

Target IIT-JAM-2018

Test Series-1

PHYSICAL CHEMISTRY

Booklet Code: **A**

Duration: 3:00 Hours

CHEMISTRY-CY

Date: 31-12-2017

Maximum Marks: 100

Read the following instructions carefully:

1. Attempt all the questions.
2. **Section-A** contains **30** Multiple Choice Questions (MCQ). Each question has 4 choices (a), (b), (c) and (d), for its answer, out of which **ONLY ONE** is correct. From **Q.1 to Q.10** carries 1 Marks and **Q.11 to Q.30** carries 2 Marks each.
3. **Section-B** contains **10** Multiple Select Questions (MSQ). Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which **ONE or MORE than ONE** is/are correct. For each correct answer you will be awarded **2 marks**.
4. **Section-C** contains **20** Numerical Answer Type (NAT) questions. From **Q.41 to Q.50** carries **1 Mark** each and **Q.51 to Q.60** carries **2 Marks** each. For each NAT type question, the value of answer is between 0 to 9.
5. In all sections, questions not attempted will result in zero mark. In Section-A (MCQ), wrong answer will result in negative marks. For all **1 mark** questions, **1/3 marks** will be deducted for each wrong answer. For all **2 marks** questions, **2/3 marks** will be deducted for each wrong answer. In Section-B (MSQ), there is no negative and no partial marking provision. There is no negative marking in Section-C (NAT) as well.

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Section-A : Multiple Choice Questions (MCQ)

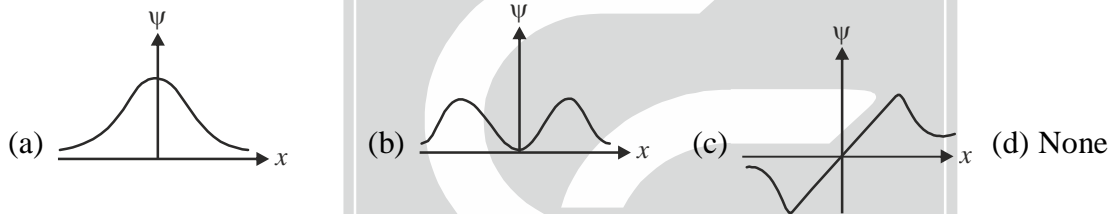
Q.1 to Q.10: Carry 1 Mark each.

- If $\psi_{n,\ell,m}$ are eigen functions of $\hat{L}_x^2 + \hat{L}_y^2$. The eigen value is
 - $\ell(\ell+1)\hbar^2 - m^2\hbar^2$
 - $\ell(\ell+1)\hbar^2 + m^2\hbar^2$
 - $\ell(\ell+1)\hbar^2 + m\hbar$
 - none
- The co-ordination number in a DCC unit cell is
 - 2
 - 4
 - 6
 - 8
- For a cell, $M | M^{2+} || X^- | X_2 | Pt$. The correct statement is (Given : $E_{M^{2+}|M}^0 > E_{X_2|X^-}^0$)
 - $M^{2+} + 2X^- \longrightarrow M + X_2$ is spontaneous cell reaction
 - $M + X_2 \longrightarrow M^{2+} + 2X^-$ is spontaneous cell reaction
 - $M^+ + 2X^- \longrightarrow M^{2+} + X_2$ is spontaneous cell reaction
 - None of the above
- On passing gas from high pressure to lower pressure under adiabatic and isoenthalpic, cooling is observed. The experimental temperature is
 - Less than inversion temperature
 - Equal to inversion temperature
 - Higher than inversion temperature
 - Not enough information is provided
- In a vessel containing SO_3 , SO_2 and O_2 at equilibrium, some helium gas is introduced so that total pressure increases while temperature and volume remain the same. The dissociation of SO_3
 - Increases
 - Decrease
 - Remain unaltered
 - Changes unpredictably
- The S.I. of Molar conductivity is
 - $S\text{cm}^2 \text{mol}^{-1}$
 - $S\text{m}^2 \text{mol}^{-1}$
 - $S\text{cm}^{-1}$
 - $S\text{dm}^{-1}$
- Expansion of a gas is carried out adiabatically from V_1 to V_2 . The change in entropy of surrounding is
 - $C_{p,m} \ln \left(\frac{V_2}{V_1} \right)$
 - 0
 - $C_{v,m} \ln \left(\frac{V_2}{V_1} \right)$
 - $nR \ln \left(\frac{T_2}{T_1} \right)$
- 10 mL of 0.1 M $\text{Ca}(\text{OH})_2$ is titrated with 20 mL of 0.1 M HCl. The pH of the resulting solution is
 - 3
 - 6
 - 7
 - 11
- In the following molecule the rotational active molecule is
 - N_2
 - N_2O
 - CH_4
 - SF_6
- The correct relation in the form of rotational constant is
 - $B = \frac{\hbar^2}{2\pi^2}$
 - $B = \frac{\hbar^2}{4\pi^2 I}$
 - $B = \frac{\hbar^2}{2Ic}$
 - $B = \frac{\hbar^2}{8\pi^2 r^2}$

