TEST SERIES CSIR-NET/JRF Dec. 2017

BOOKLET SERIES B

PHYSICAL CHEMISTRY

Paper Code 01 **Test Type: TEST SERIES**

CHEMICAL SCIENCES

Duration: 2:00 Hours

Date: 26-11-2017
Maximum Marks: 180

Read the following instructions carefully:

* Single Paper Test is divided into **THREE** Parts.

Part - A: This part shall carry **10** questions. Each question shall be of **2 marks.**

Part - B: This part shall carry **20** questions. Each question shall be of **2 marks.**

Part - C: This part shall contain **30** questions. Each question shall be of **4 marks**.

* Darken the appropriate bubbles with HB pencil/Ball Pen to write your answer.
* There will be negative marking @25% for each wrong answer.
* The candidates shall be allowed to carry the Question Paper Booklet after completion of the exam.
* For rough work, blank sheet is attached at the end of test booklet.

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PART – A

1. A milk vendor has 2 cans of milk the first contains 25% water and the rest milk the second contains 50% water. How much milk should, He mix from each of the containers so as to get 12 litres of milk such that the ratio of water to milk is 3:5?
(a) 4 litres, 8 litres (b) 6 litres, 6 litres
(c) 5 litres, 7 litres (d) 7 litres, 5 litres

2. Find out the missing number :

25	17	41
32	83	11
26	?	31

(a) 26 (b) 25 (c) 34 (d) 38

3. Two trains, one from Howrah to Patna and the other from Patna to Howrah, start simultaneously. After they meet, the trains reach their destinations after 9 hours and 16 hours respectively. The ratio of their speeds is
(a) 2 : 3 (b) 4 : 3 (c) 6 : 7 (d) 9 : 16

4. A man gains 20% by selling an article for a certain price. If he sells is at double the price, the percentage of profit would be
(a) 40 (b) 100 (c) 120 (d) 140

5. How many times are the hands of a clock at right angle in a day?
(a) 24 (b) 48 (c) 22 (d) 44

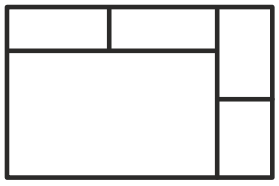
6. What is the smallest number of ducks that could swim in this formation - two ducks in front of a duck, two ducks behind a duck and a duck between two ducks
(a) 3 (b) 5 (c) 7 (d) 9

7. The product $\left(1-\frac{1}{2}\right)\left(1-\frac{1}{3}\right)\left(1-\frac{1}{4}\right).....\left(1-\frac{1}{n}\right)$ gives
(a) $\frac{1}{n}$ (b) $\frac{2}{n}$ (c) $\frac{2(n-1)}{n}$ (d) $\frac{2}{n(n+1)}$

8. A speaks truth in 75% cases and B in 80% of the cases. In what percentage of cases are they likely to contradict each other, narrating the same incident
(a) 5% (b) 15% (c) 35% (d) 45%

9. A sphere of maximum volume is cut-out from a solid hemisphere of radius *r*. The ratio of the volume of the hemisphere to that of the cut-out sphere is
(a) 3:2 (b) 4:1 (c) 4:3 (d) 7:4

10. How many rectangles are there in the figure below



(a) 6 (b) 7 (c) 8 (d) 9

PART – B

11. The incorrect statement among the following is
(a) In D.C. polarography, the interference from H^+ is negligible due to high overpotential of H^+ in mercury electrode.
(b) Migration current is removed by adding supporting electrolyte.
(c) Purpose of passing inert gas through the solution in polarography is to dissolve the gas in solution
(d) Diffusion current is directly proportional to concentration of solution

12. The molar conductivity of an electrolytic solution is 326 Scm^2mol^{-1}. If the ratio of velocity of cation and anion is 1.4. The molar conductivity of cation is
(a) 136.6 Scm^2mol^{-1} (b) 190.1 Scm^2mol^{-1}
(c) 150 Scm^2mol^{-1} (d) 176 Scm^2mol^{-1}

13. Fugacity coefficient for a gas is 1.25 at 2 bar pressure. The chemical potential of a gas at 2 bar and 300K is (Given, μ^0 for ideal gas is 335 $Jmol^{-1}$)
(a) 2 kJ mol^{-1} (b) 1.5 kJ mol^{-1} (c) 2.6 kJ mol^{-1} (d) 700 J mol^{-1}

