Target IIT-JAM-2017

Test Series-1

PHYSICAL CHEMISTRY

[SOLUTION]

Booklet Code: A

Duration: 2:00 Hours | **CHEMISTRY-CY** | **Date: 29-12-2016**

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.3**0 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 in 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.

Regn. No. | | | | | | | | | | |

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Section-A : Multiple Choice Questions (MCQ)

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

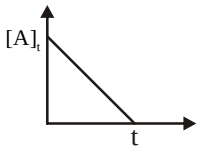
1. The angle between (100) and (200) planes is

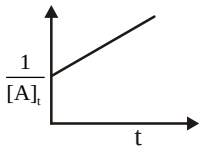
(a) 90º (b) 45º (c) 30º (d) 0º

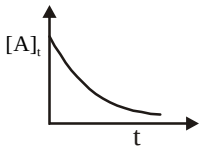
Soln. $\cos\theta = \dfrac{2+0+0}{\sqrt{1}\sqrt{4}} = 1 = \cos 0$

Correct option is (d)

2. A substance decomposes following first order kinetics the correct plot for A is

(a) 

(b) 

(c) 

(d) None

Soln. For first order

$C_t = C_0\, e^{-kt}$

Therfore, exponentially ↓ graph

Correct option is (c)

3. The eigen value of y^3e^{4x} with respect to the operator $\dfrac{\hat{\partial}}{\partial x}$ is

(a) 4 (b) $4y^3$ (c) y^3 (d) 0

Soln. $\dfrac{\partial}{\partial x}\left[y^3e^{4x}\right] = 4\left[y^3e^{4x}\right]$

Correct option is (a)

4. The intercept of Temkin isotherm for θ vs lnp is

(a) V_m (b) $\dfrac{1}{V_m}$ (c) $\dfrac{1}{KV_m}$ (d) 0

Soln. $\theta = c_1 \ln c_2 p$

for $c_1 = c_2 = 1 \quad \Rightarrow \quad \theta = \ln p + 0$

$y = mx + c$

Correct option is (d)

5. The probability of getting a 2 or a 5 when a die is rolled is

(a) $\dfrac{1}{6}$ (b) $\dfrac{1}{3}$ (c) $\dfrac{1}{4}$ (d) $\dfrac{1}{2}$

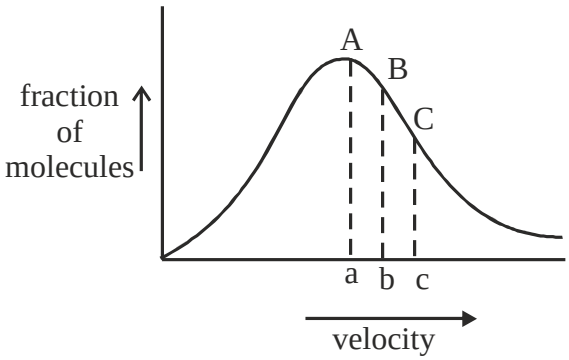
Soln. The individual probabilities of each number, (getting a 2 or a 5) is $\dfrac{1}{6}$

Now, compound probability of getting a 2 or a 5

P(2 or 5) = P(2) + P(5) – P(2 and 5) = $\dfrac{1}{6}+\dfrac{1}{6}-0=\dfrac{1}{3}$

Correct option is (b)

6. 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) $\sqrt{\frac{2RT}{\pi M}}$

Soln. (b) represents the average velocity of the molecule which is $\sqrt{\frac{8RT}{\pi M}}$

Correct option is (c)

7. The correct order of equivalent conductance at infinite dilution of LiCl, NaCl and KCl is
(a) LiCl > NaCl > KCl (b) KCl > NaCl > LiCl
(c) NaCl > KCl > LiCl (d) LiCl > KCl > NaCl

Soln. KCl > NaCl > LiCl

At infinite dilution, degree of hydration is minimum for K^+ and maximum for Li^+.
Correct option is (b)

8. The rate at which substance react depends on its
(a) Active mass (b) Molecular mass (c) Equivalent mass (d) Total volume

Soln. Active mass.
Correct option is (a)

9. N_2 does not show pure vibrational spectra because
(a) triple bond in N_2 is very strong (b) the dipole moment of N_2 is zero
(c) both (a) and (b) (d) none of the above

Soln. Since, the dipole moment of N_2 is zero
Correct option is (b)

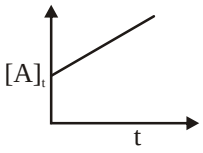
10. The correct form of radio frequency region in which NMR lies is
(a) $3\times10^6 - 3\times10^8$ Hz (b) $3\times10^4 - 3\times10^6$ Hz
(c) $3\times10^8 - 3\times10^{10}$ Hz (d) $3\times10^2 - 3\times10^4$ Hz

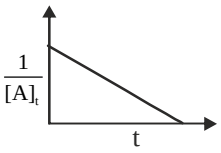
Soln. **Region :** $3\times10^6 - 3\times10^8$ Hz

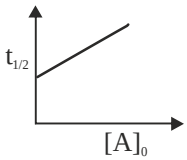
Correct option is (a)

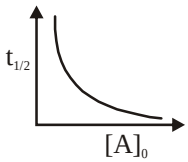
Q.11 to Q.30: Carry 2 Marks each.