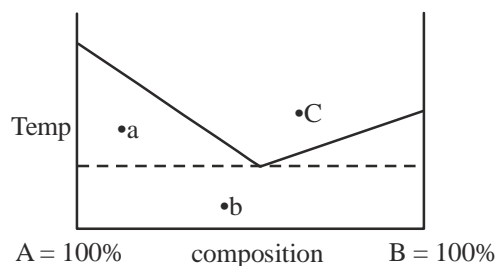


Q.11 to Q.30: Carry 2 Marks each.

11. The eigen value of momentum in x -direction w.r.to the eigen function e^{ikx} is
 (a) $+k$ (b) $-k$ (c) $+\hbar k$ (d) $-\hbar k$
12. If γx^3 perturbation is applied to the ground state of a 1-D SHO, then energy correction is
 (a) γ^3 (b) $\frac{1}{\gamma^3}$ (c) 1 (d) 0
13. The average value of $\langle r^2 \rangle$ is orbital is
 (a) $\frac{3}{2} a_0^2$ (b) $3a_0^2$ (c) $\frac{1}{3} a_0^2$ (d) none
14. The percentage volume unoccupied in a BCC unit cell is
 (a) 524% (b) 68% (c) 74% (d) 32%
15. The value of d_{111} is 100 pm. The value of d_{222} will be
 (a) 50 pm (b) 100 pm (c) 200 pm (d) 400 pm
16. The first excited state wave function for a 1-D SHO is



17. In aqueous solution of NaCl, the ratio of velocity of Na^+ and Cl^- is 6 : 5. The Λ_M^∞ NaCl is $390.4 \text{ Scm}^2 \text{ mol}^{-1}$. If Λ_M^∞ NaBr is $300 \text{ Scm}^2 \text{ mol}^{-1}$. The ratio of velocity of Na^+ and Br^- is
 (a) 1 : 1 (b) 2.4 : 1 (c) 1 : 2.4 (d) 3.6 : 1
18. The minimum work required by an engine to transfer 5J of heat from reservoir at 100K to one at 300K is
 (a) 5J (b) 10J (c) 15J (d) 20J
19. For the phase diagram,



The degree of freedom at point a , b and c is

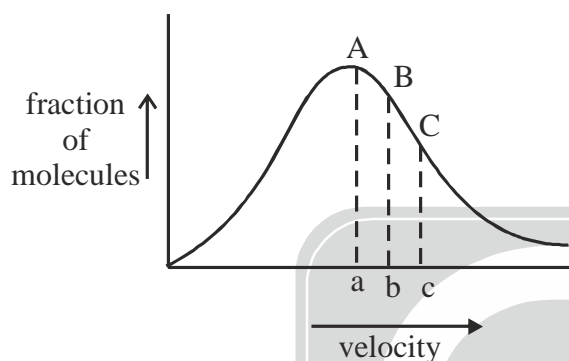
- (a) 2, 1, 1 (b) 1, 1, 2 (c) 1, 0, 2 (d) 1, 0, 1

