CSIR-UGC-NET | CHEMICAL SCIENCES

PAPER : TIFR CHEMISTRY 2019

1. The equation y = exp(ikx) where i = sqrt (–1) has a purely oscillatory solution if an only if
(a) When k is imaginary
(b) When k is complex
(c) When k is real and negative
(d) When k is real and non-zero

2. According to the laws of thermodynamics for which of the following processes is the entropy of a system equal to zero
(a) Irreversible process
(b) Endothermic process (heat is absorbed during the process)
(c) Reversible process
(d) Exothermic process (heat is released during the process)

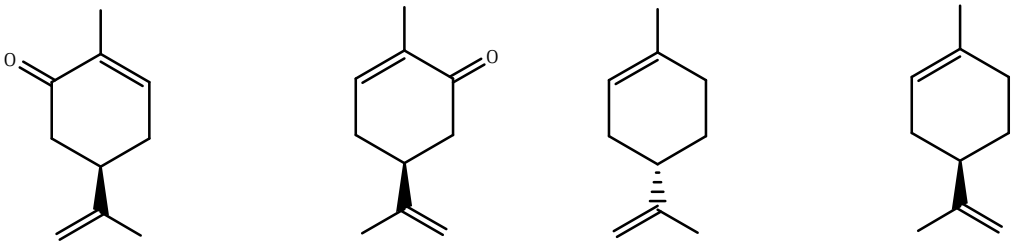
3. The first order reaction is 90% complete in 30 min. How long will it take to be 99.9% completed?
(a) 33.3 min (b) 1.5 hr (c) 55 hr (d) None of the above

4. The Gibbs free energy of a chemical reaction is given by $\Delta G = \Delta H - T\Delta S$, where ΔH is the enthalpy change, ΔS is the entropy change and T is the temperature. The chemical reaction is said to occur spontaneously and unidirectionally if
(a) $\Delta G = 0$ (b) $\Delta H = 0$ (c) $\Delta S = 0$ (d) $\Delta G < 0$

5. The rotation constant for $^{14}N^{15}N$ is measured to be 1.92 cm^{-1}. Which of the statement holds true for the bond length (r_0) for $^{14}N^{15}N$ and its comparison with r_0 for $^{14}N^{14}N$?
(a) $r_0(^{14}N^{15}N) = 1.1$ Angstrom and $r_0(^{14}N^{15}N) > r_0(^{14}N^{14}N)$
(b) $r_0(^{14}N^{15}N) = 1.5$ Angstrom and $r_0(^{14}N^{15}N) < r_0(^{14}N^{14}N)$
(c) $r_0(^{14}N^{15}N) = 1.3$ Angstrom and $r_0(^{14}N^{15}N) > r_0(^{14}N^{14}N)$
(d) $r_0(^{14}N^{15}N) = 1.1$ Angstrom and $r_0(^{14}N^{15}N) < r_0(^{14}N^{14}N)$

6. A bag contains 20 coins each labeled with one-letter code for amino acids. A coin is drawn at random the letter on the coin is noted down and the coin it kept back in the bag before the next draw. If the process is continued for five times, then what is the probability that the letters on the drawn coins make the word 'DRAWN', in that sequence?
(a) 1.0×10^{-10}
(b) .05
(c) Not possible as the word 'DRAWN' has letters which are not codes for amino acids
(d) 3.125×10^{-7}

7. Many times enantiomers give rise to different odors For example. (–)Carvone (I) has sweetish minty smell and (+)-Carvone (II) has a spicy aroma, like Persian cumin seeds. Similarly, (+)-Limonene (III) is found in oranges and (–).Limonene (III) is found in lemons. What would be the stereochemical descriptors of their absolute configurations?



(–) Carvone
(found in garden mint)
I

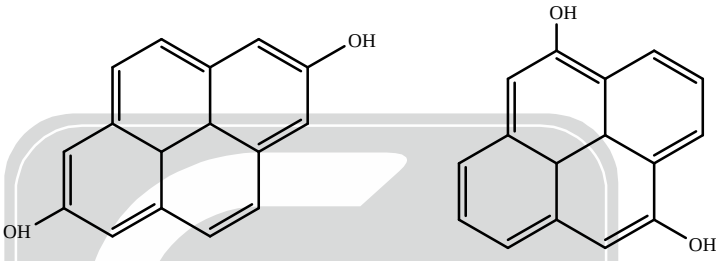
(+) Carvone
(found in Persian cumin)
II

(–) Limonene
(found in Lemons)
III

(+) Limonene
(found in oranges)
IV

(a) I) S, II) R, III) R, IV) S
(b) I) R, II) S, III) R, IV) S
(c) I) R, II) S, III) S, IV) R
(d) I) S, II) R, III) S, IV) R

