

# IIT-JAM: Model Test

## Chemistry

1. 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. Form Q.1 to Q.10 carries 1 Marks and Q.11 to Q.30 carries 2 Marks each.
2. 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.
3. Section-C contains 20 Numerical Answer Type (NAT) questions. Form Q.41 to Q.50 carries 1 Marks 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.
4. In all sections, questions not attempted will result in zero mark. In Section-A (MCQ), wrong will be deducted for each wrong answer. For all 1 marks 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 provisions. There is no negative marking in Section-C (NAT) as well.

### ❖ Question Paper

#### Section-A: Multiple Choice Questions (MCQ)

**Q.1 – Q.10 carry one mark each**

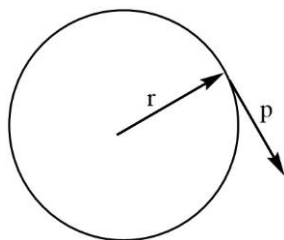
Q.1 For an ideal gas, the plot that is nonlinear is:

- |                          |                                      |
|--------------------------|--------------------------------------|
| (a) PV vs T              | (b) PV vs P at constant T            |
| (c) P vs V at constant T | (d) $\ln P$ vs $\ln V$ at constant T |

Q.2 Consider two identical containers, one with 1 mole of  $H_2$  and the other with 1 mole of He. If the root-mean square (RMS) velocities of the two gases are the same, then the ratio of the temperature,  $T(H_2)/T(He)$  is:

- |         |       |                  |                |
|---------|-------|------------------|----------------|
| (a) 1/2 | (b) 2 | (c) $1/\sqrt{2}$ | (d) $\sqrt{2}$ |
|---------|-------|------------------|----------------|

Q.3 An electron moves around the nucleus in a circular orbit, according to the Bohr Model. The radial vector  $\vec{r}$  and the instantaneous linear momentum vector  $\vec{p}$  are shown in the diagram below.



The direction of the angular momentum vector is:

- (a) along  $\vec{r}$  (b) along  $\vec{p}$   
 (c) opposite to  $\vec{p}$  (d) perpendicular to both  $\vec{r}$  and  $\vec{p}$

Q.4 X and Y transformed co-ordinates obtained from p and q as follows:

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} a_1 & a_3 \\ a_2 & a_4 \end{pmatrix} \begin{pmatrix} p \\ q \end{pmatrix}$$

The correct set of linear equations that represent X and Y are

- (a)  $X = a_1p + a_2q$  (b)  $X = a_1p + a_3q$  (c)  $X = a_2p + a_4q$  (d)  $X = a_1p + a_4q$   
 $Y = a_3p + a_4q$   $Y = a_2p + a_4q$   $Y = a_1p + a_3q$   $Y = a_2p + a_3q$

Q.5 Which of the following is not a solution of the equation  $\frac{d^2x}{dt^2} + \omega^2x = 0$

- (a)  $x = A\cos\omega t$  (b)  $x = A\sin\omega t$  (c)  $x = At^2$  (d)  $x = A(e^{i\omega t} + e^{-i\omega t})$

Q.6 An electron is found in an orbital with one radial node and two angular nodes. Which orbital the electron is in?

- (a) 1s (b) 2p (c) 3d (d) 4d

Q.7 Among the following, the correct statement concerning the optical activity is:

- (a) A molecule containing two and more chiral centres is always optically active  
 (b) A molecule containing just one chiral centre is always optically active  
 (c) A molecule containing alternating axis of symmetry optically active  
 (d) An optically active molecule should have at least one chiral centre

Q.8 If  $K_{sp}$  is the solubility product of a sparingly soluble salt  $A_3X_2$ , then its solubility is:

- (a)  $(K_{sp}/108)^{1/5}$       (b)  $(K_{sp})^{1/5}$       (c)  $(K_{sp}/72)^{1/5}$       (d)  $(K_{sp})^{1/2}$

Q.9 For the formation of B from A, heat liberated is  $20\text{kJ mol}^{-1}$ . If the activation energy for the reaction  $B \rightarrow A$  is  $100\text{kJ mol}^{-1}$ , then the activation energy (in  $\text{kJ mol}^{-1}$ ) for the reaction  $A \rightarrow B$  is:

- (a) 120      (b) 100      (c) 80      (d) 60

Q.10 For the reaction  $A+B \rightarrow Z$ , the concentration of Z at time t is given by  $[Z] = [A]_{t=0}(1 - e^{-kt}) + [Z]_{t=0}$  where k is rate constant. The rate law is:

- (a)  $-\frac{d[Z]}{dt} = k[A]$       (b)  $\frac{d[Z]}{dt} = k[A]$       (c)  $\frac{d[Z]}{dt} = k[Z]$       (d)  $\frac{d[Z]}{dt} = k[A][B]$

Q.11 – Q.30 carry two marks each.

Q.11 In the periodic table, on moving from left to right along a period

- (a) The atomic size of the element increases.  
(b) The first ionisation potential of the element decreases.  
(c) The oxide of element becomes less basic.  
(d) The oxide of element becomes more basic.

Q.12 Among the following the incorrect statement is

- (a) Diamond and graphite are two allotropes of carbon.  
(b) In diamond, each carbon is  $sp^3$  hybridised.  
(c) In graphite, each carbon is  $sp^2$  hybridised.  
(d) Graphite show high electrical conductivity in one direction only.

Q.13 The pH of a  $1 \times 10^{-8}\text{M}$  HCl solution is close to

- (a) 8.0      (b) 7.1      (c) 6.9      (d) 6.0

Q14 The indicator phenolphthalein changes colour at  $pH \sim 9$ . This indicator is not suitable for accurate determination of the end point in the titration of

- (a)  $CH_3COOH$  with  $NaOH$  (b)  $HCl$  with  $NH_4OH$   
(c)  $HCl$  with  $NaOH$  (d)  $HCl$  with  $KOH$

Q.15 In the thermite process, iron oxide is reduced to molten iron by aluminium powder because

- (a) The melting point of iron is low  
(b) The reaction is highly endothermic  
(c) Large amount of heat is liberated in the formation of  $Al_2O_3$   
(d) Aluminium is an amphoteric

Q16 The number of  $P=O$  bonds present in the tetrabasic acid  $H_4P_2O_7$  is

- (a) Three (b) Two (c) One (d) None

Q.17 Egyptian blue is  $CaSi_4O_{10}$  an example

- (a) Sheet silicate (b) Cyclic silicate (c) Pyrosilicate (d) Chain silicate

Q.18 The formal charges on the nitrogen atom from left to right in the azide anion,  $[N=N=N]^-$  are

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

Q.19 The unit cell of diamond can be obtained from the unit cell of

- (a)  $ZnS$  (b)  $NaCl$  (c)  $CsCl$  (d)  $AgCl$

Q.20 Calgon used for water softening is  $Na_2[Na_4(PO_3)_6]$  and it is prepared by heating microscopic salt. The microscopic salt is:

- (a)  $Na_2HPO_3$  (b)  $NaH_2PO_4$  (c)  $Na_2HPO_4$  (d)  $Na(NH_4)HPO_4$

Q.21 The V-shape of  $\text{SO}_2$  is due to presence of

- (a) Two  $\sigma$ - and one  $\pi$ -bonds
- (b) Two  $\sigma$ - and two  $\pi$ -bonds
- (c) Two  $\sigma$ -bonds and one lone pair of electrons
- (d) Two  $\sigma$ - and two  $\pi$ -bonds, and one lone pair of electrons

Q.22 The correct order of the mean bond energies in the binary hydrides is:

- (a)  $\text{CH}_4 > \text{NH}_3 > \text{H}_2\text{O} > \text{HF}$
- (b)  $\text{NH}_3 > \text{CH}_4 > \text{H}_2\text{O} > \text{HF}$
- (c)  $\text{HF} > \text{H}_2\text{O} > \text{CH}_4 > \text{NH}_3$
- (d)  $\text{HF} > \text{H}_2\text{O} > \text{NH}_3 > \text{CH}_4$

