Date: 14/10/2021

Q1. Calculate the percentage of naturally occurring isotopes ^{35}Cl and ^{37}Cl that accounts for the atomic mass of chlorine taken as 35.45.

Q2. How many significant figures should be present in the answer of the following calculations?

$$\frac{2.5 \times 1.25 \times 3.5}{2.01}$$

Q3. What is the mass per cent of carbon in carbon dioxide?

Q4. Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid (HCl) according to the reaction.

$$4HCl(aq) + MnO_2(s) \longrightarrow 2H_2O(l) + MnCl_2(aq) + Cl_2(g)$$

How many grams of HCl react with 5.0 g of manganese dioxide? [Atomic mass of Mn = 55u]

Q5. Calculate the molarity of a solution of ethanol in water in which the mole fraction of ethanol is 0.040.

Q6. How many moles of iron can be made from Fe_2O_3 by the use of 16 moles of carbon monoxide in the following reaction?

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

Q7. (a) A sample of phosphorus trichloride (PCl_3) contains 1.4 moles of the substance. How many atoms are there in the sample?

(b) How many grams of NaOH will be required to neutralise 12.2 g of benzoic acid?

Q8. (a) The cost of table salt (NaCl) and table sugar ($C_{12}H_{22}O_{11}$) is Rs. 2 per kg and Rs. 6 per kg, respectively. Calculate their costs per mol.

(b) Calculate the conncentration of sugar ($C_{12}H_{22}O_{11}$) in mol L^{-1} if its 20 g are dissolved in enough water to make a final volume upto 2L.

Q9. Define molarity. What will be the molarity of solution which contains 5.85 g of NaCl(s) per 500 mL?

Q10. (a) Calculate the mass of 112 cm^3 of hydrogen at STP.

(b) 9.7×10^{17} atoms of ion weigh as much as 1 cc of H_2 at STP. What is the atomic mass of iron?

Q11. (a) What is the percentage of cation in ammonium dichromate?

(b) Calculate the number of moles of oxygen present in 1 L of air under standard conditions, if air contains 21% oxygen.

Q12. (a) Calculate the total number of electrons present in 2.8 g of nitrogen gas.

(b) How many oxygen atoms contained in 53 g of Na_2CO_3?

Q13. (a) If one atom of an element weighs 1.8×10^{-22} g. What is its atomic mass?

(b) Calculate the mass of $BaCO_3$ produced when excess of CO_2 is bubbled through a solution of 0.205 mol $Ba(OH)_2$.

Q14. What will be the molality of the solution containing 18.25 g of HCl gas in 500 g of water?

Q15. (a) How much copper can be obtained from 100 g of copper sulphate ($CuSO_4$)?

(b) The mass of one litre of oxygen at standard conditions of temperature and pressure is 1.43 g and that of one litre of SO_2 is 2.857 g. What is the mass in grams of a single molecule of SO_2?

(c) Hydrogen gas is prepared in the laboratory by reacting dilute HCl with granulated zinc, following reaction takes place:

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

Calculate the volume of hydrogen gas liberated at STP when 32.65 g of zinc reacts with HCl. [Atomic mass of zinc is 65.34]

Q16. (a) A gas is found to have a formula $(CO)_x$. Its vapour density is 70. What is the value of x?

(b) For the reaction, $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$, what is the volume of carbon monoxide required to reduce one mole of ferric oxide?

(c) Calculate the amount of H_2S required to precipitate 1.69 g BaS from $BaCl_2$ solution.

Q17. In an organic compound, C, H and N are present in 9 : 1 : 3.5 ratio by weight. If molecular weight of the compound is 108, then calculate the molecular formula of the compound.

Q18. A compound containing sodium, sulphur, hydrogen and oxygen gave the following result on analysis : Na = 14.28%, S = 9.92% and H = 6.20%.

If all the atoms of hydrogen in the compound are present in combination with oxygen as water of crystallisation, what is the structure of the anhydrous compound? The molecular mass of crystalline salt is 322.