8. In the broadband decoupled ^{13}C NMR spectrum, the number of signals appearing for the two pyrenediols A and B



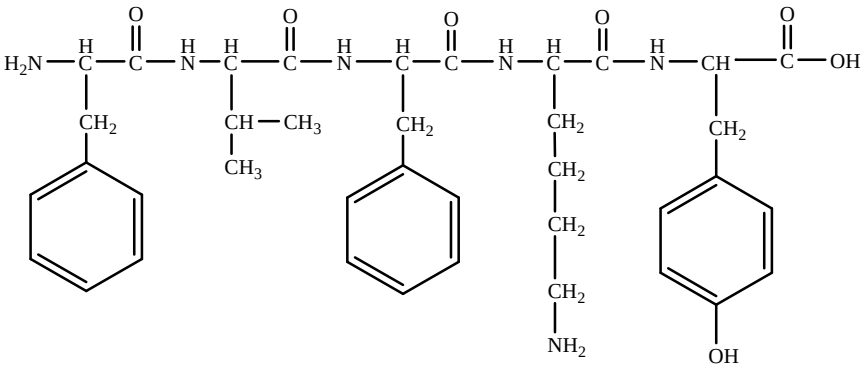
(A)

(B)

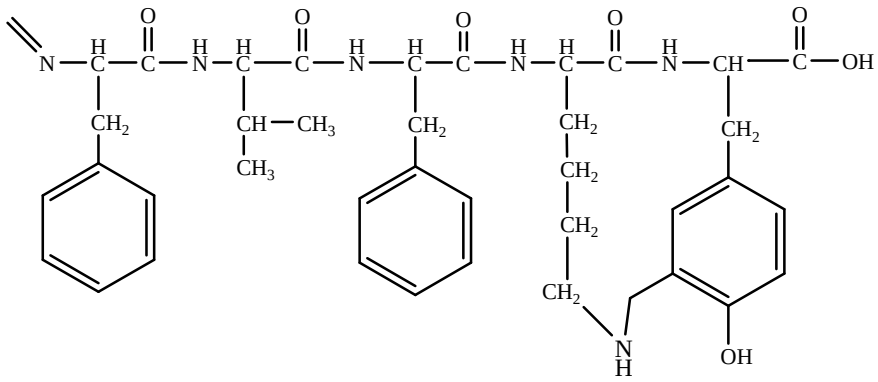
(a) five and eight (b) eight and eight (c) eight and sixteen (d) five and ten

9. While the vibrational energy of an oscillator in v = 0 state (ground state) is nonzero, the rotational energy of a rigid rotor in J = 0 state (ground state) can be zero. Pick the correct reason.
(a) Vibrational energy of an oscillator consists of both potential as well as kinetic energy whereas the rotational energy of the rotor has only the kinetic energy.
(b) It is a rigid rotor
(c) Vibrational and rotational degrees of freedom are decoupled from each other.
(d) None of the above

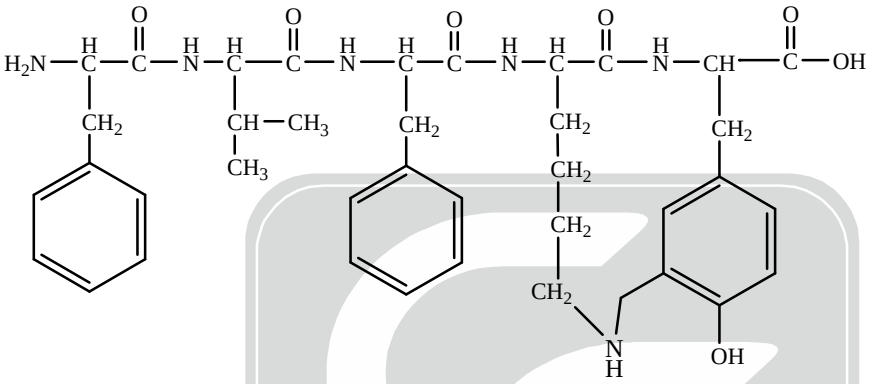
10. A dilute solution of the peptide shown is treated with excess 10 % formaldehyde in methanol. Predict the product formed.



