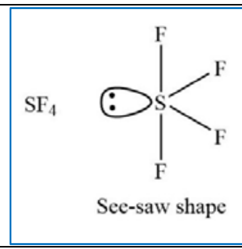
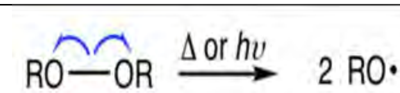
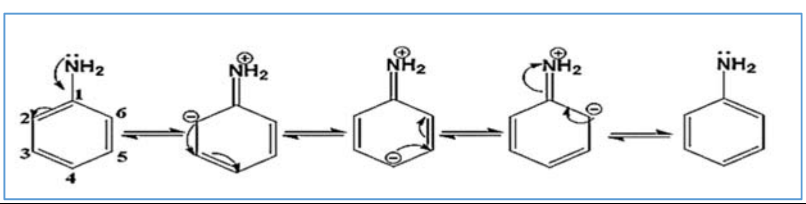
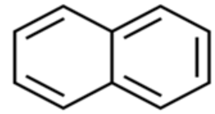
ITL PUBLIC SCHOOL
ANNUAL EXAMINATION (2023-24)

Date: 19.02.24 **Class: XI**

CHEMISTRY (043) – SET A- ANSWERKEY

Time: 3 hrs **M. M: 70**

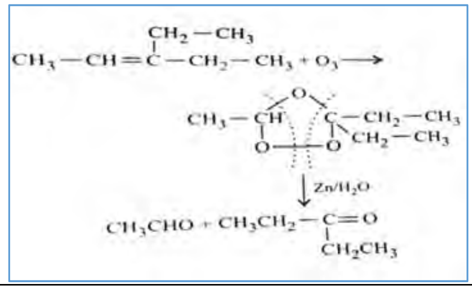
	SECTION – A	
	This section contains 16 questions. There is no internal choice in this section. The following questions are very short answer type carrying 1 mark each.	
1	Name the quantum numbers through which we determine the energy of the orbitals. **Principal quantum number (n)**	1
2	Predict the shape of SF_4 according to VSEPR theory. 	1
3	Predict whether entropy increases/decreases in the following reaction: X_2 (g) → 2X (g). Justify your answer. **The entropy will increase as the number of moles are increasing on going towards product side.**	1
4	For an exothermic reaction, when the temperature of the system is increased, the reaction goes in which direction? Justify. **Backward direction**	1
5	Justify whether the thermal decomposition of calcium carbonate reaction is redox or not? **No, $CaCO_3 \rightarrow CaO + CO_2$ is not a redox reaction because oxidation number of none of the atoms changes.**	1
6	Identify the type of fission -as a homolysis or heterolysis and write the reactive intermediate produced.  **The homolytic fission results in the formation of free radicals.**	1
7	Calculate the number of carbon atoms in 3 g of ethane. (Atomic mass of C = 12 u , H =1 u) **3 g ethane will contain 0.2 mole of carbon atoms (12.046 x 10^{22} atoms of carbon)**	1
8	Write all the four quantum numbers of the 19^{th} electron of copper. (Atomic number of Cu = 29) **$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$ 19^{th} electron will be in 4s orbital with n=4, l=0, m_l=0, m_s=+1/2**	1
9	Out of benzene, nitrobenzene and phenol which will undergo nitration (electrophilic substitution reaction) most easily and why? **Phenol because OH is shows +R effect and activating gp and NO_2− is electron withdrawing and shows -R -effect ie deactivating gp . Therefore, phenol will have the maximum electron density among the three compounds followed by benzene.**	1
10	Aniline acts as ortho and para directing for incoming electrophiles. Explain by showing resonating structures. 	1
11	Identify the reagents shown in bold in the following equations as nucleophiles or electrophiles: (a) CH_3CH_2Cl + **OH^-** → CH_3CH_2OH + Cl^- **nucleophile** (b) C_6H_6 + **Cl^+** → C_6H_5Cl + H^+ **electrophile**	1