20. The correct statement among the following is/are
- (a) E_{cell}^0 is zero for concentration cell
 (b) E_{cell}^0 is zero at equilibrium
 (c) $E_{\text{cell}} = E_1 + E_2$ where E_1 and E_2 are reduction potential of half cell
 (d) $\Delta G > 0$ for spontaneous cell reaction
21. The correct relation among the following is
- (a) $\left(\frac{\partial G}{\partial T}\right)_P = \left(\frac{\partial A}{\partial P}\right)_V$ (b) $\left(\frac{\partial T}{\partial V}\right)_S = \left(\frac{\partial P}{\partial S}\right)_V$ (c) $\left(\frac{\partial U}{\partial S}\right)_V = \left(\frac{\partial H}{\partial P}\right)_S$ (d) $\left(\frac{\partial U}{\partial S}\right)_V = \left(\frac{\partial H}{\partial S}\right)_P$
22. For a reaction, $A + B \longrightarrow \text{Product}$
- The rate of reaction become three times on increasing the concentration of B is 27 times. The rate of reaction become double on doubles the concentration of A. The order of reaction
- (a) 1.2 (b) 1.3 (c) 1.4 (d) 1.5
23. The average kinetic energy of O_2 and H_2 at 300 K follows. (Consider both gas ideal)
- (a) $K.E_{\text{O}_2} > K.E_{\text{H}_2}$ (b) $K.E_{\text{O}_2} < K.E_{\text{H}_2}$
 (c) $K.E_{\text{O}_2} = K.E_{\text{H}_2}$ (d) cannot predicted
24. The intercept of Temkin isotherm for θ vs $\ln p$ is
- (a) V_m (b) $\frac{1}{V_m}$ (c) $\frac{1}{KV_m}$ (d) 0
25. The correct statement about a molecule to be infrared active
- (a) It should having change in dipole moment
 (b) Molecule having symmetric stretching
 (c) Molecule having no dipole moment
 (d) Molecule having permanent dipole moment
26. Which of the following molecules has microwave spectra
- (a) CO_2 (b) $\text{CH}_2 = \text{CH}_2$ (c) C_6H_6 (d) OCS
27. The fundamental vibrational frequency ν of a homonuclear diatomic molecule with atomic mass m and force constant k is
- (a) $\nu = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$ (b) $\nu = \frac{1}{2\pi} \sqrt{\frac{2k}{m}}$ (c) $\nu = \frac{1}{2\pi} \sqrt{\frac{k}{2m}}$ (d) $\nu = \frac{2}{2\pi} \sqrt{\frac{k}{m}}$
28. Regarding B.E.T. theory of multilayer adsorption, the ratio $\frac{V_{\text{ad}}}{V_m}$ is
- (a) $\frac{k_1 p}{1 + k p}$ (b) $\frac{k_1 p \theta_0}{\left(1 - \frac{p}{p_0}\right)^2}$ (c) $\frac{k_1 p \theta_0}{\left(1 - \frac{p}{p_0}\right)}$ (d) $\frac{1 - \frac{p}{p_0}}{k_1 p \theta_0}$

29. The correct statement among the following is

- (a) The slope of $\frac{1}{V_{ad}}$ vs $\frac{1}{p}$ plot for Langmuir adsorption has unit of $p_a^{+1} \text{cm}^{-3}$
- (b) The slope of $\frac{p}{V_{ad}}$ vs p for Langmuir adsorption has unit of cm^3
- (c) The intercept unit of $\frac{p}{V_{ad}}$ vs p Langmuir plot is cm^{-3}
- (d) The intercept unit of $\frac{1}{V_{ad}}$ vs $\frac{1}{p}$ Langmuir plot is $p_a \text{cm}^{-3}$

30. Distribution of velocity of molecules is represented by the curve as shown



velocities at point a , b and c represents average velocity, most probable velocity and rms velocity (not necessarily in that order). Points b represents which of the following velocity

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

Section-B : Multiple Select Questions (MSQ)

Q.31 to Q.40: Carry 2 Marks each.

31. Which of the following pair of operators do not commute

- (a) \hat{x} and $\frac{\hat{d}}{dx}$ (b) $\frac{\hat{d}}{dx}$ and $\frac{d^2}{dx^2}$ (c) \hat{x} and \hat{p}_x (d) $\frac{\hat{d}^2}{dx^2}$ and $\frac{\hat{d}^3}{dx^3}$

32. The Hermitian operator(s) is/are

- (a) $\frac{\partial}{\partial x}$ (b) $i \frac{\partial}{\partial x}$ (c) $i\hbar \frac{\partial}{\partial x}$ (d) $-i\hbar \frac{\partial}{\partial x}$

33. The correct statement(s) is/are

- (a) All crystals are isotropic
- (b) The number of formula units in CsCl is one
- (c) There are four C_3 axes in a cubic crystal
- (d) Miller indices can never be zero for a particular axis.