14. Which of the following statement is correct
(a) At constant temperature and volume, the spontaneous direction is the decrease in Gibbs free energy.
(b) $T\Delta S$ represents the energy used to do some useful work.
(c) It is possible to construct refrigerator with single reservoir but not carnot cycle
(d) At constant temperature, the Gibbs free energy is same as Helmholtz free energy

15. The number of component in the system

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

(a) 1 (b) 2 (c) 3 (d) 4

16. Calculate ionic strength of a solution having 0.4 M $MgCl_2$ and 0.2 M $AlCl_3$.
(a) 1.2 (b) 2.4 (c) 3.6 (d) 4.8

17. When $^{14}N_2\left(B = 1.99\ cm^{-1}\right)$ is exposed to 340 nm light, then the stokes and antistokes lines for molecule in second rotational state can be observed at
(a) 29412 cm^{-1} and 29410 cm^{-1} (b) 340.3 nm and 339.9 nm
(c) 14779.9 cm^{-1} and 58529.9 cm^{-1} (d) 29384 cm^{-1} and 29424 cm^{-1}

18. The difference between energies of adjacent rotational energy levels of a molecule in rotational RAMAN spectroscopy is given by (on following the convention that energy is represented in Joules)
(a) B(4J + 6) (b) Bhc (4J + 6) (c) 2B (J + 1) (d) 2Bhc (J + 1)
where, B is in cm^{-1} and J = 0, 1, 2)

19. The rotational partition function for NH_3 under high temperature approximation $\left[\theta_r = \frac{Bhc}{R}, B\left(cm^{-1}\right)\right]$

(a) $\frac{T}{2\theta_\sigma}$ (b) $\frac{T}{3\theta_r}$ (c) $\frac{T}{\theta_r}$ (d) none of these

20. The number 0.0008 has significant figures :
(a) 3 (b) 8 (c) 4 (d) 1

21. Number of two fold degenerate irreducible representations for D_{4h} point group is two. What is the correct number of non-degenerate irreducible representation?
(a) Ten (b) Eight (c) Six (d) Five

22. In a cubic crystal, the value of d_{123} is 400 pm. The Edge length of the unit cell is approximately

(a) 1500 pm (b) 1000 pm (c) 500 pm (d) 50 pm

23. The polymer having random sequence of D and L configurations are

(a) isotactic polymers (b) syndiotactic polymers
(c) Atactic polymers (d) Grafted polymers

24. The commutation $\left[x,\left[x,\hat{H}\right]\right]$ is equal to

(a) $-\hbar^2$ (b) $-\frac{\hbar^2}{m}$ (c) $-\frac{\hbar^2}{2m}$ (d) none

25. The time derivative of the expectation value of x^2 is

(a) $\frac{1}{2m}\langle Xp_x\rangle$ (b) $\frac{1}{2m}\langle Xp_x + p_xX\rangle$ (c) $\frac{1}{m}\langle Xp_x + p_xX\rangle$ (d) zero

26. According to Hückel theory of conjugated systems, the free valence at any electron of benzene

is

(a) 0.20 (b) 0.40 (c) 0.60 (d) 0.80

27. For the following reversible reaction

$$A \rightleftharpoons 2B$$

$t=0$	a	0
$t=t$		x

The relaxation time (ρ) is

(a) $\frac{1}{k_1+k_{-1}}$ (b) $\frac{1}{k_1+k_{-1}(x_e)}$ (c) $\frac{1}{k_1(4a_e)+k_{-1}}$ (d) $\frac{1}{k_1\left(\frac{1}{2}\right)+k_{-1}(2x_e)}$

28. According to Arrhenius equation for n[th] order reaction

(a) $t_{1/2}$ is indepedent of temperature (b) $t_{1/2}$ increases with increase in temperature
(c) $t_{1/2}$ decreases with increase in temperature (d) $t_{1/2}$ decreases with decrease in temperature

29. The correct matches

Isotherm	**Adsorption equation**
(I) Langmuir	$\theta=\frac{kP}{1+kP}$
(II) Gibbs	$\theta=kP^{1/n}$
(III) Freundlich	$\theta=c_1\ell n(c_2P)$
(IV) Temkin	$\theta=-\frac{\partial\gamma}{\partial u_2}$

(a) II and III (b) I, II and IV (c) I only (d) II, III and IV

30. In case of lattice point at the face centre in a F.C.C. lattice, the C.N. is
(a) 6, 6 from adjacent edge centres
(b) 8, 4 from adjacent corners and 4 from adjacent face centres
(c) 12, 4 from adjacent corners and 8 from adjacent face centres
(d) 12, 8 from adjacent corners and 4 from adjacent face centres

