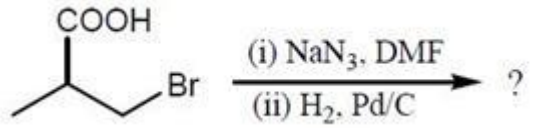
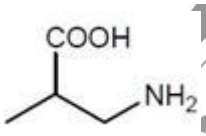
IIT JAM 2015

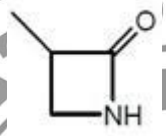
1. The first row transition metal complexes having tetrahedral geometry are high-spin due to

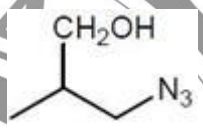
(a) $\Delta_t > P$ (b) $\Delta_t < P$ (c) $\Delta_t = P$ (d) $\Delta_t > \Delta_0$

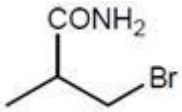
2. The major product formed in the following reaction is



(a) 

(b) 

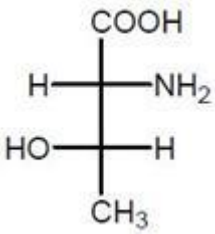
(c) 

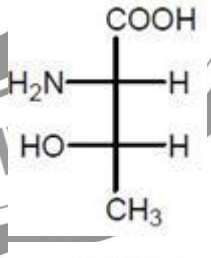
(d) 

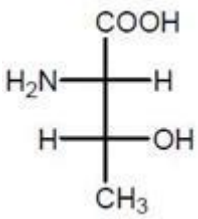
3. Which one of the following is an identity matrix?

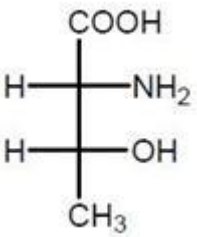
(a) $\begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$ (b) $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ (c) $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ (d) $\begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}$

4. The structure of (2S, 3R)-2-amino-3-hydroxy butanoic acid is

(a) 

(b) 

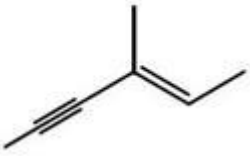
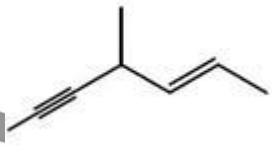
(c) 

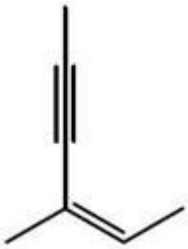
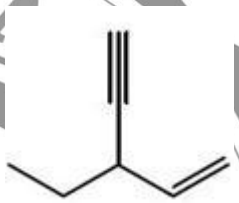
(d) 

5. The intermolecular van der Waal's potential is inversely proportional to I^6. The corresponding force is proportional to

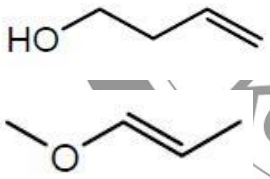
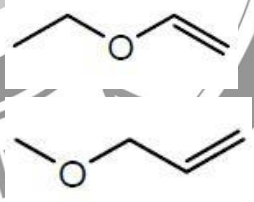
(a) $\frac{1}{r^5}$ (b) $\frac{1}{r^6}$ (c) $\frac{1}{r^7}$ (d) $\frac{1}{r^{12}}$

6. The ene-yne that produces a chiral compound upon treatment with Lindlar's catalyst is

(a)  (b) 

(c)  (d) 

7. An organic compound P(C_4H_8O) is positive to Bayer's test, but iner to sodium metal. On treatment with conc. HCl, P gives CH_3CH_2Cl and CH_3CHO. The structure of P is

(a)  (b) 

(c) (d)

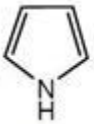
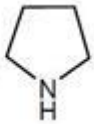
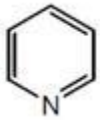
8. Low-spin iron (III) centre is present in
(a) deoxy form of haemoglobin (b) oxy form of haemoglobin
(c) hemocyanin (d) carbonic anhydrase