Q.23 In CsCl structure, the number of  $\text{Cs}^+$  ions that occupy second nearest neighbour locations of a  $\text{Cs}^+$  ion is:

- (a) 6
- (b) 8
- (c) 10
- (d) 12

Q.24 In the process



X is:

- (a)  $\alpha$ -particle
- (b)  $\beta$ -particle
- (c)  $\beta^+$ -emission
- (d)  $\gamma$ -emission

Q.25 For tetrahedral complexes, which always exhibit high spin states, the maximum CFSE (crystal field stabilization energy) is:

- (a)  $-8 Dq$
- (b)  $-12 Dq$
- (c)  $-16 Dq$
- (d)  $-20 Dq$

Q.26 The most abundant element in earth's crust is:

- (a) Aluminium
- (b) Iron
- (c) Silicon
- (d) Oxygen

Q.27 Metal-carbon multiple bonds in metal carbonyl are preferably identified from the stretching frequency of

- (a) Carbon-oxygen bond      (b) Metal-Carbon bond      (c) Metal-oxygen bond      (d) Carbon-Carbon bond

Q.28 In general, magnetic moment of paramagnetic complexes varies with temperature as

- (a)  $T^2$       (b)  $T$       (c)  $T^2$       (d)  $T^{-1}$

Q.29 The compound having an S-S single bond is:

- (a)  $H_2S_2O_3$       (b)  $H_2S_2O_4$       (c)  $H_2S_2O_7$       (d)  $H_2S_2O_8$

Q.30 In a reaction,  $Na_2S_2O_3$  is converted to  $Na_2S_4O_6$ . The equivalent weight of  $Na_2S_2O_3$  for this reaction is (mol. wt. of  $Na_2S_2O_3 = M$ )

- (a)  $M$       (b)  $M/4$       (c)  $M/2$       (d)  $M/3$

Section-B: Multiple Select Questions (MSQ)

Q.31 – Q.40 carry two marks each.

Q.31 When one mole of ice is converted to water at  $0^\circ\text{C}$  and 1 atm., the work done (1 atm.) is:

- (a)  $1.1 \times 10^{-4}$       (b)  $2.0 \times 10^{-3}$       (c)  $2.0 \times 10^{-4}$       (d)  $1.1 \times 10^{-5}$

Q.32 When 100g of water is reversibly heated from  $50^\circ\text{C}$  to  $75^\circ\text{C}$  at 1 atm., the change in entropy ( $\text{JK}^{-1}$ ) of the universe is:

- (a)  $-0.31$       (b)  $0.31$       (c)  $0$       (d)  $3.1$

Q.33 For a zero-order reaction, units of the rate constant is expressed as

- (a)  $M^1s^{-1}$       (b)  $M^0s^{-1}$       (c)  $M^{-1}s^{-1}$       (d)  $M^0s^0$

Q.34  $1 \times 10^{-6}$  moles of the enzyme carbonic anhydrase dehydrates  $H_2CO_3$  to produce 0.6 mol of  $CO_2$  per second. The turnover number of the enzyme is:

- (a)  $N_A \times 6 \times 10^{-5}$       (b)  $1/6 \times 10^{-5}$       (c)  $6 \times 10^{-5} / N_A$       (d)  $6 \times 10^5$



Q.35 Given that the most probable speed of oxygen gas is  $1000 \text{ ms}^{-1}$ , the mean/average speed ( $\text{ms}^{-1}$ ) under the same conditions is:

- (a) 1224                      (b) 1128                      (c) 886                      (d) 816

Q.36 If the electron were spin  $3/2$  particles, instead of spin  $1/2$ , then the number of electrons that can be accommodated in a level are

- (a) 2                      (b) 3                      (c) 4                      (d) 5

Q.37 For a particle in a cubic box, the total number of quantum numbers needed to specify its state are

- (a) 1                      (b) 3                      (c) 4                      (d) 9

Q.38 The maximum number of phases that can co-exist in equilibrium for a one component system is:

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

Q.39 With increasing pressure, the temperature range over which the liquid state is stable.