PART – C

31. The dielectric constant of 0.1M NaCl and 0.2 M $MgCl_2$ solution is 121 and 100. The Debye screening length is same for both the solution if

(a) $T_{NaCl} = 2.5\, T_{MgCl_2}$ (b) $T_{NaCl} = 7.3\, T_{MgCl_2}$

(c) $T_{MgCl_2} = 2.5\, T_{NaCl}$ (d) $T_{MgCl_2} = 7.3\, T_{NaCl}$

32. $NO_3^- \longrightarrow NO_2\,(\text{acidic medium})$ $E^0 = 0.8$ V

$NO_3^- \longrightarrow NH_4OH\,(\text{acidic medium})$ $E^0 = 0.74$ V

The pH at which both the half cell have same E_{cell} is
(a) 8.23 (b) 1.16 (c) 4.23 (d) 3.28

33. The cell potential of the given half cell is

$$Pt\,|\,Cl_2\,(10\text{ atm})\,|\,HCl(0.1\text{ M}) \qquad E^0 = 1.36\text{ V}$$

(a) 1.45 V (b) 1.27 V (c) 1.56 V (d) 1.16 V

34. $C_p – C_V$ for a gas following the equation P(V–nb) = nRT is

(a) nR (b) 1 (c) nRT (d) $\dfrac{nR}{V - nb}$

35. If the pressure P(system) is less than the P(surrounding), then
(a) work is done by the system on the surroundings
(b) work is done on the system by the surrounding
(c) internal energy of the system decreases
(d) work done on the system by the surroundings is equal to the work done on the surroundings by the system.

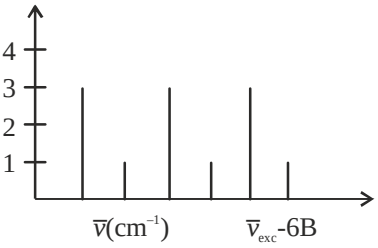
36. The temperature of a mono atomic ideal gas raised from 300K to 400K at constant pressure reversibly. The molar entropy change for the process is
(a) zero (b) –5.97 $JK^{-1}mol^{-1}$ (c) 5.97 $JK^{-1}mol^{-1}$ (d) 10.8 $JK^{-1}mol^{-1}$

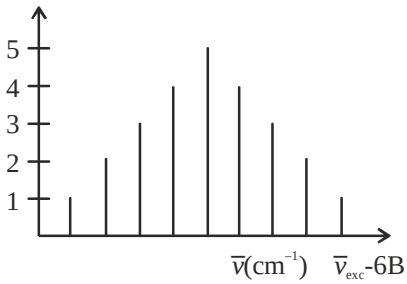
37. 0.1 mol of NaOH and 0.3 mol of $Ca(OH)_2$ is added in a flask and volume is raised to 100 L. The pH of resulting solution is
(a) 2.7 (b) 11.3 (c) 2.3 (d) 11.7

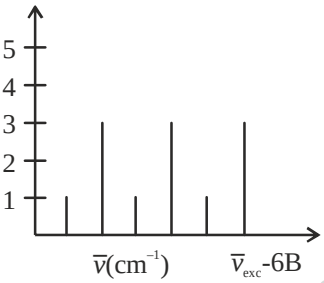
38. The phase diagram of A and B is of simple eutectic type. The eutectic composition is 74% by weight of A and mixture gets freeze at 92ºC. The freezing point of A and B are 300ºC and 200ºC. The phase at 50% B and 100ºC are
(a) A(s) + B(s) (b) A(s) + Melt (c) B(s) + Melt (d) B(s)

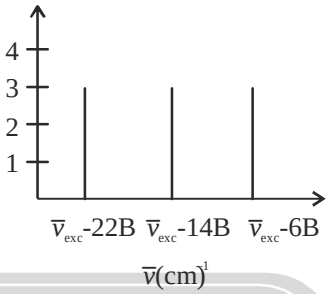
39. For HCl molecule $\bar{\nu} = 2989.7\ cm^{-1}$ and $\bar{\nu}_x = 52.05\ cm^{-1}$, where $\bar{\nu}$ equilibrium vibrational frequency and x = anharmonicity constant. The zero point energy under anharmonic potential of HCl and DCl is
(a) 1482 cm^{-1} and 1054 cm^{-1} (b) 1482 cm^{-1} and 1048 cm^{-1}
(c) 1494.85 cm^{-1} and 1057.18 cm^{-1} (d) 1494.85 cm^{-1} and 1048 cm^{-1}