9. A filter paper moistened with cadmium acetate solution turns yellow upon exposure to H_2S. the transition responsible for the yellow colour is
(a) d-d (b) Metal-to-ligand charge transfer
(c) ligand-to-metal charge transfer (d) $\sigma - \sigma^*$

10. The species responsible for the super-acidity of $SbF_5 - HSO_3F$ system is
(a) HSO_3F (b) SbF_5 (c) HF
(d) $H_2SO_3F^+$

Q-11 to Q30 carry two marks each

11. The correct order of the pKa values for the conjugate acids of heterocyclic compounds given below is

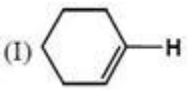
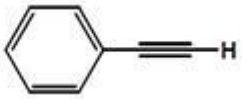
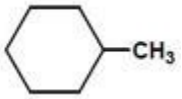
(I)  (II)  (III)  (IV) 

(a) II > III > I > IV (b) IV > II > III > I (c) III > II > IV > I (d) III > IV > II> I

12. The species having trigonal pyramidal shape is.
(a) NO_3^- (b) CO_3^{2-} (c) BrF_3 (d) SO_3^{2-}

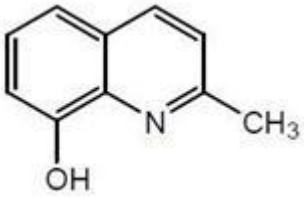
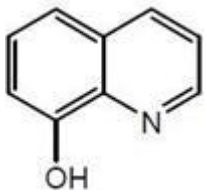
13. The Volhard method is used for the estimation of
(a) cyanide ion by titration wish silver nitrate
(b) silver ion dirwctly
(c) Oxygen in water
(d) glucose in blood

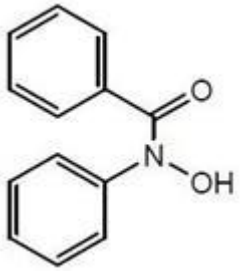
14. The correct order of the ^1H NMR chemical shift values (δ) for the indicated hydrogenes (in bold) in the following compounds is

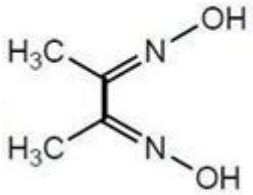
(I)  (II)  (III)  (IV) 

(a) I > II > III > IV (b_) II > I > III > IV (c) III > II > I > IV (d) II > III > IV >I

15. The reagent 'oxide' commonly used in analytical chemistry is

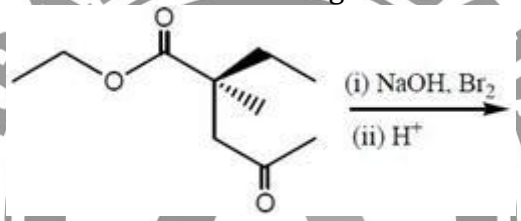
(a)  (b) 

(c) 

(d) 

16. The correct statements about ionization potential (IP) is
(a) non-metalic character of an element decreases as the IP increases
(b) IP decreases down the group in the periodic table
(c) second IP of Ca is larger than second IP of K
(d) IP decreases on going from left to right in the periodic table

17. The set of products formed in the following reaction is

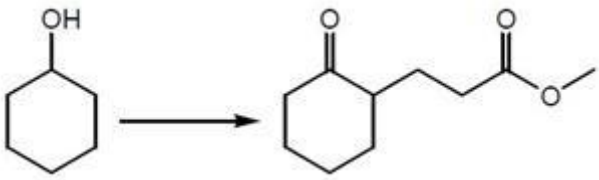


(a) $CHBr_3$ and a racemic acid (b) $CHBr_3$ and a chiral acid
(c)Br_3 and a racemic ester (d) CH_3Br_2 and a chiral ester

18. The normal spinel among the following mixed metal-oxides is
(a) $^4F_{3/2}$ (b) $^4F_{9/2}$ (c) $^4F_{1/2}$ (d)$^4F_{5/2}$

19. The ground state term for a free ion with $3d^7$ configuration is
(a) $^4F_{3/2}$ (b) $^4F_{9/2}$ (c) $^4F_{1/2}$ (d) $^4F_{5/2}$

20. The correct set of reagents required for the following transformation is



(a) (i) CrO_3; (ii) acrylonitrile; (iii) H_3O^+
(b) (i) O_2; (ii) methyl acrylate
(c) (i) CrO_3; (ii) NaOMe/MeOH, methyl acrylate; (iii) H_3O^+
(d) (i) H_2O; (ii) methyl acrylate.