12	Is the given species aromatic or non-aromatic? Support your answer with a reason.  **This is aromatic in nature because it follows Huckel's rule as it is a planar molecule with complete conjugation and 10 pi electrons.**	1
	Given below are two statements labeled as Assertion (A) and Reason (R) **Select the most appropriate answer from the options given below:** **(a) Both A and R are true and R is the correct explanation of A.** **(b) Both A and R are true but R is not the correct explanation of A.** **(c) A is true but R is false.** **(d) A is false but R is true.**	
13	**Assertion:** Methane cannot be obtained by Wurtz reaction. **Reason:** Wurtz reaction leads to the formation of symmetrical alkane having an even number of carbon atoms. **(A)**	1
14	**Assertion:** Ethyne is more acidic than propyne. **Reason:** +I effect increases the acidic character on alkynes. **(C)**	1
15	**Assertion:** Smaller the size of an atom, greater is the electronegativity. **(C)** **Reason:** Electronegativity refers to the tendency to gain an electron from an isolated gaseous atom.	1
16	**Assertion:** BCl_3 acts as a Lewis acid. **(A)** **Reason:** BCl_3 can accept a lone pair of electrons from species like ammonia.	1
	SECTION – B	
	This section contains 5 questions with internal choice in one question. The following questions are short answer type and carry 2 marks each.	
17	At what minimum atomic number would a transition from n = 2 to n = 1 energy level result in emission of X-rays with wavelength = 3×10^{-8} m? (given $R_H = 1.1 \times 10^{7}\ m^{-1}$) **Answer** $\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ $\frac{1}{3\times10^{-8}} = 1.1 \times 10^7 z^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$ $z^2 = \frac{4}{3\times10^{-8}\times1.1\times10^7\times3} \Rightarrow z = 2$	2
18	Calculate Δ_rG^0 for conversion of oxygen to ozone, 3/2 O_2 (g) → O_3 (g) at 298 K. if K_p for this conversion is 2.47×10^{-29} at 298 K. (log 2.47= 0.39 , R= 8.314 J $K^{-1}mol^{-1}$) **Answer** The correct option is A 163.23 kJ Given : T = 298 K, $K_p = 2.47 \times 10^{-29}(atm)^{-\frac{1}{2}}$ We know the relation, $\Delta G^\circ = -2.303\ RT \log_{10} K_p$ $= -2.303 \times 8.314 \times 298 \times \log 2.47 \times 10^{-29}$ $= 5705.848 \times \log 2.47 \times 10^{-29}$ $= 5705.848 \times (-29 + \log 2.47$ $= 5705.848 \times (-29 + 0.3926$ = 163229 J = 163.229 kJ = 163.23 kJ	2
19	Which of the following will produce **only ketones** on ozonolysis followed by hydrolysis? **2-methyl but-2-ene; 2,3 dimethyl but -2 -ene** Also, give the reaction and name of products formed. **OR** An alkene **'A'** on ozonolysis gives a mixture of ethanal and pentan-3-one. Write structure and IUPAC name of **'A'**.	2

Answer: 2,3 dimethyl but -2 –ene will only produce ketones and will produce 2 moles of acetone.

OR

A is 3-Ethylpent-2-ene



20 $CaCO_3$ reacts with aqueous HCl to give $CaCl_2$ and CO_2 according to the reaction- (2)

$$CaCO_3\,(s) + 2\,HCl\,(aq) \rightarrow CaCl_2\,(aq) + CO_2\,(g) + H_2O\,(l)$$

What moles of $CaCO_3$ is required to react completely with 50 mL of 0.2 M HCl?

