work

PHYSICS-PH

Date: 09-01-2018

GATE TEST SERIES-A

ANSWER KEY

1. (c) **2.** (d) **3.** (b) **4.** (d)
5. (c) **6.** (d) **7.** (a) **8.** (c)
9. (b) **10.** (2) **11.** (0.66 to 0.70) **12.** (d)
13. (15) **14.** (d) **15.** (16) **16.** (–0.1)
17. (b) **18.** (d) **19.** (c) **20.** (278 to 280)
21. (b) **22.** (2) **23.** (a) **24.** (0.74 to 0.76)
25. (c) **26.** (c) **27.** (6) **28.** (b)
29. (a) **30.** (0.43 to 0.45) **31.** (0.33 to 0.34) **32.** (0.753 to 0.755)
33. (c) **34.** (1.40 to 1.42) **35.** (b) **36.** (1.30 to 1.34)
37. (c) **38.** (b) **39.** (0.055 to 0.064)
40. (1.20 to 1.30) **41.** (8) **42.** (b) **43.** (c)
44. (**2.03 to 2.09**) **45.** (3) **46.** (a) **47.** (a)
48. (d) **49.** (c) **50.** (c) **51.** (6)
52. (2) **53.** (b) **54.** (c) **55.** (d)
56. (0.012 to 0.014) **57.** (b) **58.** (**3.65 to 3.70**) **59.** (a)
60. (4) **61.** (b) **62.** (c) **63.** (0.8)
64. (d) **65.** (5.30 to 5.55)