Q19. (a) A gaseous hydrocarbon on combustion gives 0.72 g of water and 3.08 g of CO_2. What is the empirical formula of the hydrocarbon?

(b) How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms?

(c) How many moles of electron weigh one kilogram?

Q20. Consider the reaction:

$$MgCO_3(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

What mass of $MgCl_2$ will be formed when 250 mL of 0.76 M HCl reacts with 1000 g $MgCO_3$? Name the limiting reagent. Calculate the number of moles of $MgCl_2$ formed in the reaction.

Q21. (a) If 6.3 g of $NaHCO_3$ are added to 15.0 g of CH_3COOH solution, the residue is found to weigh 18.0 g. What is the mass of CO_2 released in the reaction? Also, find the mass of unreacted reactant, if any.

Consider the chemical reaction involved

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + CO_2 + H_2O$$

(b) The gas has molecular formula $(CH)_n$. If vapour density of the gas is 39, what should be the molecular formula of the compound?

Q22. (a) A sample of nitric acid is 69% by mass an it has a concentration of 15.44 mol L^{-1}. Calculate its density.

(b) Calculate the amount of silver obtained (in g) on strongly heating 2.76 g of Ag_2CO_3.

(c) Calculate the amount of $CuCl_2$ which is required to get 1.0 g of copper after reaction with aluminium. (Cu = 63.5, Cl = 35.5, Al = 27)

Q23. In Ostwald's process for the manufacturing of nitric acid, the first step involves the oxidation of ammonia gas by oxygen gas to give nitric oxide gas and steam. What is the maximum weight of nitric oxide that can be obtained starting only with 10.0 g of ammonia and 20.0 g of oxygen?

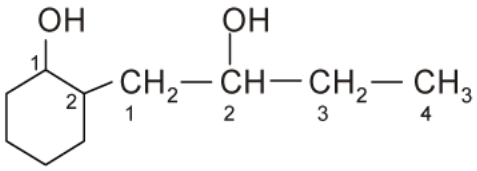
Q24. An organic compound containing carbon and hydrogen has 49.3% carbon, 6.84% hydrogen and its vapour density is 73. What is the molecular formula of the compound?

Q25. (a) An organc compound having molecular mass 60 is found to contain C = 20%, H = 6.67% and N = 46.67% while rest is oxygen. On heating, it gives NH_3 along with a solid residue. The solid residue gives violet colour with alkaline copper sulphate solution. Find out the structure of the compound.

(b) Formic acid is a stronger acid than acetic acid. Why?

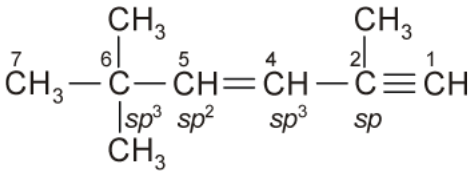
Date: 16/10/2021

S1.



2-(2-hydroxybut-1-yl) cyclohexane-1-ol

S2. Triple bonded carbon atoms are *sp*-hybridised double bonded carbon atoms are: sp^2-hybridised and single bonded carbon atoms are sp^3-hybridised.



S3. Greater the alkylation of an alkene, *i.e.*, greater the number of alkyl groups present around the double bond in an alkene, greater is its stability. Thus, the stability order is

$$\underset{\text{Tetraalkylated ethylene (most stable)}}{R-C=C-R} > R_2C=CHR > RCH=CHR$$

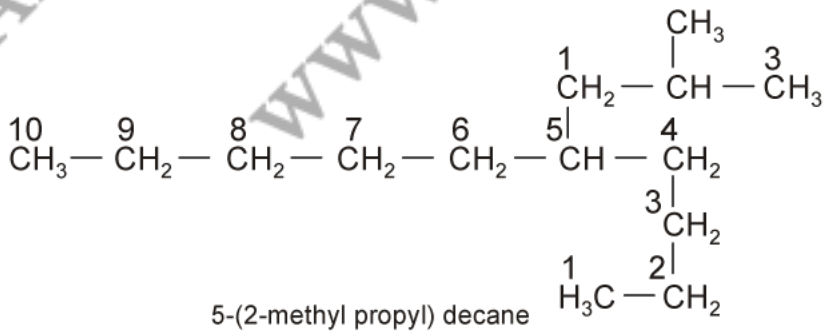
S4. The hydridisation states of carbon in given compouns is:

CH_4	$HC \equiv CH$	$CH_2=CH\ CH_2CH_3$
methane	acetylene	1-butene
sp^3	sp	sp^2
s-character 25%	50%	33.3%

Since, *s*-electrons lie more closer to the nucleus than *p*-electrons. Therefore, as the *s*-character of the orbital makinh C — H bond increases, the electrons of C — H bond lie closer to the carbon. In other words, the partial positive charge of H-atom increases and hence, the acidic character increases as the *s*-character of the orbital increases. Thus, the acidic character decreases in the order:

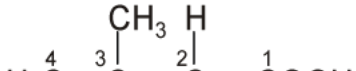
Acetylene, 1-butene, Methane.

S5.



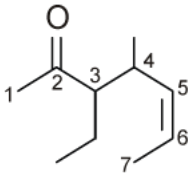
5-(2-methyl propyl) decane

S6.



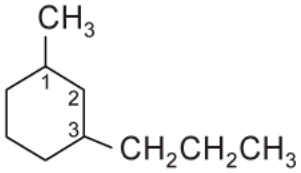
3-methylbut-2-enoic acid

S7.



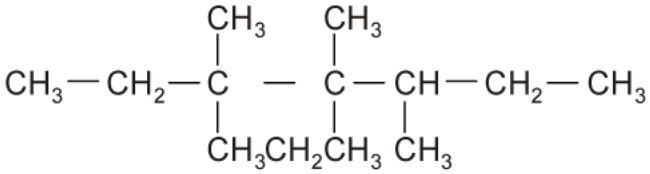
3-methyl-4-methylhept-5-ene-2-one

S8.

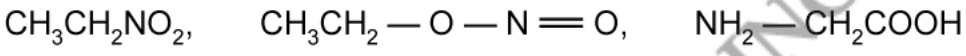


1-methyl-3-propylcyclohexane

S9.

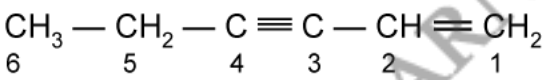


S10. There are three functional isomers whose structures and IUPAC names are:



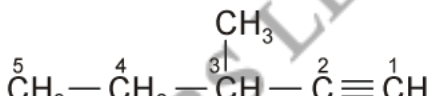
Nitroethane | Ethyl nitrite | 2-aminoethanoic acid

S11.



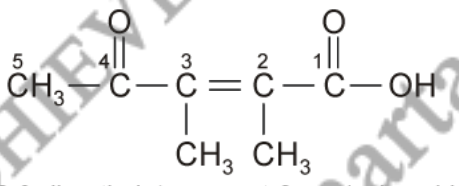
Hex-1-en-3-yne

S12.



3-methyl pent-1-yne

S13.



2,3-dimethyl-4-oxopent-2-en-1-oic acid

S14. Sodium extract is boiled with nitric acid to decompose NaCN and Na_2S, if present,

$$NaCN + HNO_3 \longrightarrow NaNO_3 + HCN\uparrow$$

$$Na_2S + 2HNO_3 \longrightarrow 2NaNO_3 + H_2S\uparrow$$

Otherwise these will react with AgNO3 and hence, will interfere with the test.

$$NaCN + AgNO_3 \longrightarrow AgCN\downarrow + NaNO_3$$

(White ppt.)

$$Na_2S + 2AgNO_3 \longrightarrow Ag_2S\downarrow + 2NaNO_3$$

(Black ppt.)

S15. Diazonium salts ($C_6H_5N_2^-X^-$) readily lose N_2 on heating before reaction with fused sodium metal. Therefore, these do not give positive Lassagne's test for nitrogen.

S16. $\overset{+}{C}H_3$ is the most stable species because the replacement of H by Br increases positive charge on carbon atom and destabilises the species.