- (a) Decrease      (b) Increase      (c) Remains constant      (d) Decrease till the critical pressure and then increase

Q.40 The conductance at infinite dilution follows the order

- (a)  $\text{Li}^+ > \text{Na}^+ > \text{K}^+$       (b)  $\text{Na}^+ > \text{Li}^+ > \text{K}^+$       (c)  $\text{K}^+ > \text{Li}^+ > \text{Na}^+$       (d)  $\text{K}^+ > \text{Na}^+ > \text{Li}^+$

### Section-C: Numerical Answer Type (NAT)

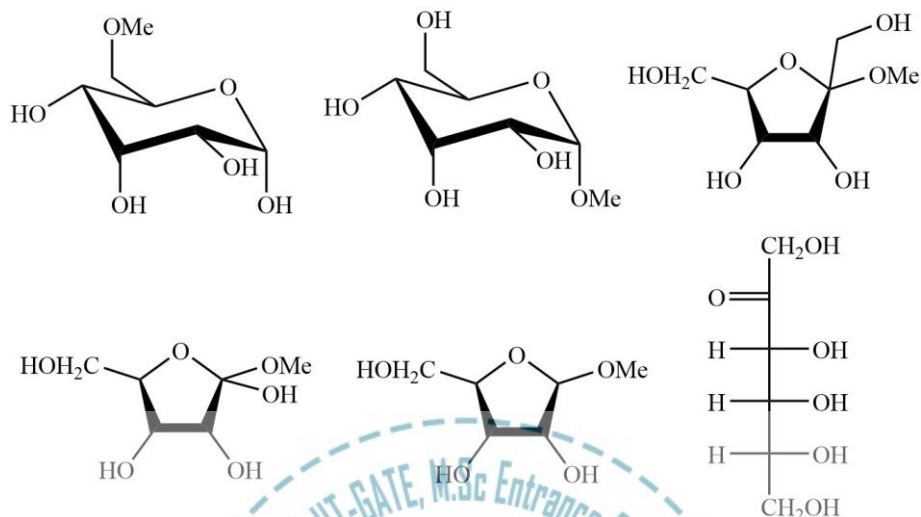
Q.41 – Q.50 carry one mark each.

Q.41 The number of isomeric structures of di-substituted borazine  $[\text{B}_3\text{N}_3\text{H}_4\text{X}_2]$  is .....

Q.42 The number of S – S bond(s) in tetrathionate ion is .....

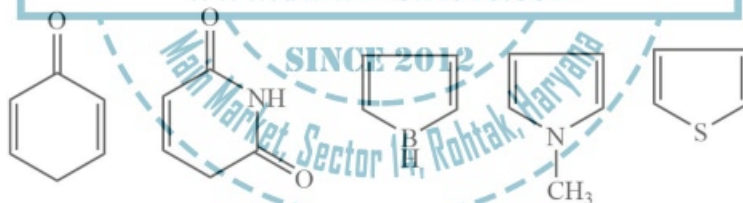
Q.43 The number of unpaired electron(s) in  $\text{K}_2\text{NiF}_6$  is .....

Q.44 The number of reducing sugars among the following is .....



Q.45 The maximum number of dipeptides that could be obtained by reaction of phenylalanine with leucine is .....

Q.46 Among the following, the number of aromatic compound(s) is .....



Q.47 At an operating frequency of 350 MHz, the shift (in Hz) of resonance from TMS (tetramethylsilane) of a proton with chemical shift of 2ppm is .....

Q.48 At 298K and 1 atm, the molar enthalpies of combustion of cyclopropane and propane are  $-2091 \text{ kJ mol}^{-1}$  and  $-2058 \text{ kJ mol}^{-1}$ , respectively. The enthalpy change (in  $\text{kJ mol}^{-1}$ ) for the conversion of one mole of propene to one mole of cyclopropane is .....

Q.49 For a cell reaction,  $\text{Pb(s)} + \text{Hg}_2\text{Cl}_2(\text{g}) \rightarrow \text{PbCl}_2(\text{s}) + 2\text{Hg}(\ell)$ ,  $\left\{ \frac{\partial E^0}{\partial T} \right\}_p$  is  $1.45 \times 10^{-4} \text{ VK}^{-1}$ . The enthalpy change (in  $\text{J mol}^{-1} \text{ K}^{-1}$ ) for the reaction is .....