11. The correct plot(s) for a 2nd order reaction is/are

(a) 

(b) 

(c) 

(d) 

Soln. $t_{1/2} = \dfrac{1}{[A]_0\, k}$

$$y = \frac{1}{xk} \Rightarrow xy = \text{constant i.e., Hyperbola}$$

Correct option is (d)

12. In the sequential reaction,

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

the time when the concentration of B reaches its maximum concentration is

(a) $\dfrac{\ln(k_1/k_2)}{k_2}$ (b) $\dfrac{\ln(k_2/k_1)}{k_1}$ (c) $\dfrac{\ln(k_1/k_2)}{k_1 k_2}$ (d) $\dfrac{\ln(k_1/k_2)}{k_1 - k_2}$

Soln. $y = a\left(\dfrac{k_1}{k_2 - k_1}\right)\left[e^{-k_1 t} - e^{-k_2 t}\right]$

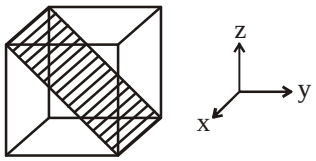
$$\frac{dy}{dt} = a\left(\frac{k_1}{k_2 - k_1}\right)\left[-k_1 e^{-k_1 t} + k_2 e^{-k_2 t}\right]$$

For maxima and minima, $\dfrac{dy}{dt} = 0$

$$\Rightarrow \quad k_1 e^{-k_1 t} = k_2 e^{-k_2 t} \Rightarrow \frac{k_1}{k_2} = e^{(k_1 - k_2)t} \Rightarrow t = \frac{\ln(k_1/k_2)}{k_1 - k_2}$$

Correct option is (d)

13. The miller indices of the shaded plane as shown below is



(a) (100) (b) (011) (c) (111) (d) $(\bar{1}\bar{1}0)$

Soln. Intercept on $\begin{matrix} x & y & z \\ \infty & 1 & 1 \end{matrix}$

Reciprocal 0 1 1

Therefore, Miller-indices are (011)

Correct option is (b)

14. If we write a normalised wave function ψ as $\psi = \hat{A}\phi$, then ϕ is also normalised when

(a) $\hat{A}$ is Hermitian (b) $\hat{A}$ is Anti Hermitian

(c) $\hat{A}$ is unitary (d) $\hat{A}$ is any linear operator

Soln. $\because$ ψ is normalised

$$\therefore \quad \int \psi^* \psi d\tau = 1$$

$$\int \phi^* A^* A \phi d\tau = 1$$

$$\int \phi^* \phi d\tau = 1 \qquad \text{i.e. A is unitary}$$

Correct option is (c)

15. The transition that belongs to the Lymann series in the H-atom spectrum is

(a) $1s \leftarrow 4s$ (b) $1s \leftarrow 4p$ (c) $1s \leftarrow 4d$ (d) $1s \leftarrow 4f$

Soln. For allowed transition $\Delta\ell = \pm 1$

Correct option is (b)

16. Two bound stationary states 1 and 2 of a one e^- atom with $E_2 > E_1$ (E is the total energy) obey the following statement about their kinetic energy (T) and potential energy (V)

(a) $T_2 < T_1,\ V_2 > V_1$ (b) $T_2 > T_1,\ V_2 > V_1$ (c) $T_2 > T_1,\ V_2 < V_1$ (d) $T_2 = T_1,\ V_2 > V_1$

Soln. $E_1 < E_2$

$$T_1 + V_1 < T_2 + V_2$$

$$-\frac{V_1}{2} + V_1 < -\frac{V_2}{2} + V_2$$

$\Rightarrow$ $V_1 < V_2$ and $T_1 > T_2$

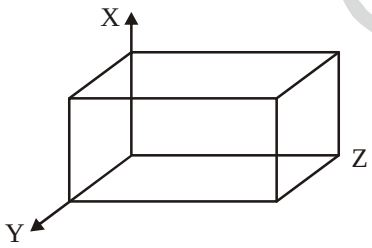
Correct option is (a)

17. A tetragonal crystal has the parameters

(a) $a = b = c;\ \alpha = \beta = \gamma \neq 90^o$ (b) $a = b \neq c;\ \alpha = \beta = \gamma = 90^o$

(c) $a \neq b \neq c;\ \alpha = \beta = \gamma = 90^o$ (d) $a \neq b \neq c;\ \alpha = \beta = \gamma \neq 90^o$

Soln.



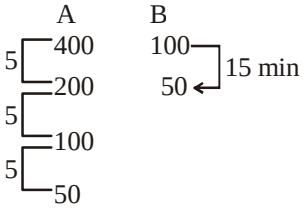
$\therefore$ $a = b \neq c$ and $\alpha = \beta = \gamma = 90^o$

Correct option is (b)

18. Two substances A and B are present such that the initial concentration of A is four times the initial concentration of B and half lives of A and B are 5 mins and 15 mins respectively. If they start decaying at the same time following first order kinetics, then how much time later would the concentration of both of them would be the same?

(a) 10 mins (b) 15 mins (c) 30 mins (d) 60 mins

Soln.



Therefore, after 15 mins both 'A' and B will have the same concentration.