S17. When CCl_4 is heated with $AgNO_3$ solution, white precipitate of AgCl is not formed because CCl_4 is a covalent compound, therefore it does not ionise to give Cl^- ions needed for the formation of precipitate of AgCl.

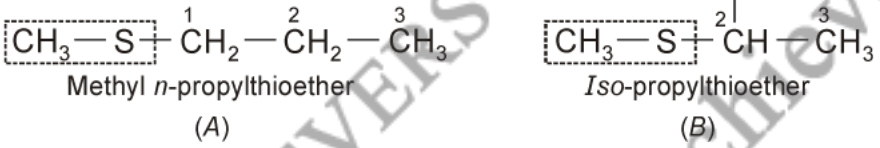
S18. In $CH_2 = CH^-$, the carbon atom carrying the negative charge is sp^2-hybridised while in $HC \equiv C^-$, the carbon atom carrying the negative is sp-hybridised. Since, a sp^2-hybridised carbon is less electronegative than *sp*-hybridised carbon, therefore, $CH_2 = CH^-$ is a better nuecleophile than $HC \equiv C^-$.

S19. $O_2N \leftarrow CH_2 \leftarrow CH_2 \leftarrow$ is more stable than $CH_3 \rightarrow CH_2 \rightarrow O^-$ because — NO_2 group being an electron withdrawing (*i.e.*, – *I*-effect exerting) group tends to disperse the negative charge on the O-atom. In contrast, CH_3CH_2 — being an electron releasing in nature (*i.e.*, + *I*-exeerting group) tends to increase the negative charge on the O-atom and hence, destabilises it.

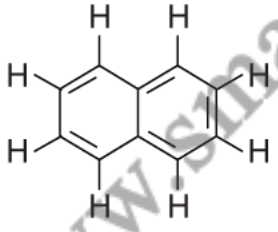
S20. The two isomerswhich differ in the position of the functional group on the carbon skeleton are called position isomers and this phenomenon is known as position isomerism.

Thus, *A* and *B* may be regarded as position isomers and further they cannot be regarded as metamers, since metamers are those isomers which have different number of carbon atoms on either side of the functional group.

But here, the number of carbon atoms on either side of sulphur atom (functional group) are same, *i.e.*, 1 and 3.



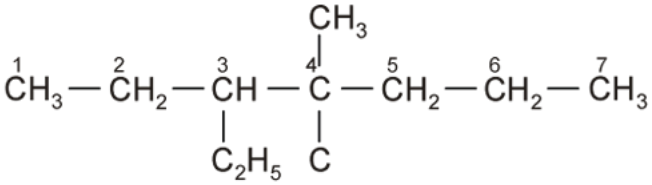
S21. (a) The given compound is



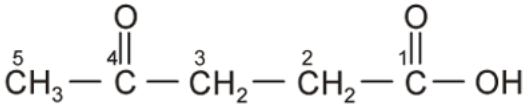
In double bond, there is one σ and one π-bond. Thus, there are 5 π-bonds and 19 σ-bonds (8C — H + 11C — C) are present in the above molecule.

(b) $O_2^{2-} = \sigma 1s^2, \sigma 1s^2, \sigma 2s^2, \overset{*}{\sigma} 2s^2, \sigma 2p_z^2, \pi 2p_x^2 = \pi 2p_y^2, \overset{*}{\pi} 2p_x^2 = \overset{*}{\pi} 2p_y^2$, O_2^{2-} has 8 antibonding and 10 bonding electrons. It has no unpaired electron.

S22.

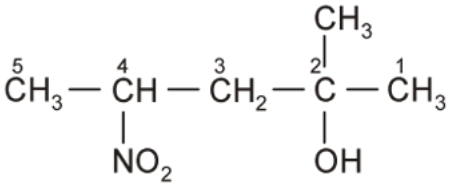
(a) 

3-ethyl-4,4-dimethylheptane

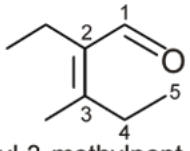
(b) 

4-oxopentanoic acid

S23.