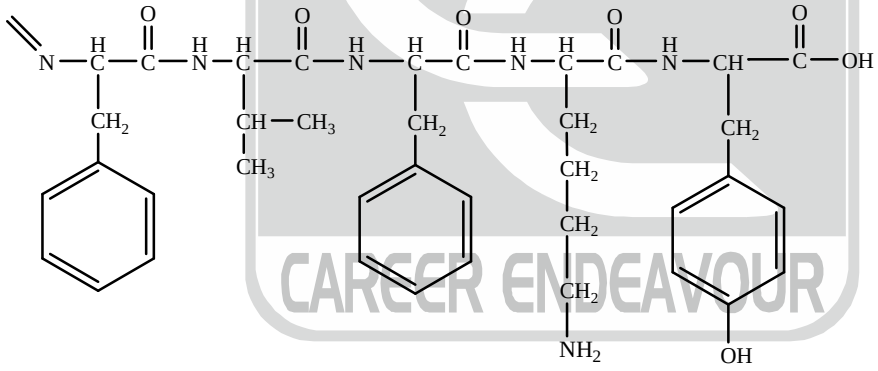
(a)



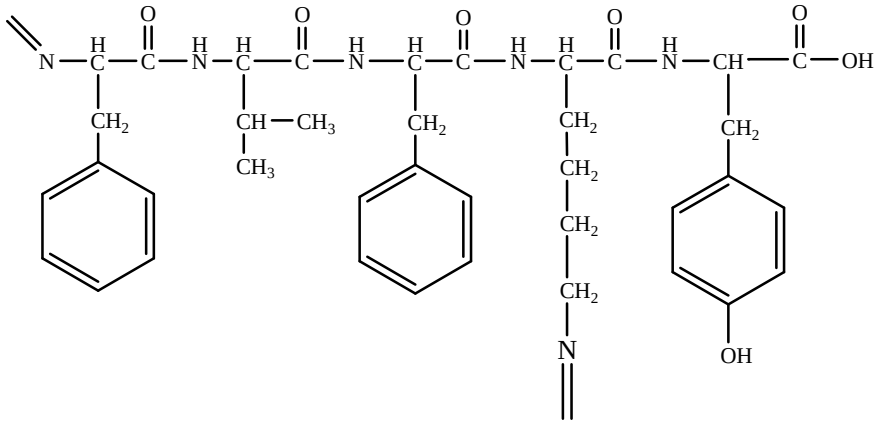
(b)



(c)

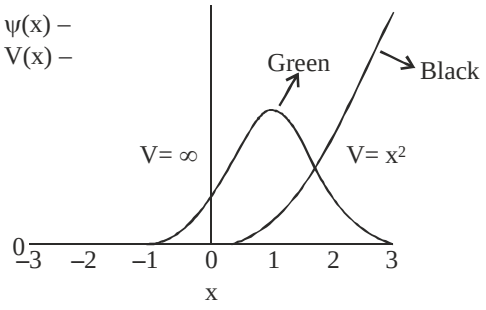


(d)

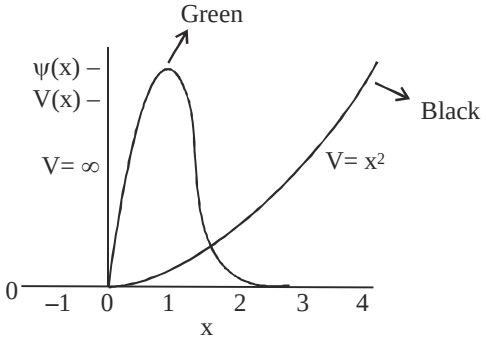


11. Which of the wavefunctions sketched below (in green) are valid for the half parabolic potential (in black). Note that the $V(x) = x^2$ for $x > 0$ while ∞ elsewhere.

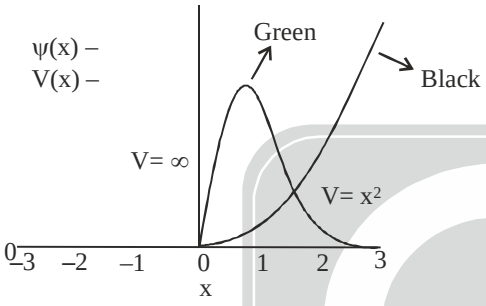
(a)



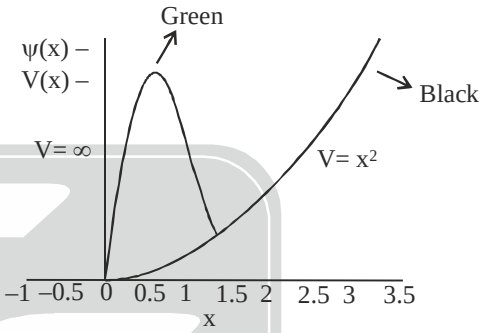
(b)



(c)



(d)



12. Suppose one is recording a Raman spectrum of a solution with yellow colour light as an excitation source.The detected photons have both green and red colour resulting in two peaks. If one starts heating the solution , which of the following is likely to happen?