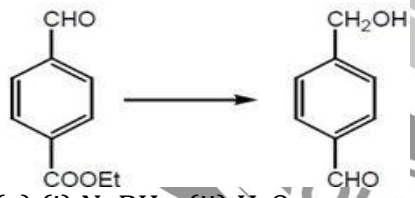
21. The concentration of K^+ ion inside a biological cell is 20 times higher than outside. The magnitude of potential difference between the two sides is [Given : 2.303 RT/F = 59 mV]
(a) 0 mV (b) 26 mV (c) 77 mV (d) 177 mV

22. At 25°C, the solubility product $\left(K_{sp}\right)$ of CaF_2 in water is 302×10^{-11}. The solubility (in mole per kg of water) of the salt at the same temperature (ignore ion pairing) is
(a) 4.0×10^{-6} (b) 3.2×10^{-4} (c) 2.5×10^{-4} (d) 2.0×10^{-4}

23. The complex that is expected to show orbital contribution to the overall magnetic moment is
(a) $\left[Cr(CN)_6\right]^{3-}$ (b) $\left[Co(H_2O)_6\right]^{2+}$ (c) $\left[Ni(en)_3\right]^{2+}$ (d) $\left[Cu(NH_3)_6\right]^{2-}$

24. The correct order of the fundamental vibrational frequencies of the following diatomic molecules is
(a) $^1H^{35}Cl > {}^1H^{37}Cl > {}^2D^{35}Cl$ (b) $^2D^{35}Cl > {}^1H^{37}Cl > {}^1H^{35}Cl$
(c) $^1H^{37}Cl > {}^1H^{35}Cl > {}^2D^{35}Cl$ (d) $^1H^{37}Cl > {}^2D^{35}Cl > {}^1H^{35}Cl$

25. Identify the correct reagents required for the following transformation



(a) (i) $NaBH_4$; (ii) H_3O^+
(b) (i) $LiAlH_4$; (ii) H_3O^+
(c) (i) $HOCH_2CH_2OH$, H^+; (ii) $LiAlH_4$; (iii) H_3O^+
(d) (i) $HSCH_2CH_2SH$, H^+; (ii) $LiAlH_4$; (iii) H_3O^+

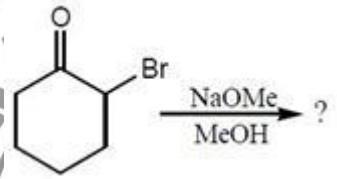
26. For an isothermal free expansion of an ideal gas into vacuum, which one of the following set of values is correct?
(a) $\Delta U=0, q>0, w<0$ (b) $\Delta U>0, q>0, w=0$
(c) $\Delta U=0, q=0, w=0$ (d) $\Delta U<0, q=0, w<0$

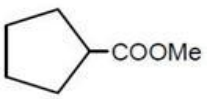
27. The kinetics of the reaction $2N_2O_5 \rightarrow 4NO_2 + O_2$ in liquid bromine medium was measured in-dependently for there different initial concentrations of N_2O_5 : 0.11, 0.07 and 0.05 mol L^{-1}. The order of the reaction is
(a) 0 (b) 1 (c) 2 (d) 0.5

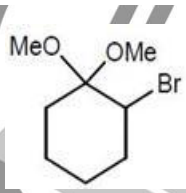
28. Which of the following statements are correct for S_NAr reaction?
(i) Follows second order kinetics
(ii) $K_H/K_D > 1$
(iii) Involves carbanion-type intermediate
(iv) Involves two transition states
(a) (i) and (ii) only (b) (ii) and (iii) only
(c) (i), (iii) and (iv) only (d) (i) and (iii) only