Correct option is (b)

19. Regarding B.E.T. theory of multilayer adsorption, the ratio $\frac{V_{ad}}{V_m}$ is

(a) $\frac{k_1 p}{1+kp}$ (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) $\frac{\left(1-\frac{p}{p_0}\right)}{k_1 p\theta_0}$

Soln. $V_{ad} = V_m\theta_1 + V_m 2\theta_2 + V_m 3\theta_3 + \cdots$

$$\frac{V_{ad}}{V_m} = k_1 p\theta_0 + 2k_1 p\theta_0\left(\frac{p}{p_0}\right) + 3k_1 p\theta_0\left(\frac{p}{p_0}\right)^2$$

$$= k_1 p\theta_0\left[1+2\left(\frac{p}{p_0}\right)+3\left(\frac{p}{p_0}\right)^2+\cdots\right] = \frac{k_1 p\theta_0}{\left(1-\frac{p}{p_0}\right)^2}$$

Correct option is (b)

20. For non-dissociative Langmuir theory of adsorption the order of reaction at low pressure is

(a) 0 (b) 1 (c) 2 (d) 3

Soln. $\theta = \frac{kp}{1+kp}$

At low P, $kp << 1 \;\therefore\; \theta = kp \;\therefore$ order $= 1$

Correct option is (b)

21. The molar heat capacity for a gas at constant T and P is

(a) $\frac{3}{2}R$ (b) $\frac{5}{2}R$

(c) Depend on the atomicity of the gas (d) Infinity

Soln. $C_P = \left(\frac{\partial H}{\partial T}\right)_P$

At constant temperature, dT = 0

$\Rightarrow \quad \boxed{C_P = \infty}$

Correct option is (d)

22. Heat of combustion of CH_4, C_2H_6 and C_3H_8 are respectively –210, –368.4 and –526.3 kcalmol^{-1}. Hence, heat of combustion of C_8H_{18} is approximately (in kcalmol^{-1}).
(a) –1314 (b) –684 (c) –840 (d) –1000

Soln. $2\times\left(CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O\right)$

$$C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O$$

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

$$C_8H_{18} + \frac{25}{2}O_2 \longrightarrow 8CO_2 + 9H_2O$$

$$\Delta H_{comb\ C_8H_{18}} = 2\Delta H_{comb\ CH_4^+} + \Delta H_{comb\ C_2H_6} + \Delta H_{combC_3H_8}$$

$$= -2\times 210 - 368.4 - 526.3 = -1314.7$$

Correct option is (a)

23. On carrying out the electrolysis of acidified water, the volume hydrogen liberated at STP condition in 22.4L. The volume of oxygen liberated is
(a) 22.4L (b) 44.8L (c) 11.2L (d) 2.24L

Soln. $H_2O \longrightarrow H_2 + \frac{1}{2}O_2$

From the reaction, if 22.4L of H_2 liberated
then, **11.2 of O_2** will release out.
Correct option is (c)

24. For the following reaction,

$$2MnO_4^- + 5H_2C_2O_4 + 6H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$$

$E^0\left(MnO_4^- \mid Mn^{2+}\right) = +1.51V \qquad E^0\left(CO_2 / H_2C_2O_4\right) = -0.49V$

at 298K, the equilibrium constant is
(a) 10^{560} (b) 10^{338} (c) 10^{228} (d) 10^{284}

Soln. $E^0_{cell} = E^{0\,cat.}_{red} - E^{0\,anode}_{red} = 1.51 - (-0.49) = 2.0V$

$$E^0 = \frac{0.0591}{n}\log k_{eq} \Rightarrow 2 = \frac{0.0591}{2}\log k_{eq} \Rightarrow \frac{20}{0.0591} = \log k_{eq}$$

$$\Rightarrow 338.4 = \log k_{eq} \Rightarrow k_{eq} \approx 10^{338}$$

Correct option is (b)

25. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + 22.4\,kcal$

The maximum yield of ammonia will be obtained when the process is made to take place

(a) at low pressure and high temperature (b) at low pressure and low temperature

(c) at high pressure and high temperature (d) at high pressure and low temperature

Soln. At high pressure and low temperature applying Le-Chatlier principle

Correct option is (d)

26. The pH of 0.1 M NH_4 solution is (given:- $pK_b = 4.76$)

(a) 4.8 (b) 2.8 (c) 9.2 (d) 11.2

Soln. $\left[OH^-\right] = \sqrt{k_b \times C} = \sqrt{1.85\times10^{-5}\times0.1} = \sqrt{1.85\times10^{-6}} = 1.36\times10^{-3}$

$pOH = -\log\left(1.36\times10^{-3}\right) = 3 - 0.1335$

$pOH = 2.866$

$\boxed{pH = 2.866}$

Correct option is (d)

27. How many normal modes does the CO_2 molecule have? What if the C and the O atoms were constrained to move in one dimension?

(a) 4 normal modes for free CO_2 and 4 for constrained CO_2

(b) 3 normal modes for free CO_2 and 2 for constrained CO_2

(c) 3 normal modes for free CO_2 and 3 for constrained CO_2

(d) 4 normal modes for free CO_2 and 2 for constrained CO_2

Soln. For free CO_2, $3N-5 = 3\times3-5 = 9-5 = 4$

If O-atom is constrained to move in one dimension.