(a) Temperatrue has no effect on the spectrum
(b) The green peak becomes red
(c) The green peak becomes blue
(d) The photon counts of green peak increases

13. The Arrhenius rate expression $k = A\exp(-E_a/RT)$ is only an approximation as one finds that the pre-exponential factor. A is not completely temperature independent. Assume that it weakly depends on temperatrue as $A = BT^m$. Then the rate expression becomes $k = BT^m\exp(-E_b/RT)$. Under these circumstances the relation between E_a and E_b is given by

(a) $E_a - E_b = mRT$ (b) $E_a = E_b + (RT^m)$ (c) $E_b = E_a + (RT^m)$ (d) $E_b - E_a = mRT$

14. In isoelectronic series VO_4^{3-}, CrO_4^{2-} and MnO_4^-, all members have intense charge transfer transition. The INCORRECT statement is

(a) The charge on the metal nucleus increases in the order $VO_4^{3-} < CrO_4^{2-} < MnO_4^-$.

(b) The wavelengths of transitions increase in the order $VO_4^{3-} < CrO_4^{2-} < MnO_4^-$.

(c) Charge transfer transitions are attributed to excitations of electrons from ligand to metal

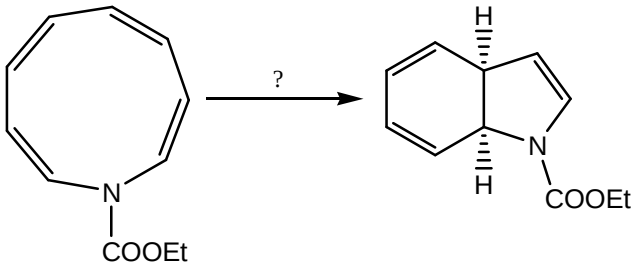
(d) MnO_4^- exhibits charge transfer at shortest wavelength amongst the three.

15. Consider the following reactions
Reaction 1: 2 cm^3 of hydrogen gas and 1 cm^3 oxygen gas combine to form H_2O (gas)
Reaction 2 : 1 cm^3 of hydrogen gas and 1 cm^3 chlorine gas combine to form HCl (gas)
Assuming ideal gas behaviour, the volumes of the H_2O (gas) and HCl (gas) are :

(a) $2cm^3 H_2O(gas)$ and $2cm^3 HCl(gas)$ (b) $1cm^3 H_2O(gas)$ and $1cm^3 HCl(gas)$

(c) $3cm^3 H_2O(gas)$ and $2cm^3 HCl(gas)$ (d) $3cm^3 H_2O(gas)$ and $1cm^3 HCl(gas)$

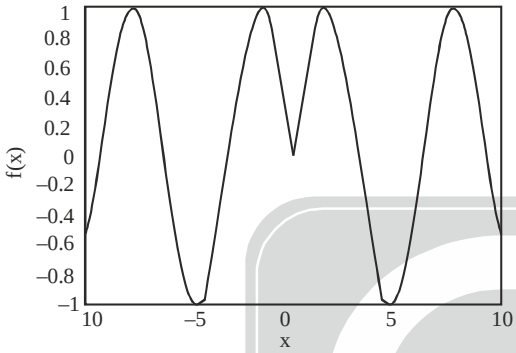
16. Pre dict the reaction condition for the following synthetic transformation ?