Answer

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

molarity $= \dfrac{\text{moles}}{\text{Volume(L)}}$

moles of HCl $= \dfrac{50}{1000} \times \dfrac{0.2}{1} = 0.01$ moles

According to stoichiometry, 1 mole of $CaCO_3 \equiv$ 2 moles of HCl

so 0.01 moles of HCl $\equiv \dfrac{0.01}{2}$ moles of $CaCO_3$

$= 0.005$ moles

21 Using M.O. Theory, compare the bond lengths and magnetic character of O_2 and O_2^{2-} (2)

O_2 = 16 electrons, paramagnetic in nature with bond order = (10-6)/2=2

O_2^{2-} = 18 electrons, diamagnetic in nature with bond order = (10-8)/2=1

O_2^{2-} will have more bond length

SECTION – C

This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.

22 A solution contains 50 % solute (by mass) with molar mass 200 g/mol, and the density of the solution is 1.2 g/mL. Calculate the molarity and molality of the solution. (3)

50% solute (by mass) means 50g solute is dissolved in 100g solution

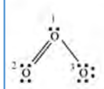
mass of solvent = 100g − 50g = 50g

density of solution = $\dfrac{\text{mass}}{\text{volume}}$

ie 1.2 g/mL $= \dfrac{100\text{ g}}{\text{volume}}$ so volume $= \dfrac{100}{1.2}$ mL

molarity $= \dfrac{50 \times 1.2 \times 1000}{200 \times 100} = 3$ Molar

molality $= \dfrac{50 \times 1000}{200 \times 50} = 5$ molal

23	(a) Predict hybridization of P in PCl_5 molecule. **sp^3d** (b) Justify that BH_3 is non-polar while NH_3 is polar. **As all the bonds in BH_3 cancel out the dipole of each other but this is not the case in NH_3 due to the presence of lone pair on it.** (c) Calculate the formal charge on all the atoms of ozone molecule. **Answer** Lewis structure of O_3 is  F.C on the O-1 atom $= 6 - 2 - \frac{1}{2}(6) = +1$ F.C on the O-2 atom $= 6 - 4 - \frac{1}{2}(4) = 0$ F.C on the O-3 atom $= 6 - 6 - \frac{1}{2}(2) = -1$	1x3
24	(a) State Heisenberg's uncertainty principle. **Heisenberg's uncertainty principle states that it is impossible to measure or calculate exactly both the position and the momentum of an object.** (b) If the position of the electron is measured with an accuracy of 0.002 nm, calculate the uncertainty in the momentum of electron. (Planck's constant = 6.626×10^{-34} Js ; mass of electron = 9.1×10^{-31} Kg). **Answer** By applying the uncertainty principle, $\Delta P = \frac{h}{4\pi\Delta x} = \frac{6.626 \times 10^{-34}}{4 \times 3.1416 \times 0.002 \times 10^{-9}} = 2.63 \times 10^{-23}$ kg m/s	1+2
25	The reaction between gaseous sulfur dioxide and oxygen is a key step in the industrial synthesis of sulfuric acid: $2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$ A mixture of SO_2 and O_2 was maintained at 800 K until the system reached equilibrium. The equilibrium mixture contained 5.0×10^{-2} M SO_3, 2.5×10^{-3} M O_2, and 2.0×10^{-3} M SO_2. Calculate Kc and Kp at this temperature. (R = 0.0821 L atm K^{-1} mol^{-1}) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ at equilibrium $[SO_3] = 5 \times 10^{-2}$ $[O_2] = 2.5 \times 10^{-3}$ $[SO_2] = 2 \times 10^{-3}$ $K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{(5 \times 10^{-2})^2}{(2 \times 10^{-3})^2(2.5 \times 10^{-3})}$ $= 2.5 \times 10^5$ $K_p = K_c(RT)^{2-3} = K_c(RT)^{-1}$ $K_p = \frac{2.5 \times 10^5}{0.0821 \times 800} = 3.806 \times 10^3$	3
26	(a) Arrange in increasing order of acidic character CH_3COOH, FCH_2COOH, $ClCH_2COOH$. **$CH_3COOH < ClCH_2COOH < FCH_2COOH$** (b) Write the positional isomers of C_4H_9OH. **Butan-1-ol and butan-2-ol** **(c)** What happens when 2-chlorobutane is treated with alcoholic KOH? Write the reaction involved. **But-2-ene forms as a major product (1/2) reaction (1/2)**	1x3
27	(a) Which of the following species, do not show disproportionation reaction and why? ClO^-, ClO_2^-, ClO_3^- and ClO_4^- **ClO_4^- will not show disproportionation reaction as it is in +7 oxidation state.** (b) Balance the following equation in the acidic medium- $Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$	1+2