Then degree of freedom could replace by 2

Therefore, modes of vibration = 2

Correct option is (d)

28. The correct form of moment of inertia for CO_2 molecule is ($\underset{m_o}{O}\overset{r}{=}\underset{m_c}{C}\overset{r}{=}\underset{m_o}{O}$)

(a) $I = \dfrac{m_o\, m_c\, m_o}{m_o + m_c + m_o} r^2$ (b) $I = 2m_c m_o r^2$

(c) $I = 2m_o r^2$ (d) $I = 2m_o{}^2 m_c r^2$

Soln. ($\underset{m_o}{O}\overset{r}{=}\underset{m_c}{C}\overset{r}{=}\underset{m_o}{O}$)

$I = 2m_o r^2$

Correct option is (c)

29. Vibrations which are of highest energy requirement

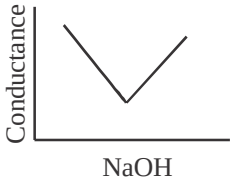
(a) asymmetric stretching (b) symmetric stretching

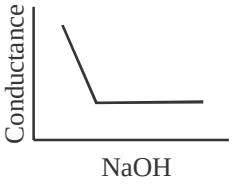
(c) scissoring stretching (d) wagging stretching

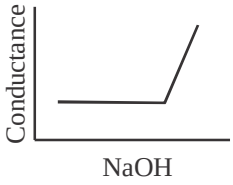
Soln. asymmetric stretching

Correct option is (a)

30. Benzoic acid solution is titrated with NaOH conductometrically, physical representation of titration is

(a) 

(b) 

(c) 

(d) none of the above

Soln. Correct option is (d)

Section-B : Multiple Select Questions (MSQ)

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

31. The correct statement(s) is/are

(a) For a 3-D S.H.O with energy $\frac{17}{2}h\nu$, degeneracy is 30

(b) For a 1-D box of width a and infinite height the average value of momentum is zero.

(c) For a 1-D S.H.O, the average value of position is zero.

(d) $\frac{\hat{d}^2}{dx^2}$ is a Hermitian operator

Soln. (a) $g = \frac{(n+1)(n+2)}{2} = \frac{8\times 9}{2} = 36$

(b) $\langle p_x \rangle = \int_0^a \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right)\left(-i\hbar\frac{\partial}{\partial x}\right)\sqrt{\frac{2}{a}}\sin\left(\frac{n\pi x}{a}\right)dx = 0$

(c) $\langle x \rangle = \int_{-\infty}^{\infty}\left(\frac{\beta}{\pi}\right)^{1/4} e^{-\beta x^2/2} x \left(\frac{\beta}{\pi}\right)^{1/4} e^{-\beta x^2/2}dx = 0$

(d) $\left(\frac{\partial}{\partial x}\frac{\partial}{\partial x}\right)^{\dagger} = \frac{\partial^{\dagger}}{\partial x}\frac{\partial^{\dagger}}{\partial x} = \frac{\partial^2}{\partial x^2}$

Correct options are (b), (c) and (d)

32. The angle(s) at which reflection maxima can be observed from a crystal lattice with interplanar spacing of 1.5 Å and using x-ray of wavelength 150 pm is/are

(a) 30° (b) 45° (c) 60° (d) 90°

Soln. $2d\sin\theta = n\lambda$

$\Rightarrow \theta = \sin^{-1}\left(\frac{n\lambda}{2d}\right) = \sin^{-1}\left(\frac{1\times 1.50}{2\times 1.5}\right) = 30^\circ$

and $\sin^{-1}\left(\frac{2\times 1.5}{2\times 1.5}\right) = 90^\circ$

Correct options are (a) and (d)

33. The correct statement(s) is/are

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

(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 $p_a\ cm^{-3}$

Soln. $\frac{V_{ad}}{V_m} = \frac{KP}{1+KP}$

$\frac{V_m}{V_{ad}} = \frac{1}{KP} + 1$

$\frac{1}{V_{ad}} = \left(\frac{1}{KV_m}\right)\frac{1}{P} + \frac{1}{V_m}$

$y = mx + c$

and $\frac{P}{V_{ad}} = \frac{1}{V_m}P + \frac{1}{KV_m}$

Correct options are (a) and (b)

34. Among the following inwhich matrix multiplication is/are possible?

(a) $\begin{bmatrix}1 & 2 & 3\end{bmatrix}\begin{bmatrix}1 & 3 & 5\\ 2 & 4 & 6\end{bmatrix}$

(b) $\begin{bmatrix}1 & 2 & 3\end{bmatrix}\begin{bmatrix}2 & 1 & 3\\ 3 & 3 & 2\\ 4 & 1 & 2\end{bmatrix}$

(c) $\begin{bmatrix}1 & 2 & 3\end{bmatrix}\begin{bmatrix}4\\ 5\\ 6\end{bmatrix}$

(d) $\begin{bmatrix}4\\ 5\\ 6\end{bmatrix}\begin{bmatrix}1 & 2 & 3\end{bmatrix}$

Soln. Multiplication AB of two matrices (A) and (B) is possible if
Number of Column(C) of A = Number of Row(R) of B
(a) C = 3 and R = 2, therefore, not possible
(b) C = 3 and R = 3, therefore, possible
(c) C = 3 and R = 3, therefore, possible
(d) C = 1 and R = 1, therefore, possible
Correct options are (b), (c) and (d)

35. Select the incorrect statement
(a) at absolute zero temperature of sink work obtained is maximum
(b) kinetic energy of a molecule is zero at 0°C
(c) volume of one mole of gas is 224L at 0K
(d) options (b) and (c) are correct.