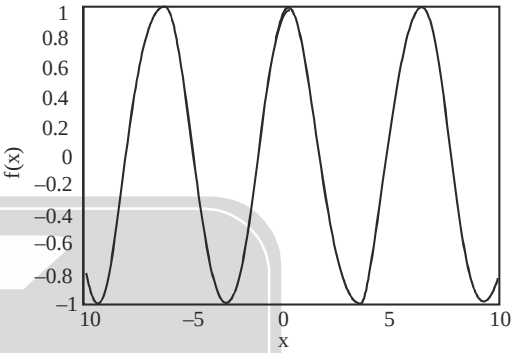
(a) Acid (b) Heat (c) Base (d) Light

17. Which of these represents f(x) = sin|x|?

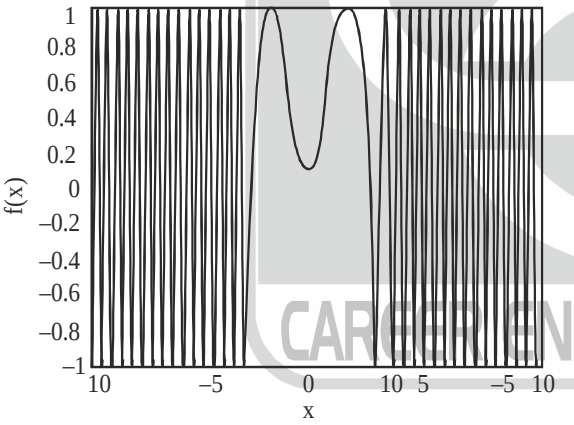
(a)



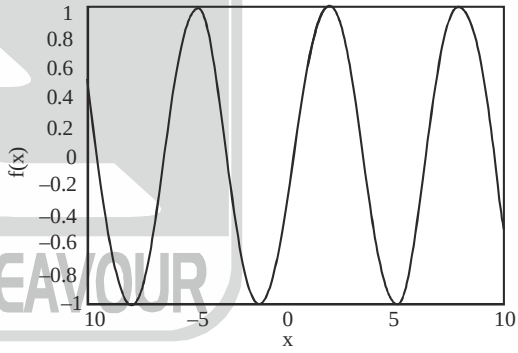
(b)



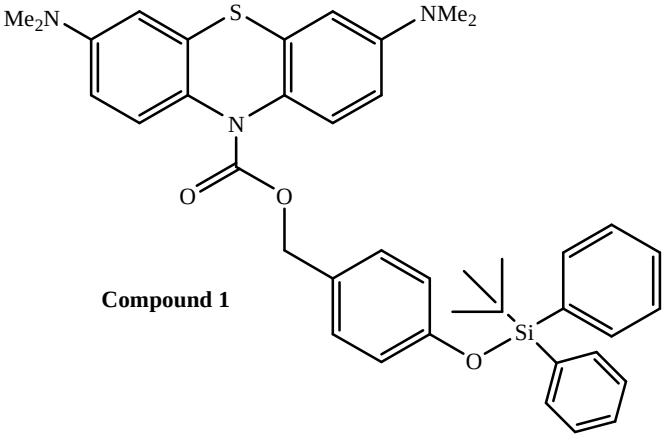
(c)



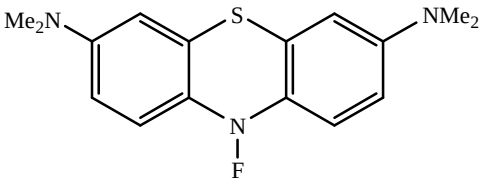
(d)

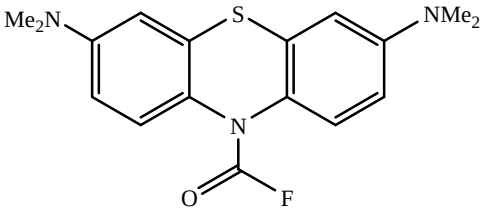


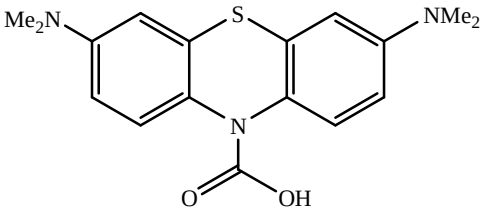
18. Compound I (I mg) was added to an anti-cavity fluoride toothpaste (25 mg). The toothpaste turned blue. What did compound I get converted to?

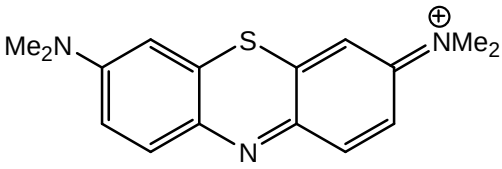


Compound 1

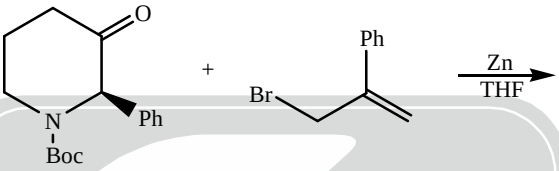
(a) 

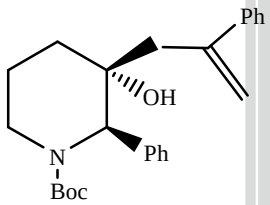
(b) 