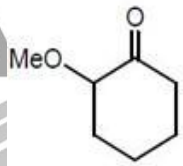
29. According to the equipartition principle, the predicted high temperature limiting value of the molar heat capacity at constant volume for C_2H_2 is
(a) 5.5 R (b) 6.0 R (c) 9.0 R (d) 9.5 R

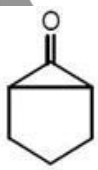
30. The major product formed in the following reaction is



(a) 

(b) 

(c) 

(d) 

SECTION-B

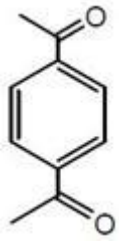
1. If $x = x$ and $p_x = \frac{h}{2\pi i}\frac{d}{dx}$, then the value (s) of $p_x x - x p_x$ is/ are
(a) $\frac{\hbar}{i}$ (b) $-i\hbar$ (c) 0 (d) $\frac{i}{\hbar}$

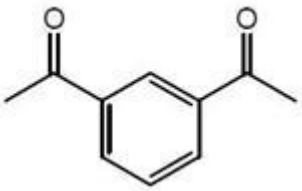
2. The common feature(s) of Rb^+, Kr and Br^- is/are that they
(a) have same number of valence electrons
(b) have same magnitude of effective nuclear charge
(c) have same magnitude of first ionization potential
(d) are isoelectronic species

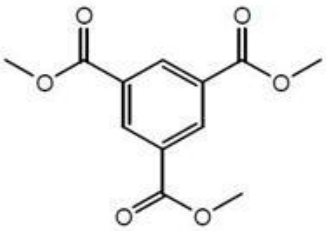
3. The characteristics of the blue solution of sodium in liquid ammonia is/are
(a) diamagnetic (b) paramagnetic

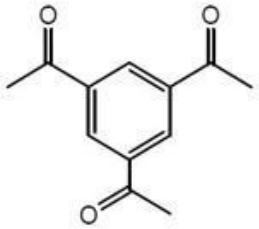
(c) reducing in nature (d) conducts electricity

4. Which of the following compound(s) show(s) only two signals in ^1H NMR and a strong IR band at ~ 1690 cm^{-1}

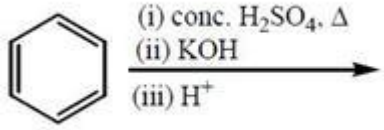
(a) 

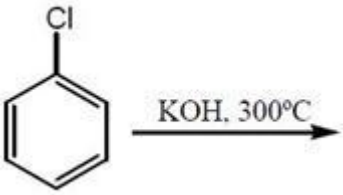
(b) 

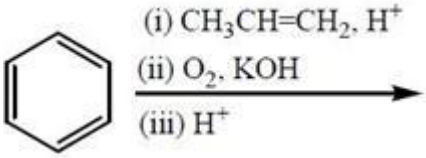
(c) 

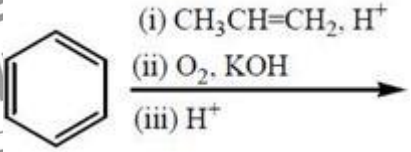
(d) 

5. The reaction(s) which give(s) phenol is/are

(a) 

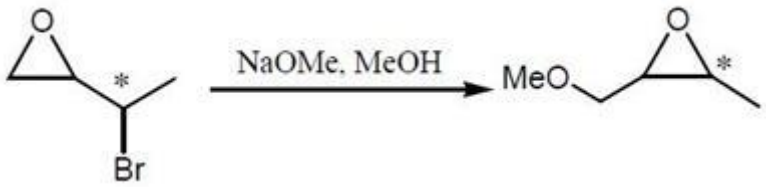
(b) 

(c) 

(d) 

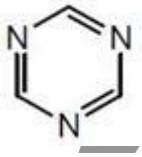
6. At what angle (s) of incidence, X-rays of wavelength $5.0\,\text{Å}$ will produce diffracted beam from the (110) planes in a simple cubic lattice with a = $10\,\text{Å}$?
(a) 6.8^o (b) 10.2^o (c) 20.7^o (d) 45.0^o

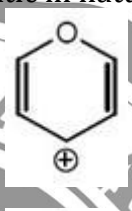
7. Which of the following statements(s) is/are true about the reaction given below?