(a) 

2-methyl-4-nitropentane-2-ol

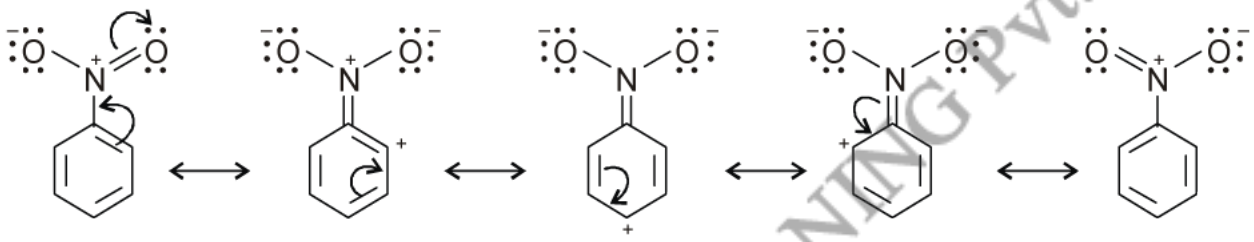
(b) 

20ethyl-3-methylpent-2-en-1-al

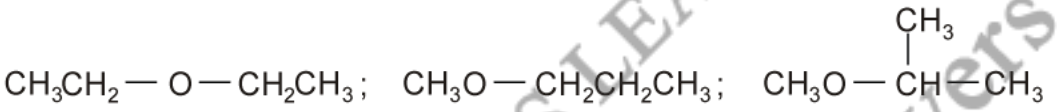
S24. (a) Hyperconjugation occurs through the H-atoms present on the carbon atom next to the double bond, i.e., a-hydrogen atoms. More the number of such a-hydrogen atoms, more the number of hyperconjugative structures and hence, greater is the inductive effect. Thus, increasing order of hyperconjugation is

$$CH_3- < CH_3CH_2 < (CH_3)_2CH- < (CH_3)_3C-$$

(b) Resonance structures of $C_6H_5NO_2$



S25. Two position isomers (I and II) of diethyl ther are possible:



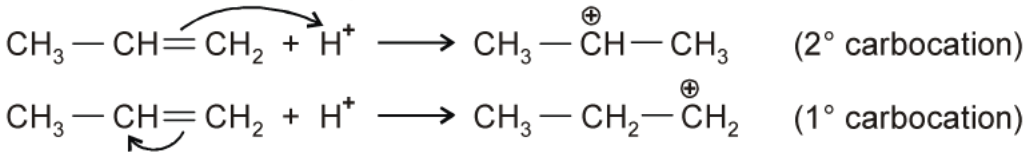
Diethyl ether | 1-methyl propane (i) | 2-ethyl propane (ii)

Both these (I and II) can also be regarded as metamers of diethl ether because these differ in the number of C-atoms on either side of ethereral oxygen.

S26. For testing sulphur, the sodium extract is acidified with acetic acid because lead acetate is soluble and does not interfere with the test. If H_2SO_4 was used, lead acetate itself will react with H_2SO_4 to form white precipitate of lead sulphate which will interfere with the test.

$$\underset{\text{Lead acetate}}{Pb(OCOCH_3)_2} + H_2SO_4 \longrightarrow \underset{\text{(White ppt.)}}{PbSO_4\downarrow} + 2CH_3COOH$$

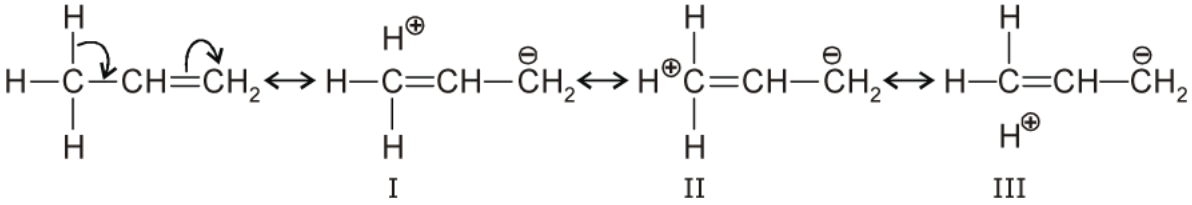
S27. (a) When electrophile attacks on $CH_3-CH=CH_2$, delocalisation of electrons can take place in two possible ways:



As 2° carbocation is more stable than 1° carbocation, thus first addition is more feasible.