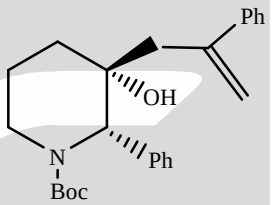
(c) 

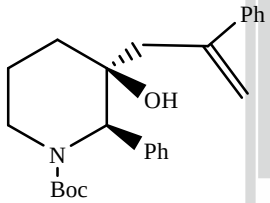
(d) 

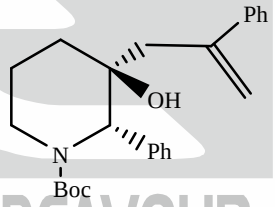
19. Product of the following reaction is



(a) 

(b) 

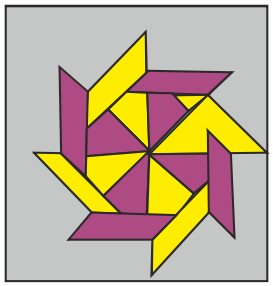
(c) 

(d) 

20. Water boils at a temperature of 373 K and atmospheric pressure of 1 atm. Assuming a constant enthalpy of vaporization of 40.66 kJ/mol, what is the boiling temperature at a high altitude, where the pressure is 0.5 atm?

(a) 270 K (b) 354 K (c) 403 K (d) 373 K

21. Below is a picture of an Origami pinwheel. What elements of symmetry are present in the pinwheel?



(a) A mirror plane perpendicular to the plane of the paper and a 2-fold axis of rotation perpendicular to the plane of the pinwheel.
(b) 4 fold rotation axis perpendicular to the plane of the pinwheel and an inversion centre.
(c) Only one 4-fold rotation axis perpendicular to the plane of the pinwheel
(d) 2 mirror planes perpendicular to the plane of the paper

22. If the peak in the mass spectrum of C_2F_6 at mass number 138 is 100 units tall, what will be the heights of the peaks at mass numbers 139 and 140. Isotopic abundances: ^{12}C,98.89%, ^{13}C,1.11%,^{19}F,100%

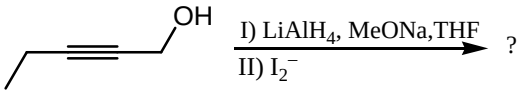
(a) 2.24 and 0.0126 (b) 50 and 25 (c) 2.24 and 0.025 (d) 1.12 and 0.0126

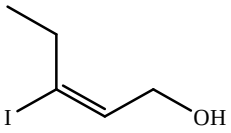
23. $\psi(r)$ is the wavefunction for the 1s orbital and r is the distance of the electron form the nucleus. Then the average distance of the 1s electron form the nucleus is given by :

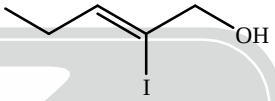
(a) $4\pi\int_0^{\infty}\psi(r)r\psi^*(r)r^2dr$ (b) $4\pi\int_{-\infty}^{\infty}\psi(r)r\psi^*(r)r^2dr$

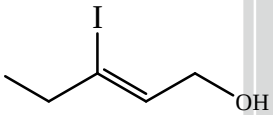
(c) $\int_0^{\infty}\psi(r)\psi^*(r)dr$ (d) $4\pi\int_0^{r}\psi(r)r\psi^*(r)r^2dr$

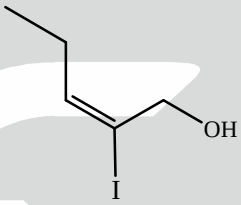
24. What is the main product of below reaction ?



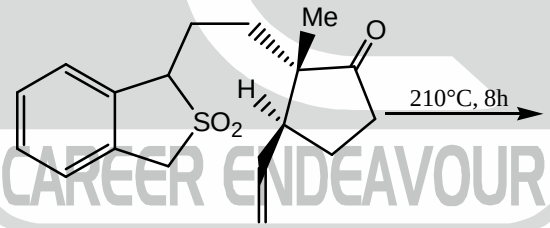
(a) 

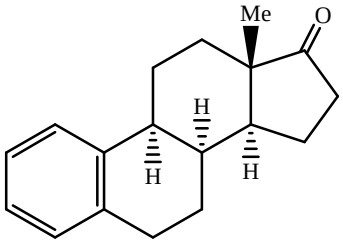
(b) 

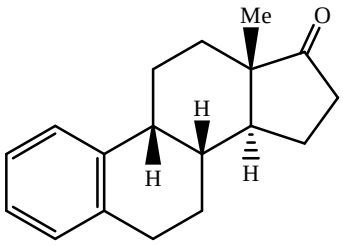
(c) 