Soln. (a) For carnot engine

$$\eta = 1 - \frac{T_1}{T_2}$$

when $T_1 = 0$, $\eta = 1$, maximum efficiency. So, work done is maximum
(b) Kinetic energy of molecule is zero at 0 K not at 0°C.
(c) Volume of one mole of gas is 22.4L at STP.
So, incorrect options are (b), (c) and (d)
Correct option (b), (c) and (d).

36. $Pt\,|\,H_2(P_1)\,|\,H^+(x_1M)\,||\,H^+(x_2M)\,|\,H_2(P_2)\,|\,Pt$. The cell be spontaneous if

(a) $P_1 = P_2$ and $x_1 > x_2$ (b) $P_1 = P_2$ and $x_1 < x_2$

(c) $x_1 = x_2$ and $P_1 > P_2$ (d) $x_1 = x_2$ and $P_1 < P_2$

Soln.

$$Pt\,|\,H_2(P_1)\,|\,H^+(x_1M)\,||\,H^+(x_2M)\,|\,H_2(P_2)\,|\,Pt$$

Anode: $\frac{1}{2}H_2(P_1) \longrightarrow H^+(x_1) + e^-$

Cathode: $H^+(x_2) + e^- \longrightarrow \frac{1}{2}H_2(P_2)$

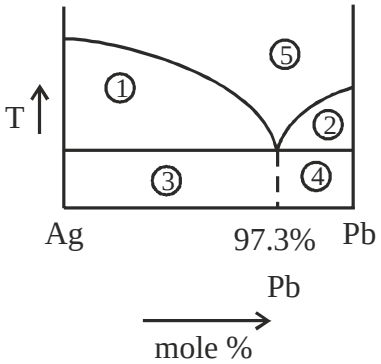
Net reaction: $\frac{1}{2}H_2(P_1) + H^+(x_2) \longrightarrow H^+(x_1) + \frac{1}{2}H_2(P_2)$

Reaction will be spontaneous only when

$P_1 = P_2$ and $x_1 < x_2$
$P_1 > P_2$ and $x_1 = x_2$

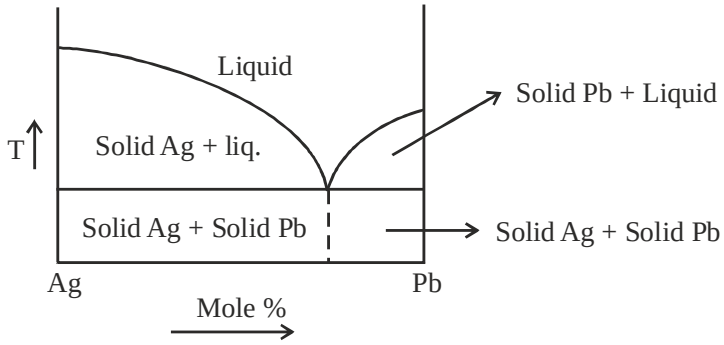
Correct options are (b) and (c)

37. Following is the phase diagram of Pb-Ag system



Which of the following statements are incorrect
(a) composition of phase (1) is solid Pb + liquid `
(b) composition of phase (2) is solid Ag + liquid
(c) At eutectic point (3) phases are in equilibrium
(d) composition of phase (3) is solid Ag + solid Pb

Soln.



at eutectic point 3 phases are in equilibrium

$\text{liquid} \rightleftharpoons \text{solid Ag} + \text{solid Pb}$

Correct options are (a) and (b)

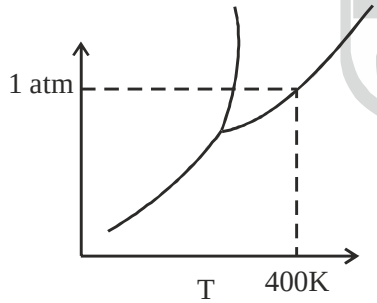
38. Which of the following statements are TRUE?
(a) For a harmonic oscillator potential, the spacing between adjacent energy levels remain constant with increasing quantum number
(b) For a Morse potential, the spacing between adjacent energy levels increases with increasing the vibrational quantum number
(c) Harmonic oscillators are be used to explain the bond direction
(d) Morse oscillators can be used to explain the vibration of molecules.

Soln. For harmonic oscillator distance between adjacent energy level = $h\nu$ = constant
Vibration of molecule can be explained by Morse potential.
Correct option is (a) and (b)

39. The normal boiling point of a liquid 'X' is 400K. Which of the following statement is true about the process $X(\ell) \longrightarrow X(g)$?

(a) at 400K and 1 atm pressure $\Delta G = 0$ (b) at 400 K and 2 atm pressure $\Delta G = +ve$
(c) at 400K and 0.1 atm pressure $\Delta G = -ve$ (d) at 410K and 1 atm pressure $\Delta G = +ve$

Soln.