Answer

$MnO_4^- + Fe^{2+} \rightarrow Fe^{3+} + Mn^{2+}$

$[Fe^{2+} \rightarrow Fe^{3+}] \times 5$ ...(i)

$8H^+ + MnO_4^- > Mn^{2+} + 4H_2O$ ...(ii)

Adding (i) and (ii), we get

$5Fe^{2+} + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$

OR

(a) Predict which one out of P and Q is a better oxidizing agent if $E^o_{P2+/P} = +2.34V$ and $E^o_{Q2+/Q} = +3.65V$. Also give reason for the same.

Q is a better oxidizing agent as it undergoes reduction easily.

(b) Balance the given ionic equations as per the medium given below:

$Br^- + Cr_2O_7^{2-} \rightarrow Cr^{3+} + BrO_3^-$ (acidic medium)

$\overset{-1}{Br^-} + \overset{+6}{Cr_2O_7^{-2}} \longrightarrow \overset{+5}{BrO_3^-} + Cr^{+3}$

OHR :- $Br^- + 3H_2O \longrightarrow BrO_3^- + 6H^+ + 6e^-$ —(1)

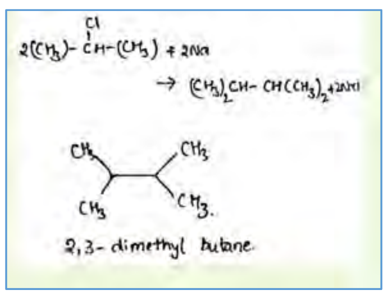
RHR :- $Cr_2O_7^{-2} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$ —(2)

Adding eq (1) and (2)

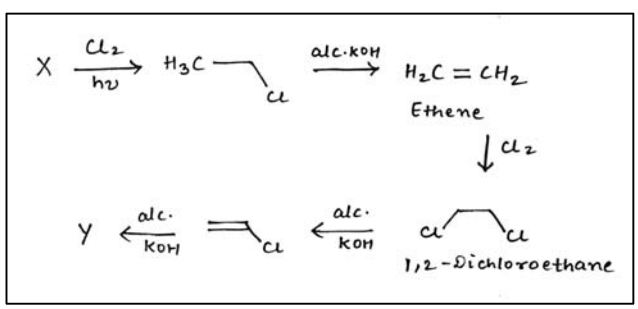
$Cr_2O_7^{-2} + Br^- + 8H^+ \longrightarrow 2Cr^{3+} + BrO_3^- + 4H_2O$

28 (a) Give the reaction of 2-chloropropane with Na and dry ether. Also write the IUPAC name of the product formed. 1+2

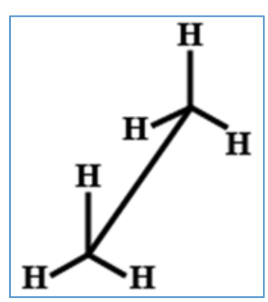
Answer



(b) Draw the least stable sawhorse conformation of X. Give one chemical test to distinguish between X and Y.