Q.50 For a reaction  $2A + B \rightarrow C + D$ , if rate of consumption of A is  $0.1 \text{ mol L}^{-1} \text{ K}^{-1}$ , the rate of production of C is .....

**Q.51 – Q.60 carry two marks each.**

Q.51 The ionization energy of hydrogen atom is 13.6 eV and the first ionization energy of sodium atom is 5.1 eV. The effective nuclear charge experienced by the valance electron of sodium atom is ..... (Round off to one decimal place)

Q.52 One mole of an ideal gas is subjected to an isothermal increase in pressure from 100 kPa to 1000 kPa at 300 K. The change in Gibbs free energy of the system is .....  $\text{kJ mol}^{-1}$ . (Round off to one decimal place)

[Given: Gas constant (R) is  $8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ ]

Q.53 One litre of an aqueous urea solution contains 6g of urea. The osmotic pressure of the solution at 300K (assuming ideal behaviour) is ..... kPa. (Round off to one decimal place)

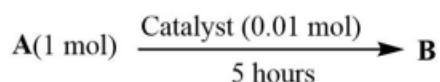
[Given: Molecular weight of the urea is 60, gas constant (R) is  $8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ ]

Q.54 A first order reflection of X-ray from {220} plane of copper crystal is observed at a glancing angle of  $22^\circ$ . the wavelength of the X-ray used is ..... pm. (Round off to one decimal place)

[Given: Copper forms fcc crystal with unit cell edge length of 361 pm.]

Q.55 The collision flux of a monoatomic gas on copper surface is  $3.0 \times 10^{18} \text{ m}^{-2} \text{ s}^{-1}$ . Note that copper surface forms a square lattice with lattice constant of 210 pm. If the sticking coefficient of the atom with copper is 1.0, the time taken by the gas to form a complete monolayer on the surface is ..... s. (Round off to one decimal place)

Q.56 The turnover frequency (TOF) for the catalytic reaction,

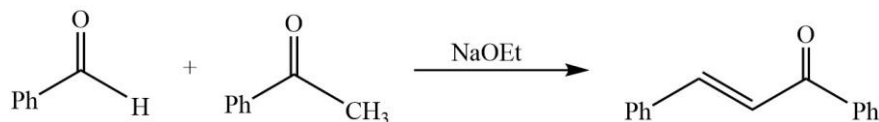


with 90% yield of the product is .....  $\text{hour}^{-1}$ . (Round off to the nearest integer)

Q.57 A radioactive sample decays to 10% of its initial amount in 4600 minutes. The rate constant of this process is .....  $\text{hour}^{-1}$ . (Round off to two decimal places)

Q.58 Given that the radius of the first Bohr orbit of hydrogen atom is 53 pm, the radius of its third Bohr orbit is .....pm. (Round off to the nearest integer)

Q.59 5.3g of benzaldehyde was reacted with an excess of acetophenone to product 5.2g of the enone product as per the reaction shown below. The yield of the reaction is .....%.(Round off to the nearest integer)



Q.60 Assume that the reaction of MeMgBr with ethylacetate proceeds with 100% conversion to give tert-butanol. The volume of 0.2 M solution of MeMgBr required to convert 10mL of a 0.025 M solution of ethylacetate to tert-butanol is .....mL. (Round off to one decimal place)



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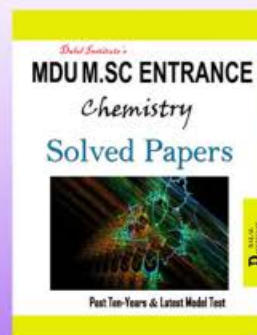
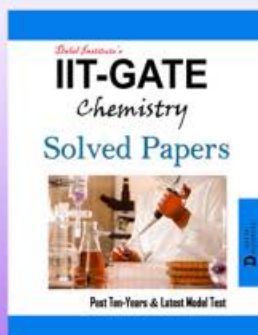
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