(a) at 1 atm and 400K, $liq \rightleftharpoons vap$

So, $\Delta G = 0$ because equilibrium is established

(b) at 400K and 2 atm it will be in liquid region. So, process wil not go in forward direction.

So, ΔG = positive

(c) Similarly at 400K and 0.1 atm it will be vapour region. So, reaction is going in forward direction,

So, ΔG = negative

Correct options are (a), (b) and (c).

40. In Arrhenius's equation, $k = A\exp\left(-\frac{E_a}{RT}\right)$. A may be termed as the rate constant at

(a) very low temperature
(b) very high temperature
(c) zero activation energy
(d) the boiling temperature of the reaction mixture.

Soln. Correct options are (b) and (c)

Section-C : Numerical Answer Type (NAT)

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

41. An electron is confined in a 1-D box of length 1 Å. The energy of the 1st excited state in eV is _____

Soln. $$E = \frac{4\times\left(6.626\times10^{-34}\,\text{Jsec}\right)^2}{8\times9.1\times10^{-31}\,\text{kg}\times\left(10^{-10}\,\text{m}\right)^2\times\left(1.6\times10^{-19}\,\text{J/eV}\right)} = 150.4\ \text{eV}$$

Correct answer is (149 to 151).

42. Consider a particle of mass $10^{-30}\,\text{kg}$ in an infinitely deep potential well of width 0.6 nm. The value of k in ground state is approximately _____ nm^{-1}.

Soln. $$K = \frac{n\pi}{L} = \frac{1\times3.14}{0.6\,\text{nm}} = 5.23\,\text{nm}^{-1}$$

Correct answer is (5 to 5.5)

43. The surface tension of dilute solution of a solute varies with the solute concentration as $\gamma = \gamma_0 - 5\ln c_2$

The surface excess in units of $\frac{1}{RT}$ is _____

Soln. $$\Gamma = -\frac{c_2}{RT}\left(\frac{\partial\gamma}{\partial c_2}\right) = -\frac{c_2}{RT}\left[-\frac{5}{c_2}\right] = \frac{5}{RT}$$

Correct answer is (4 to 6)

44. The radius of Po atom is 1.2 unit the nearest atom to atom contact distance is _____unit.

Soln. $d = 2r = 2\times1.2 = 2.4\,\text{unit}$

Correct answer is (2 to 3)

45. The angle between the vectors $\hat{i} - 2\hat{j} + 3\hat{k}$ and $3\hat{i} - 2\hat{j} + \hat{k}$ is _____(in degree)

Soln. $|\vec{a}| = \sqrt{1+4+9} = \sqrt{14} = |\vec{b}|$

$\vec{a}\cdot\vec{b} = 3+4+3 = 10$

$$\cos\theta = \frac{\vec{a}\cdot\vec{b}}{|\vec{a}||\vec{b}|} = \frac{10}{\sqrt{14}\sqrt{14}} = \frac{10}{14} = \frac{5}{7}$$

$$\theta = \cos^{-1}\left(\frac{5}{7}\right) = 44.41$$

Correct answer is (44 to 45)

46. The bond energies of $C = C$ and $C - C$ at 298 K are 590 and 331 kJ mol^{-1}. The enthalpy of polymerisation per mole of ethylene is _____kJ mol^{-1}.

Soln. $n(CH_2 = CH_2) \longrightarrow -\left(CH_2-CH_2\right)_n-$

Energy change = energy required to break, C = C + Energy released by forming 2C–C bonds.

$$= 590 + 2\times(-331) = 590 - 662 \Rightarrow \boxed{\Delta H = -72 \text{ kJ mol}^{-1}}$$

Correct answer is (–72 to –73)

47. Cost of electricity for production of xL < H_2 at STP at cathode is rate *x*, during electrolysis of water. Then cost of electricity for the production of xL < O_2 gas at STP at anode will be (assume 1 mol of electron as one unit electricity) *ax*. The value of *a* is _____

Soln. Electrolysis of H_2O

$$H_2O \rightleftharpoons H_2 + \frac{1}{2}O_2$$

So, 1 mole of O_2 will be equivalent to 2 mole of H_2 produced in terms of cost.
So, *x* L of O_2 will take 2*x*cost.
So, $ax = 2x$
Therefore, a = 2
Correct answer is (2 to 2)

48. The pH of a solution made by mixing 0.1 M NH_3 and 0.1 M $(NH_4)_2SO_4$. (pK_b of NH_3 = 4.73) is _____

Soln. Basic buffer

$$[\text{Base}] = 0.1\,\text{M}$$

$$[\text{cation}] = 2[\text{salt}] = 0.2\text{M}$$

$$\text{pOH} = \text{pK}_b + \log\frac{[\text{cation}]}{[\text{base}]}$$

$$\text{pOH} = \text{pK}_b + \log\frac{2[\text{salt}]}{[\text{base}]}$$

$$\text{pOH} = 4.76 + \log 2$$

$$\text{pOH} = 5.06 \Rightarrow \boxed{\text{pH} = 8.94}$$

Correct answer is (8.5 to 9.0)

49. The vibrational energy level of CO molecule is given by

$$E_V / J\ mol^{-1} = 25940\left(v+\frac{1}{2}\right) - 152\left(v+\frac{1}{2}\right)^2$$

where *v* is vibrational quantum number. The equilibrium vibrational frequency is _____$\times 10^{13} s^{-1}$.