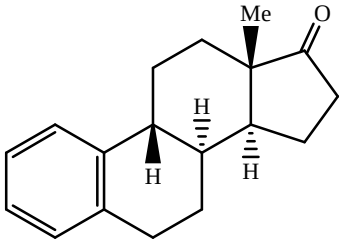
(d) 

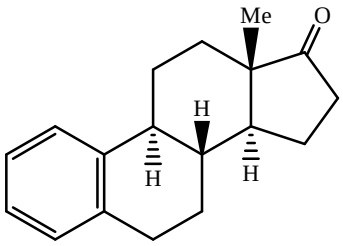
25. Predict the product of the following reaction



(a) 

(b) 

(c) 

(d) 

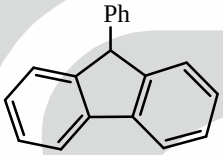
26. Identify the compound whose molecular ion appears as a pair of equal intensity peaks at m/z = 122 & m/z = 124. Large fragment ions are seen at m/z = 43 (base peak).
(a) 1-bromopropane (b) 2-bromopropane (c) Both A and B (d) None of them

27. As electron is confined to a 2-D square potential well with dimension of 10 nm and well depth of 1 eV. For a bound state, what is the maximum possible value of n_x?
(a) 0
(b) Can not be determined from the information provided
(c) 266
(d) 16

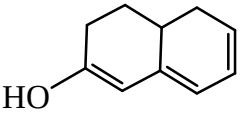
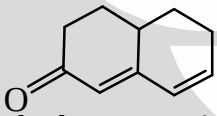
28. You are measuring the weight of a sample using a balance. After 7 measurements, the measured weight is 10 ± 1 gm. To get the standard error to ± 0.5 gm, approximately how many measurements will you have to do ?
(a) 14 (b) 100 (c) 49 (d) 28

29. Which of the following natural amino acids is not hydrophobic?
(a) Valine (b) Arginine (c) Leucine (d) Isoleucine

30. Which of the following is **INCORRECT**

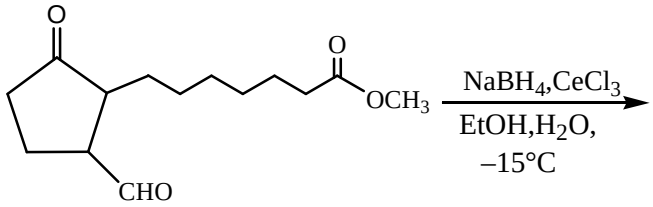
(a)  is more acidic than 

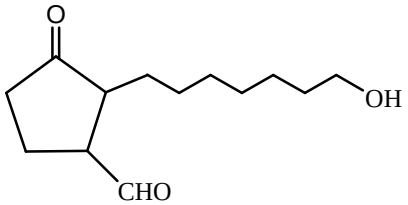
(b) Acidity of following oxy-acids in water $HIO < HIO_2 < HIO_3 < HIO_4$
(c) $[Fe(H_2O)_6]^{3+}$ is less acidic than $[Fe(H_2O)_6]^{2+}$ in water

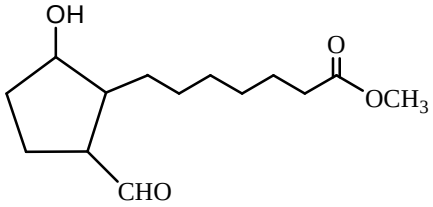
(d)  and  are tautomers

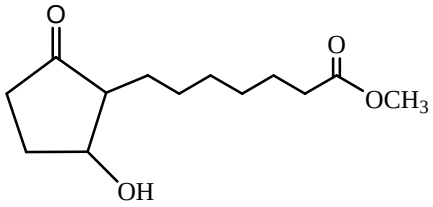
31. The total volume of an ethanol solution at 25 °C containing 1.000 kg of water is experimentally found to obey the following expression
$V/ml = 1002.9 + 54.67b - 0.3639b^2 + 0.02825b^3$
where b is numerical value of the molality of ethanol in the solution. At what molality would the partial molar volume of ethanol be the minimum ?
(a) b = 4.29 mol/kg (approx.)
(b) b = 0 mol/kg
(c) b = 21.74 mol/kg (approx.)
(d) Cannot be answered, as not enough information is given

32. Predict the product obtained in the following reaction



(a) all of these (b) 

(c) 

(d) 

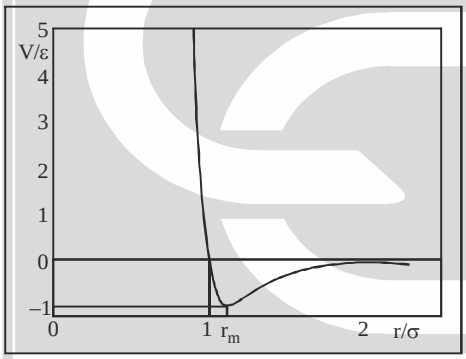
33. Which of the following is true for the closest distance D that two solvated ions with like charges (q) can achieve at temperature T.