34. The correct statement(s) regarding FCC unit cell is/are

- (a) The number of Td Vd is 4 (b) The number of Oh Vd is 8
- (c) Packing fraction is 74% (d) Co-ordination number is 12



35. The correct statement among the following is/are
- For electrolytic cells, $\Delta G = nFE_{cell}$
 - Transport number is directly proportional to the velocity of ion
 - The value of activity coefficient decrease with increase in ionic strength for dilute solution
 - E_{cell} is an extensive property.
36. Under isothermal condition, which of the following statement is correct
- the change in internal energy for ideal gas is not zero with change in pressure
 - Change in Gibbs free energy of a system is equal to change in Helmholtz free energy for ideal gas
 - All the process in which $\Delta T = 0$ is isothermal process
 - Heat lost by system is equal to work done on the system for ideal gas
37. In the dissociation of $2HI \rightleftharpoons H_2 + I_2$, the degree of dissociation will be affected by
- increase of temperature
 - Addition of inert gas
 - Increase of pressure
 - Decrease of pressure
38. The correct statement among the following statement is/are
- Rate constant increases with temperature
 - The concentration of substrate at which rate of reaction is half of maximum rate is Michaelis-Menten constant
 - At high pressure rate of reaction is first order with respect to concentration of substrate
 - Faster step determines the rate of reaction
39. The correct statement in the following is/are
- Rotational constant increases with increase the bond length
 - Rotational constant decreases with increase the reduce mass
 - The intensity of spectral line depends on population
 - In rotational spectra energy is proportional to $J(J + 1)$
40. The correct statement about CO_2 molecule
- Molecule having four normal modes of vibration
 - Three mode of vibrations are IR active
 - Symmetric stretching mode is IR inactive
 - Three bending modes are present in this molecule

Section-C : Numerical Answer Type (NAT)

Q.41 to Q.50: Carry 1 Mark each.

41. The number of angular node(s) present in $\sin \theta \cos \theta (\sin^2 \theta - 1)$ is/are _____
42. The eigen value of $\frac{d}{dx}$ w.r.to., the function xe^{2x} is _____
43. The number of edges common to a corner in a cubic crystal is/are _____
44. $M^{2+} + 2e^- \longrightarrow M \quad E = 0.04V$
 $M^{3+} + 3e^- \longrightarrow M \quad E = 0.20V$
 The electrode potential for half cell $M^{3+} + e^- \longrightarrow M^{2+}$ is _____ V
45. In the titration of a solution of weak acid HX with 0.1 M NaOH, the pH is 5.8 after 10 mL of NaOH solution has been added and 6.40 after 20 mL of NaOH is added. The ionisation constant of acid is _____ $\times 10^{-7}$.



46. $\text{NaCl} + \text{aq} \longrightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \quad \Delta H_1 = 3.9 \text{ kJ}$
 $\text{Na}^+(\text{g}) + \text{Cl}^-(\text{g}) \longrightarrow \text{NaCl}(\text{s}) \quad \Delta H_2 = -788 \text{ kJ}$
 $\text{Cl}^-(\text{g}) \longrightarrow \text{Cl}^-(\text{aq}) \quad \Delta H_3 = -394.1 \text{ kJ}$
 The enthalpy of hydration of Na^+ ions is _____ kJ.
47. The lowest energy of a quantum mechanical one dimensional simple harmonic oscillator is 500 cm^{-1} . The energy (in cm^{-1}) of the next higher level is _____
48. The spacing between the rotational lines of the HF is 80 cm^{-1} . the corresponding spacing between the rotational lines in DF is _____ cm^{-1} .
49. Given that the mean average speed of oxygen is 200 m/s . The most probable speed of oxygen under the same condition is _____ m/s .
50. If the transmittance for 1 cm path length is 10% , then the transmittance for 2 cm path length would be _____ %.

Q.51 to Q.60: Carry 2 Marks each.