Soln. $$E_v / J\ mol^{-1} = 25940\left(v=\frac{1}{2}\right) - 152\left(v-\frac{1}{2}\right)^2$$

On comparing with

$$E = N_A h\nu_e\left(v+\frac{1}{2}\right) - N_A h\nu_e x_e\left(v+\frac{1}{2}\right)^2$$

We get,

$$N_A h\nu_e = 25940\ J/mol$$

$$\nu_e = \frac{25940\ J/mole}{h \times 6.023\times10^{23}\ \frac{\text{molecule}}{mole}} = 6.5\times10^{13}\ s^{-1}$$

Correct answer is (6 to 6.5)

50. 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.

Soln. Average speed = $\sqrt{\frac{8RT}{\pi M}} = 200 \Rightarrow \sqrt{\frac{RT}{M}} = \sqrt{\frac{\pi}{8}} \times 200$

M.P. = $\sqrt{\frac{2RT}{M}} = \sqrt{2}\times\sqrt{\frac{RT}{M}} = \sqrt{2}\times\sqrt{\frac{\pi}{8}}\times200 = \sqrt{\frac{\pi}{4}}\times200 = 177.24$ m/s

Correct answer is (175 to 178)

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

51. 10^{-5} g of a fatty acid $(M = 602.3\,g\,mol^{-1})$ was placed on water as a surface film, a monolayer of area 100 cm^2 was formed on compression. The cross sectional area (in $Å^2$) of the acid molecule is _____

Soln. Total surface area = No. of molecules × A_1 molecule

$$100\,cm^2 = \frac{10^{-5}\times6.023\times10^{23}}{602.3}\times A_1$$

$$A_1 = 100\,Å^2$$

Correct answer is (98 to 102)

52. Molybdenum forms a cubic crystal (with lattice points at corners and at body centre) whose density is $1.03\times10^{-2}\ kgcm^{-3}$ $(M_0 = 95.94\,g\,mole^{-1})$. The interplanar spacing for (110) planes in pm is _____

Soln. $a^3 = \frac{Zm}{\rho N_A} = \frac{2\times95.94\times10^{-3}\ kg\,mole^{-1}}{6.023\times10^{23}\ mole^{-1}\times1.03\times10^{-2}\ kg\,cm^{-3}}$

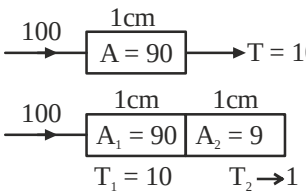
$\Rightarrow a = 3.139\times10^{-8}$ cm

$a = 313.9$ pm $= 221.9$ pm

Correct answer is (220 to 224)

53. If the transmittance for 1 cm path length is 10%, then the transmittance for 2 cm path length would be _____%.

Soln.



$\therefore\ T_R = \frac{1}{100}\times100 = 1\%$

Correct answer is (1 to 1)

54. A 3rd order reaction is 50% completed in 5 mins the time required for 90% completion will be _____ mins.

Soln. $kt = \frac{1}{2}\left[\frac{1}{C_t^{\,2}} - \frac{1}{C_0^{\,2}}\right] \quad \Rightarrow \quad kt_{50} = \frac{3}{2C_0^{\,2}}$ ... (1)

$$kt_{90} = \frac{99}{2C_0^{\,2}} \quad \text{... (2)}$$

Therefore, equation $\frac{(2)}{(1)} \Rightarrow t_{90} = 33 \times t_{50} = 33 \times 5 = 165$

Correct answer is (165 to 165)

55. For two reactions

$$X(g) + Y(g) \rightarrow Z(g) \quad \text{... (1)}$$

$$M(g) + N(g) \rightarrow P(g) \quad \text{... (2)}$$

According to collision theory, the ratio of squares of pre-exponential factors of reactions (2) and (1) at the same temperature is _____

Given

Species	mass(g/mole)	Diameter (nm)
X	5	0.3
Y	20	0.5
M	10	0.4
N	10	0.4

Soln. $\left(\frac{A_2}{A_1}\right)^2 = \left(\frac{\sigma_2}{\sigma_1}\right)^4 \left(\frac{\mu_1}{\mu_2}\right) = \frac{4}{5} = 0.8$

Correct answer is (0.8 to 0.8)

56. The entropy change when ice at –10°C is heated to 10°C at constant pressure is _____ cal deg^{-1} mol^{-1}

(given:- $C_p(ice) = 9 cal\, deg^{-1}\, mol^{-1}$

$C_p(H_2O) = 18 cal\, deg^{-1}\, mol^{-1}$

$\Delta H_{fm} = 1440 cal\, mol^{-1}$

Soln. $H_2O(s, 263K) \longrightarrow H_2O(\ell, 283K)$

This process involves three stages.