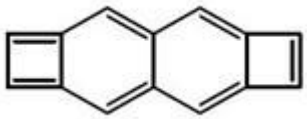


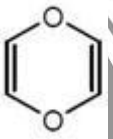
(a) It involves a carbocation intermediate
(b) rearrangement is deu to S_N1 reaction mechanism.
(c) it proceeds via a concerted S_N2 pathway
(d) it involves neighbouring group participation.

8. Which of the following species is/are aromatic in nature?

(a) 

(b) 

(c) 

(d) 

9. Which of the following statement(s) is/are true about the transition metal-alkene complexes?
(a) Back-bonding weakens the double bond of the alkene
(b) σ-bonding and back-bonding synergistically strengthen metal-alkene interaction
(c) Electron-withdrawing substituents on alkene reduce back-bonding
(d) π- acidic co-ligands on metal strengthen back-bonding

10. Which of the following thermodynamic relation (s)/are correct?

(a) $\left(\frac{\partial T}{\partial V}\right)_S = \left(\frac{\partial P}{\partial S}\right)_V$

(b) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$

(c) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$

(d) $\left(\frac{\partial S}{\partial P}\right)_T = \left(\frac{\partial V}{\partial T}\right)_P$

SECTION-C

1. In the gas phase, the ratio of excluded volume to molecular volume for a spherical molecule is _____

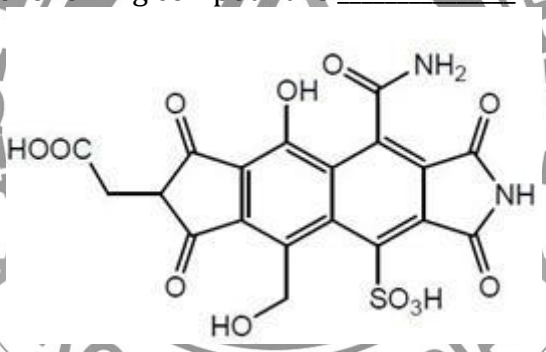
2. The pK_a values of lysine are 2.18, 8.95 and 10.79. the isoelectric point of lysine is _____

3. The amount (in grams) of potassium dichromate (MW = 294) present in 75 mL of 0.16 M aqueous solution is _____

4. Given that the expected spin-only magnetic moment for $(Et_4N)_2\left[NiCl_4\right]$ is 2.83 μ_B, the total number of unpaired electrons in this complex is _____

5. Given that the crystal field stabilization energy for $\left[Co(H_2O)_6\right]^{2+}$ is 7360 cm^{-1}, the calculated value of Δ_0 in kJ mol^{-1} is _____

6. The amount (in grams) of NaOH (MW = 40) required for complete neutralization of one mole of the following compound is _____



7. For the reaction, $2SO_2 + O_2 \rightleftharpoons 2SO_3$, the equilibrium constant $K_P = 5.0$ at 207°C. If the partial pressure of SO_2, O_2 and SO_3 are 1.0×10^{-3}, 0.20 and 1.0×10^{-4}, respectively, then the Gibbs free energy of the reaction $(\Delta_r G)$ in kJ mol^{-1} at 207°C is _____[Given : R = 8.314 J K^{-1} mol^{-1}].