40. The correct intensity pattern which H_2 molecule show in rotational RAMAN spectrum (only stokes lines are shown)

(a) 

(b) 

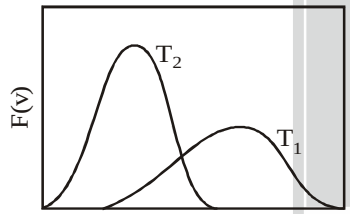
(c) 

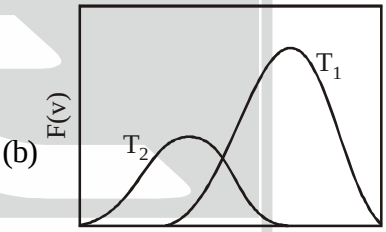
(d) 

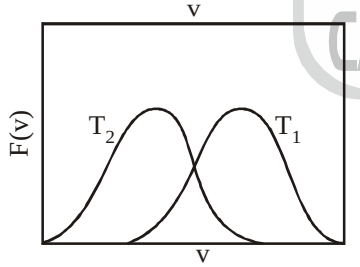
41. The mean $(\bar{x})$ variance (σ^2) and standard deviation (σ) for the numbers 2, 4, 6, 8 is respectively

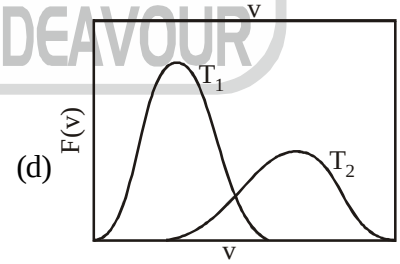
(a) 5, 25, 5 (b) 5, 5, $\sqrt{5}$ (c) 4, 16, 4 (d) 5, 1, 1

42. For temperature $T_1 > T_2$, the qualitative temperature dependence of the probability distribution F(v) of the speed v of a molecule in three dimensions is correctly represented by the following figure:

(a) 

(b) 

(c) 

(d) 

43. How much does the total angular momentum quantum number J change in the transition of $Cr(3d^6)$ atom as it ionizes to $Cr^{2+}\left(3d^4\right)$?

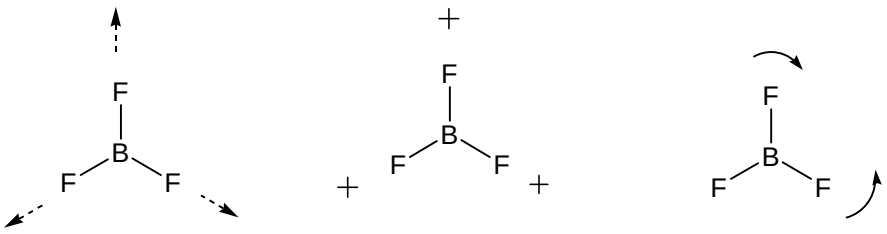
(a) increases by 2 (b) decreases by 2 (c) decreases by 4 (d) does not change

44. In a Gouy-Chapman diffuse layer the ***incorrect*** option in the favour of thickness (r_D) is

(1) Thickness is proportional to density
(2) Proportional to ionic strength
(3) Inversely proportional to dielectric constant.
(4) Proportional to temperature.

(a) 1, 2, 3 (b) 2, 3 (c) 1, 4 (d) 1 only

45. The character table of D_{3h} group is given below. What is the symmetry type of normal modes given below.



	E	$2C_3$	$3C'_2$	σ_h	$2S_3$	$3\sigma_v$	linear rotations	quadratic
A'_1	1	1	1	1	1	1		x^2+y^2, z^2
A'_2	1	1	–1	1	1	–1	R_z	
E'	2	–1	0	2	–1	0	(x, y)	(x^2-y^2, xy)
A''_1	1	1	1	–1	–1	–1		
A''_2	1	1	–1	–1	–1	1	z	
E''	2	–1	0	–2	1	0	(R_x, R_y)	(xz, yz)