51. The degeneracy of the energy level having energy $\frac{27 h^2}{8m\ell^2}$ in a cubic box is _____
52. The co-ordination number of Na^+ in NaCl is _____
53. The interplanar spacing for (100) planes in a cubic crystal of side length 90 pm is (in units of pm) _____
54. In ion transport pump, the ratio of concentration of Na^+ inside and outside the pump is $5 : 3$. The cell potential is _____ V.
55. The standard gibbs free energy (in kJ mol^{-1}) at 27°C , for the following reaction using the given data
- $$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\ell)$$
- | | CH_4 | O_2 | CO_2 | H_2O |
|--|---------------|--------------|---------------|----------------------|
| $\Delta H_f^0 (\text{kJmol}^{-1})$ | -74.8 | - | -393.5 | -285.8 |
| $\Delta S^0 (\text{JK}^{-1}\text{mol}^{-1})$ | 186 | 205 | 214 | 70 |
56. The standard heat of formation of water is $-68.3 \text{ kcalmol}^{-1}$. The standard heat of combustion of C_2H_2 is $-310.6 \text{ kcalmol}^{-1}$ and the standard heat of combustion of ethene is $-337.2 \text{ kcalmol}^{-1}$. The heat of reaction for the hydrogenation of ethyne to ethene is _____ kcalmol^{-1} .
57. The enthalpy of vapourization of water is 540 calg^{-1} . The value of ΔU for reversible isothermal evaporation of 90 g of water at 100°C is _____ calorie.
58. The equilibrium formation of phosgene is representation as
- $$\text{CO}(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{COCl}_2(\text{g})$$
- The reaction is carried out in a 500 mL flask. At equilibrium, 0.3 mol of phosgene, 0.1 mol of CO and 0.1 mol of Cl_2 are present. The equilibrium constant for the reaction is _____
59. The fundamental vibrational frequency of HBr is 2000 cm^{-1} . The corresponding values for DBr is _____ cm^{-1} .
60. The atomic masses of Fluorine and hydrogen are 19.0 a.m.u. and 1.0 a.m.u. respectively. The bond length of HF is 4\AA . The moment of inertia of HF is _____ $10^{-47} \text{ kg mtr}^2$.

***** END OF QUESTION PAPER *****



Space for Rough Work





IIT-JAM CHEMISTRY-CY

Date : 31-12-2017

TEST SERIES - 1 (Physical Chemistry)

Booklet : **A**

ANSWER KEY

Section-A : Multiple Choice Questions (MCQ)

- | | | | | |
|---------|---------|---------|---------|---------|
| 1. (a) | 2. (b) | 3. (a) | 4. (a) | 5. (c) |
| 6. (b) | 7. (b) | 8. (c) | 9. (b) | 10. (c) |
| 11. (c) | 12. (d) | 13. (b) | 14. (d) | 15. (a) |
| 16. (c) | 17. (b) | 18. (b) | 19. (b) | 20. (a) |
| 21. (d) | 22. (b) | 23. (c) | 24. (d) | 25. (a) |
| 26. (d) | 27. (b) | 28. (b) | 29. (a) | 30. (c) |

Section-B : Multiple Select Questions (MSQ)

- | | | | |
|-------------------|------------------|-------------|-----------------|
| 31. (a),(c) | 32. (b),(c),(d) | 33. (b),(c) | 34. (c),(d) |
| 35. (b),(c) | 36. (b), (d) | 37. (a) | 38. (a),(b),(c) |
| 39. (b), (c), (d) | 40. (a), (b),(c) | | |

Section-C : Numerical Answer Type (NAT)

- | | | | |
|--------------------|------------------------|--------------------------|--------------------|
| 41. (4 to 4) | 42. (0 to 0) | 43. (6 to 6) | 44. (0.50 to 0.54) |
| 45. (7.87 to 7.90) | 46. (-388 to -392) | 47. (1500 to 1500) | 48. (38 to 41) |
| 49. (175 to 178) | 50. (1 to 1) | 51. (4 to 4) | 52. (6 to 6) |
| 53. (90 to 90) | 54. (0.012 to 0.014) | 55. (-817.68 to -817.72) | |
| 56. (-41 to -42) | 57. (44.868 to 44.872) | 58. (15 to 15) | 59. (1413 to 1416) |
| 60. (25 to 26) | | | |