8. In the given list, the total number of compounds that form a clear homogeneous solution on treatment with cold dilute H_2SO_4 is _____
1-propyne
Cyclohexanone
Cyclohexane
1-propene
Propane-1-amine
Propoxypropane

Tetrahydropyran
Ethyl butanoate
Pyridine

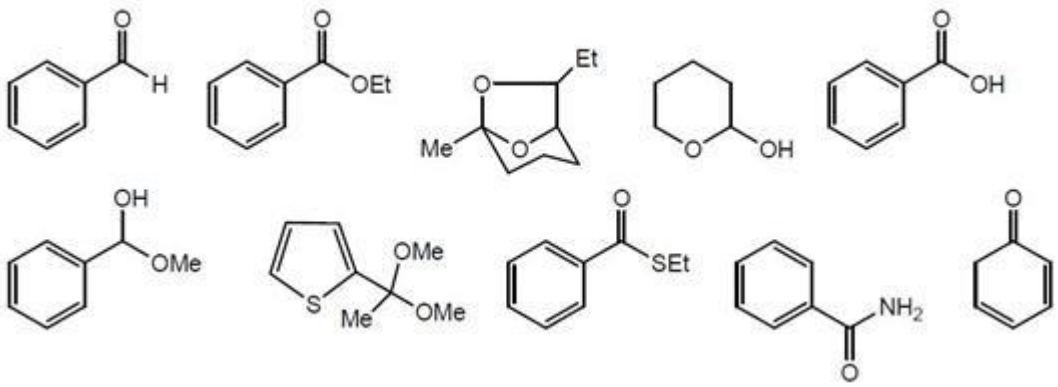
9. Two moles of an ideal gas is expanded isothermally and reversibly from 5 to 1 bar at 298K. The change in the entropy (in JK^{-1}) of the system is _____

10. The pKa values of H_3PO_4 are 2.12, 7.21 and 12.67. The pH of a phosphate buffer containing 0.2M NaH_2PO_4 and 0.1 M Na_2HPO_4 is _____

11. The ionic radii of Cs^+ and Cl^- ions are 181 and 167 pm, respectively. The born exponents for the He, Ne, Ar, Kr and Xe configuration are 5, 7, 9 10 and 12 respectively. If the value of $\frac{ANe^2}{4\pi\varepsilon_0}$ is 2.45×10^{-4} Jm, The lattice energy (in kJ mol^{-1} of CsCl according to Born-Lande equation is _____

12. A 2.5×10^{-4} M solution of a complex exhibits an absorption maximum at 625 nm with an absorbance of 0.90 when measured in a cuvette with a path length of 1.5 cm. The absorbance of 1.5×10^{-3} M solution of the same complex recorded in a cuvette with path length of 0.2 cm is _____

13. The total number of compounds (shown below) that form phenyl-hydrazone derivatives under acidic conditions is _____



14. The standard reduction potentials of the Fe^{3+}/Fe^{2+} and Fe^{2+}/Fe couples are 0.77 and –0.44 V respectively. The standard reduction potential (in V) for the Fe^{3+}/Fe couple is _____

15. The number of possible mono-alkylated products formed in the Friedel-crafts reaction of anisole with 2-chloro-3-methylbutane in the presence of anhydrous $AlCl_3$ at 50°C is _____

16. In an ideal monoatomic gas, the speed of sound is given by $\sqrt{\frac{5RT}{3M}}$. If the speed of sound in argon at 25°C is 1245 km h^{-1}, the root mean square velocity in m s^{-1} is _____

17. A wood specimen containing ^{14}C taken from an ancient palace showed 24 counts is 3 minutes per gram of carbon. Assuming no background signal in the detector and half life of ^{14}C as 5730 years, the age (in year) of the wood specimen is - _____

18. The magnetic field (in Tesla) required for flipping a ^{1}H nucleus in an NMR spectrometer operating at 400 MHz is _____ [Given : $\gamma = 2.67 \times 10^{8} T^{-1} s^{-1}, \pi = 3.14$]

19. For a reaction, the rate constant at 25°C is doubled when the temperature is raised to 45°C. The activation energy (in kJ mol^{-1}) of the reaction is _____[Given : ln2 = 0.693]

20. When a perfect monolayer of stearic acid is formed at the air-water interface, each molecule of stearic (Mol. Wt = 284, density = 0.94 g cm^{-3}) occupies an area of 20 Å^2. The length (in Å) of the molecule is _____