(1) $H_2O(s, 263K) \longrightarrow H_2O(S, 273K)$

$$\Delta S_1 = nC_{p,m} \ell n \frac{273}{263}$$

$$\Delta S_1 = 1 \times 9 \times 0.0373$$

$$\Delta S_1 = 0.336 \text{ cal } deg^{-1}\, mol^{-1}$$

(2) $H_2O(s, 273K) \rightleftharpoons H_2O(\ell, 273K)$

$$\Delta S_2 = \frac{\Delta H_{fus}}{T} = \frac{1440}{273} = 5.25 \text{ cal deg}^{-1} \text{ mol}^{-1}$$

(3) $H_2O(\ell, 273K) \longrightarrow H_2O(\ell, 283K)$

$$\Delta S_3 = nC_{p,m} \ell n \left(\frac{283}{273}\right)$$

$$\Delta S_3 = 0.647 \text{ cal deg}^{-1} \text{ mol}^{-1}$$

$$\Delta S = \Delta S_1 + \Delta S_2 + \Delta S$$

$$\boxed{\Delta S = 6.258 \text{ cal deg}^{-1} \text{ mol}^{-1}}$$

Correct answer is (6 to 6.5)

57. The standard reduction potential for Cu^{2+}/Cu is 0.34 V. K_{sp} of $Cu(OH)_2$ is $Cu(OH)_2$ is 10^{-19}. The reduction potential at pH = 14 for the above cell is _____V.

Soln. pH = 14

$$\left[H^+\right] = 10^{-14} \text{ or } \left[OH^-\right] = 1$$

$$Cu(OH)_2 \rightleftharpoons Cu^{2+} + 2OH^-$$

$$K_{sp} = \left[Cu^{2+}\right]\left[OH^{-2}\right]$$

$$\left[Cu^{2+}\right] = 10^{-19} M$$

For cell reaction, $Cu^{2+} + 2e^- \longrightarrow Cu$

$$E = E^0 - \frac{0.0591}{2} \log \frac{1}{\left[Cu^{2+}\right]}$$

$$E = 0.34 - \frac{0.0591}{2} \times 19$$

$$\boxed{E = -0.22V}$$

Correct answer is (– 0.20 to – 0.23)

58. The volume of 0.1 M CH_3COOH added to 50 mL of 0.2 M NaAc solution to have a pH = 4.91 is _____mL.

Soln. Acidic buffer, $pH = pK_a + \log \frac{[salt]}{[acid]}$

$$4.91 = 4.76 + \log \frac{[salt]}{[acid]}$$

$$\log \frac{[salt]}{[acid]} = (4.91 - 4.76) = 0.15$$

$$\frac{[\text{salt}]}{[\text{acid}]} = 1.41$$

M moles of salt = 50×0.2 = 10

M moles of acid = 0.1×V

$$\frac{[\text{salt}]}{[\text{acid}]} = 1.41 \text{ or } \frac{10}{0.1\times \text{V}} = 1.41$$

$$\boxed{\text{V} = 70.92 \text{ mL}}$$

Correct answer is (70.5 to 71.5)

59. The $J = 0 \rightarrow 1$ rotational transition for $^{1}H\,^{79}Br$ occurs at 500.72 GHz. Assuming the molecule to be rigid rotor, the $J = 3 \rightarrow 4$ transition occurs at _____cm^{-1}.

Soln. For $J = 0 \rightarrow 1$, 2B = 500.726 Hz

$J = 3 \rightarrow 4$, $\Delta E = 8B = 4\times 2B = 4\times 500.72\ GHz$

$$= 4\times 500.72\times 10^{9}\ Hz = \frac{4\times 500.72\times 10^{9}}{3\times 10^{10}}\ cm^{-1} = 66.8\ cm^{-1}$$

Correct answer is (66 to 67)

60. The nuclear g factors of ^{1}H and ^{14}N are 5.6 and 0.40 respectively. If the magnetic field in an NMR spectrometer is set such that the proton resonates at 700 MHz the ^{14}N nucleus would resonates at _____MHz.

Soln. $\omega = \gamma B_0 \Rightarrow \gamma = \frac{e}{2m} g$

$\omega \propto gB_0 \Rightarrow \omega \propto g$

$$\frac{\omega_1}{\omega_2} = \frac{g_1}{g_2} = \frac{\omega_1}{700\ MHz} = \frac{0.4}{5.6}$$

$$\omega_1 = 700\times \frac{0.4}{5.6} = 50\ MHz$$

Correct answer is (50 to 50)

IIT-JAM CHEMISTRY-CY

TEST SERIES - 1
(Physical Chemistry)

Date : 29-12-2016

Booklet : A

ANSWER KEY

Section-A : Multiple Choice Questions (MCQ)

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

Section-B : Multiple Select Questions (MSQ)

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

Section-C : Numerical Answer Type (NAT)

41. (149-151)	**42.** (4.5–5.5)	**43.** (4–6)	**44.** (2–3)
45. (44–45)	**46.** (–70 to –73)	**47.** (2–2)	**48.** (8.5–9.0)
49. (6–6.5)	**50.** (175 to 178)	**51.** (98–102)	**52.** (220–224)
53. (1–1)	**54.** (165–165)	**55.** (0.8–0.8)	**56.** (6–6.5)
57. (–0.20 to –0.23)	**58.** (70.5-71.5)	**59.** (66–67)	**60.** (50–50)