(a) A'_1 A''_2 and E'' respectively (b) A'_1 E'' and A''_2 respectively

(c) A'_1 A''_2 and E' respectively (d) A'_2 E'' and A''_2 respectively

46. The surface tension of dilute solutions of a solute varies with the solute concentration as

$$\gamma = \gamma_0 - a \ln c_2$$

The surface excess is given by

(a) aRT (b) $\frac{RT}{a}$ (c) $\left(\frac{\gamma_0 - \gamma}{\ln c_2}\right)RT$ (d) $\left(\frac{\gamma_0 - \gamma}{\ln c_2}\right)\frac{1}{RT}$

47. A solution of a compound (M = 250 $gmol^{-1}$) in Benzene contains 4g of the compound per litr. When this solution is dropped on a water surface, the benzene evaporates and the compound forms a mono layer film of the solid type. In order to cover an area of 400 cm^2 with a monolayer, the volume of solution that should be used in ltr is (The area covered by one molecule of the compound is 0.25 nm^2)

(a) 21.6×10^{-5} (b) 12.16×10^{-5} (c) 16.6×10^{-5} (d) 1.66×10^{-5}

48. E^0 of cell reaction, $\frac{1}{2}Cl_2(g) + Ag^+(aq) + e^- \longrightarrow AgCl(s)$ is 1.90 V. If K_{sp} of AgCl is 10^{-10}, then the value of E^0 for following reaction is

$$\frac{1}{2}Cl_2 + e^- \longrightarrow Cl^-$$

(a) 1.35 (b) 1.3 (c) 2.5 (d) 2.2

49. Equal masses of polymer molecules with M_1 = 10000 and M_2 = 20000 are mixed. The P.D.I. (Polydispersity Index) is

(a) 11.25 (b) 1.125 (c) 21.25 (d) 2.125

50. At higher concentrations, we observe deviations from Lamberts Beer law. Then the quantity which remains constant in place of $\in$ is

(a) $\in^2$ (b) $\left[\frac{n}{n+2}\right]\in$ (c) $\left[\frac{n}{(n+2)^2}\right]\in$ (d) $\left[\frac{n}{(n+2)^2}\right]\in^2$

51. The following Rice-Herzfeld mechanism has been proposed for the gas phase pyrolysis of methane

(i) $CH_4 \xrightarrow{k_1} \dot{C}H_3 + H^{\cdot}$ (ii) $CH_3^{\cdot} + CH_4 \xrightarrow{k_2} C_2H_6 + H^{\cdot}$

(iii) $H^{\cdot} + CH_4 \xrightarrow{k_3} CH_3^{\cdot} + H_2$ (iv) $H^{\cdot} + CH_3^{\cdot} + M \xrightarrow{k_4} CH_4 + M$

In the last reaction M is a molecule $(CH_4$ or $C_2H_6)$ which can carry away the energy of recombination of $H^{\cdot}$ and $CH_3^{\cdot}$. Assuming SSA for $H^{\cdot}$ and $CH_3^{\cdot}$. The overall activation energy of the reaction is

(a) $\frac{1}{3}[E_1 + E_2 + E_3 + E_4]$ (b) $\frac{1}{3}[E_1 + E_3 - E_2 - E_4]$

(c) $\frac{1}{2}[E_1 + E_3 + E_2 - E_4]$ (d) $\frac{1}{3}[E_1 + E_2 + E_3 - E_4]$

52. In a B.C.C. lattice, the intensity of radiation for (111) planes is (f = atomic scattering factor)
(a) f^2 (b) $4f^2$ (c) $16f^2$ (d) none

53. The fraction of volume unoccupied in the unit cell of the B.C.C. lattice is

(a) $\frac{8-\sqrt{3}\pi}{8}$ (b) $\frac{\sqrt{3}\pi}{8}$ (c) $\frac{6-\sqrt{2}\,\pi}{6}$ (d) $\frac{\pi}{3\sqrt{2}}$

54. A particle of mass 'm' is moving under a potential of the form

$$V(x) = \begin{cases} \frac{1}{2} m\omega^2 x^2 & x > 0 \\ \infty & x \le 0 \end{cases}$$

and the wave function of the particle is $\psi(x) = -\frac{1}{\sqrt{5}}\psi_0 + \frac{2}{\sqrt{5}}\psi_1$

where ψ_0 and ψ_1 are the eigen functions of ground state and first excited state respectively. The expectation value of energy will be

(a) $\frac{11}{10}\hbar\omega$ (b) $\frac{13}{10}\hbar\omega$ (c) $\frac{25}{10}\hbar\omega$ (d) $\frac{31}{10}\hbar\omega$

55. The translational, rotational and vibrational partition functions for a molecule are $f_{trans} = 10^{10}$, $f_{rotation} = 10$, $f_{vibration} = 1$. $\frac{k_B T}{h} = 10^{13}$ at room temperature, $N_A = 6\times10^{23}$.