(a) $D \propto \frac{q^2}{T}$ (b) $D \propto \frac{q^2}{T^2}$ (c) $D \propto q^2T$ (d) $D \propto q^2T^2$

34. The clusters Sn_5^{2-}, Ge_9^{4-}, and $Rh_6(CO)_{16}$ have structure respectively:

(a) nido, closo, and closo (b) closo, nido, and arachno
(c) arachno, closo, and nido (d) closo,nido, and closo

35. The short-ranged intermolecular interactions are often described by the Lennard-Jones potential $V(r) = 4\varepsilon[(\sigma / r)^{12} - (\sigma / r)^6]$, which gives the internal energy of interaction between two molecules as a function of intermolecular separation. Here ε is the depth of the potential well, σ is the finite distance at which the inter-particle potential is zero, r is the distance between the particles, and r_m is the distance at which the potential reaches its minimum. At r_m, the potential function has the value $-\varepsilon$.
If you would like to express the same potential energy function in terms of r_m and ε, the function should be



(a) $V(r) = \varepsilon[(r_m / r)^{12} - 2(r_m / r)^6]$ (b) $V(r) = \varepsilon[(r_m / r)^{12}]$
(c) $V(r) = 4\varepsilon[(r_m / r)^{12} - (r_m / r)^6]$ (d) $V(r) = \varepsilon[2(r_m / r)^{12} - (r_m / r)^6]$

36. Consider the following equations in quantum mechanics involving operators and ket vectors.

(i) $\hat{J}^2 \left| j, m_j \right\rangle = j(j+1) \left| j, m_j \right\rangle$ (ii) $\hat{J}_z \left| j, m_j \right\rangle = m_j \left| j, m_j \right\rangle$

(iii) $\hat{J}^{\pm} \left| j, m_j \right\rangle = \sqrt{j(j+1) - m_j(m_j \pm 1)} \left| j, m_j \right\rangle$

Which of them are eigenvalue equations and what would be the eigenvalue of the operator $\hat{J}_x^2 + \hat{J}_y^2$ with respect to the vector $\left| j, m_j \right\rangle$?

(a) (i) and (ii) and $j(j+1) - 2m_j^2$ (b) (i), (ii) and (iii) and $2m_j^2$
(c) (i) and (ii) and $j(j+1) - m_j^2$ (d) (iii), and $j(j+1) - m_j^2$

37. The pK_{a1} of carbonic acid (H_2CO_3) is 6.3 while that of bicarbonate/carbonate equilibrium (pK_{a2}) shown is 10.3

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

Given the above data and $pK_W = 14$, can one predict the pH of 0.01 M sodium bicarbonate solution in water?

(a) 7.5 (b) 10.5 (c) 8.3 (d) 2

38. In the photoelectric effect, if the intensity of light falling on the sample is increased, what would be the outcome on the (i) kinetic energy (K.E.) of the ejected electron and the (ii) total number of electrons that are being ejected.

(a) (i) The K.E will remain the same and (ii) number of electrons will also remain the same
(b) (i) The K.E will increases and (ii) number of electrons will also increase
(c) (i) The K.E. will increase and (ii) number of electrons will reamin the same
(d) (i) The K.E. will remain the same and (ii) number of electrons will increase

39. What is the molar mass of a compound that has a concentration w = 1.2 g/L in solution and an osmotic pressure of $\pi = 0.20$ atm at T = 300 K

(a) 147 g/mol (b) 1432 g/mol (c) 17 g/mol (d) 3031 g/mol

40. Identify the organic molecule which contains 66.6% carbon, 11.1% hydrogen. In infra-red spectrum of the molecule, bands are observed at 2941-2857, 1715 and 1640 cm^{-1}. In proton NMR, three signals appeared at : (i) 7.52 (q, 2H), (ii) 7.88 (s, 3H), (iii) 8.93 (t, 3H) in ppm scale.

(a) Ethyl methyl ketone (b) 2-Butanol
(c) 1-Butanaldehyde (d) None of them