Hence, 2° carbocation is the reactive intermediate formed in the first step of the given reaction.

(b) Hyperconjugation is the delocalisation of sigma electron also known as sigma-pi conjugation. Presence of α-H with respect to double bond, triple bond or carbon containing positive charge (in carbonium ion) or unpaired electron (in free radical) is a condition for hyperconjugation.



I II III

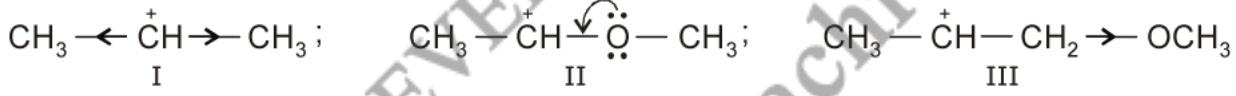
Structures I, II and III are hyperconjugative structures of propene

S28. (a) The pour resonance structures can be drawn for the given compound which are following

(b) In $R-\overset{+}{N}\equiv C^-$ although N has a +ve charge but it cannot accept a pair of electrons as it has already 8 electons in their valence shell and cannot expand its valence shell beyond 8 due to the absence of *d*-orbitals. Therefore, it cannot act as an electrophile. However, due to the presence of a –ve charge on carbon, it can easily donate a pair of electrons and hence, can act as a nucleophile.

S29. (a) – *I*-effect of Cl atom disperses the –ve charge and hence, more stable is the species. Thus, $\overset{\oplus}{C}Cl_3$ is the most stable species.

(b) Stability of the given carbocations can be understood as:



I II III

– *I*-effect of the two methyl groups stabilises carbocation I

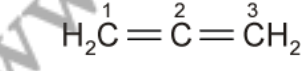
Strong +*R*-effect of — OCH_3 group stabilises carbocation II

– *I*-effect of — OCH_3 group destabilises the carbocation III

Hence, the stability of carbocations decreases in the order as:

II > I > III

S30. (a) The given structure of allene (C_3H_4) is



In allene, carbon atoms 2 and 3 are sp^2-hybridised as each one of them is joined by a double bond. And, carbon atom 2 is *sp*-hybridised as it has two double bonds at each of its sides.

(b) Carbon (2.5) is more electronegative than magnesium (1.2) therefore, Mg acquires a partial positive charge while carboon attached to it acquires a partial negative charge

$$CH_3 - CH_2 - CH_2 - \overset{-\delta}{C}H_2 \leftarrow \overset{+\delta}{M}g - X$$

(c) The given carbocation has two resonance structures:

Structure (II) is more stable because both the carbon atoms and the oxygen atom have an octet of electrons.

S31. (a) ∵ 100 g alkaloid contain nitrogen = 17.28 g

$$\therefore \quad 162 \text{ g alkaloid contain nitrogen} = \frac{17.28 \times 162}{100} = 27.9 = 28 \text{ g}$$

∵ Atomic weight of nitrogen = 14

$$\therefore \quad \text{Number of atoms of nitrogen present in one molecule of alkaloid} = \frac{28}{14} = 2.$$

(b) Both these structures involve separation of charge and hence, are of high energy. Therefore, they do not contribute substantialy towards the resonance hyrid.

Further, the contribution of structure (I) is lower than that of structure (II) since, C-atom carrying positive charge has only a sextet of electrons.

(c)
$$\% \text{ of chlorine} = \frac{35.5}{143.5} \times \frac{\text{Mass of AgCl}}{\text{Mass of the compound}} \times 100$$

$$= \frac{35.5}{143.5} \times \frac{0.287}{0.099} \times 100 = 71.71\%$$