Using approximate data given above, the frequency factor (A) for a reaction type.

Diatomic molecule + Diatomic molecule = Non-linear transition state $\rightarrow P$

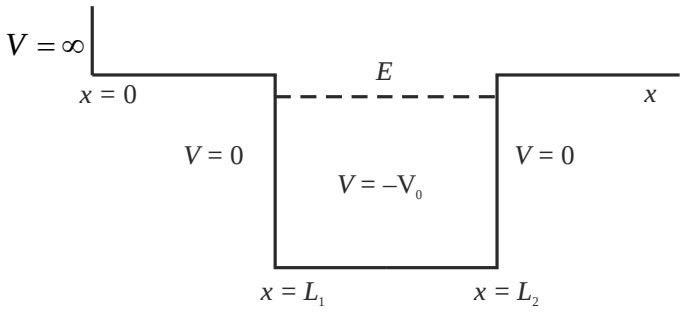
According to conventional transition state theory is
(a) 2×10^5 (b) 2×10^{12} (c) 6×10^5 (d) 6×10^{14}

56. Consider a heterodiatomic molecule AB. If the electron spends 90% of its time on 'A' and 10% of its time on 'B'. The wavefunction for the bonding molecular orbital is

(a) $\psi = .90\,\phi_A + 0.10\,\phi_B$ (b) $\psi = 0.10\,\phi_A + 0.90\,\phi_B$

(c) $\psi = 0.95\,\phi_A + 0.32\,\phi_B$ (d) $\psi = 0.32\,\phi_A + 0.95\,\phi_B$

57. Consider a particle in a potential as shown below



The wave function of the particle (having energy eigen value E) for bound state for region in between $L_1 < x < L_2$ is

(a) $A e^{\alpha x} + B e^{-\alpha x}$ with $\alpha = \sqrt{\frac{-2mE}{\hbar^2}}$ (b) $A e^{\alpha x} + B e^{-\alpha x}$ with $\alpha = \sqrt{\frac{2mE}{\hbar^2}}$

(c) $A e^{i\alpha x} + B e^{-i\alpha x}$ with $\alpha = \frac{\sqrt{2m(V_0 - E)}}{\hbar}$ (d) $A e^{i\alpha x} + B e^{-i\alpha x}$ with $\alpha = \frac{\sqrt{2m(V_0 + E)}}{\hbar}$

58. The wavefunction of a particle in one dimension deep square potential well extending from $x = 0$ to $x = L$ is

$$\psi(x) = \sqrt{30}\,\frac{x(x-L)}{L^i}$$

the value of i is

(a) 1 (b) 1.5 (c) 2 (d) 2.5

59. An atomic spectral line is observed to split into nine components due to Zeeman shift. If the upper state of the atom is $^3D_2$ then the lower state will be

(a) $^3F_2$ (b) $^3F_1$ (c) $^3P_1$ (d) $^3P_2$

60. If L_i are the components of the angular momentum operator $\vec{L}$, then the operator $\sum i = 1,2,3\left[\left[\vec{L}, L_i\right], L_i\right]$ equals

(a) $\vec{L}$ (b) $2\vec{L}$ (c) $3\vec{L}$ (d) $-\vec{L}$

Space for rough work

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CHEMICAL SCIENCES

TEST SERIES-B

Date : 26-11-2017

ANSWER KEY

PART-A

1. (b)	2. (a)	3. (b)	4. (d)	5. (d)	6. (a)	7. (a)
8. (c)	9. (b)	10. (c)				

PART-B

11. (c)	12. (b)	13. (c)	14. (d)	15. (b)	16. (b)	17. (d)
18. (d)	19. (d)	20. (d)	21. (b)	22. (a)	23. (c)	24. (b)
25. (c)	26. (b)	27. (d)	28. (c)	29. (c)	30. (c)	

PART-C

31. (d)	32. (b)	33. (a)	34. (a)	35. (b)	36. (c)	37. (d)
38. (c)	39. (a)	40. (a)	41. (b)	42. (a)	43. (c)	44. (a)
45. (c)	46. (d)	47. (d)	48. (b)	49. (b)	50. (c)	51. (c)
52. (d)	53. (a)	54. (d)	55. (c)	56. (c)	57. (d)	58. (d)
59. (c)	60. (b)					