Answer: Least stable conformation of ethane is eclipsed.
X is ethane and Y is ethyne.
It can be distinguished using Bromine water test. Ethane will not give this test and ethyne will decolorize the bromine water



	SECTION – D	
	The following questions are case-based questions. Each question has an internal choice and carries 4 marks (1+1+2) each. Read the passage carefully and answer the questions that follow.	
29	There are many observable patterns in the physical and chemical properties of elements as we descend in a group or move across a period in the Periodic Table. For example, within a period, chemical reactivity tends to be high in Group 1 metals, lower in elements towards the middle of the table, and increases to a maximum in the Group 17 non-metals. Likewise within a group of representative metals (say alkali metals) reactivity increases on moving down the group, whereas within a group of non-metals (say halogens), reactivity decreases down the group. But why do the properties of elements follow these trends? And how can we explain periodicity? To answer these questions, we must look into the theories of atomic structure and properties of the atom. **Answer the following questions-** (a) Arrange the following in their decreasing order of size- Na^{+} , F^{-}, Al^{3+}, N^{3-} **$Al^{3+} < Na^{+} < F^{-} < N^{3-}$** (b) According to IUPAC conventions, what will be the name of the element with atomic number 115? **Ununipentium (Uup)** (c) Nitrogen has positive electron gain enthalpy whereas oxygen has negative. However, oxygen has lower ionization enthalpy than nitrogen. Explain. **Nitrogen has stable configuration because p - orbital is half - filled. Therefore addition of extra electron to any of the p orbital requires energy.** **and Oxygen has $2p^4$ electrons so process of adding an electron to the p- orbital is exothermic.** **Oxygen has lower ionisation enthalpy than nitrogen because by removing one electron from 2p - orbital oxygen acquires stable configuration, i.e.,$2p^3$ On the other hand, in case of nitrogen it is not easy to remove one of the three 2p - electrons due to its stable configuration.** **OR** (c) Among the elements- O, F, Cl, Ne (i) which has the most negative electron gain enthalpy? **Chlorine** (ii) which has the highest positive electron gain enthalpy? **Neon** Give reasons for both .	1+1+2
30	All substances that conduct electricity in aqueous solutions are called electrolytes. Acids, bases and salts are electrolytes and the conduction of electricity by their aqueous solutions is due to anions and cations produced by the dissociation or ionization of electrolytes in aqueous solution. The strong electrolytes are completely dissociated. In weak electrolytes there is equilibrium between the ions and the unionized electrolyte molecules. According to Arrhenius, acids give hydrogen ions while bases produce hydroxyl ions in their aqueous solutions. Bronsted-Lowry on the other hand, defined an acid as a proton donor and a base as a proton acceptor. When a Bronsted-Lowry reacts with a base, it produces its conjugate base and a conjugate acid corresponding to the base with which it reacts. Thus a conjugate pair of acid-base differs only by one proton. **Answer the following questions :-** (a) Write the conjugate base of H_2S. **HS^{-}** (b) Give one example showing the application of 'Common ion effect'. **The dissociation of H_2S slows down in the presence of HCl.** (c) The concentration of weak acid HF is 0.01M. Calculate its pH if ionization constant of HF is 3.6×10^{-5}.	1+1+2

$HF \longrightarrow H^+ + F^-$

$0.01\,m \quad 0 \quad 0$

at equi. $\quad 0.01 - x \quad x \quad x$

$3.6 \times 10^{-5} = \frac{x^2}{0.01 - x}$

$\simeq 3.6 \times 10^{-5} = \frac{x^2}{0.01}$

$\boxed{x = 6 \times 10^{-4}\,m}$

$[H^+] = 6 \times 10^{-4}\,m$

$pH = -\log(6 \times 10^{-4}) = 3.222$

OR

(c) The solubility of $Fe(OH)_3$ is 0.001 M at 298 K. Calculate its Ksp.

Answer

$Fe(OH)_3 \longrightarrow Fe^{3+} + 3OH^-$

$s \qquad 3s$

$K_{sp} = (s)(3s)^3 = 27s^4 = 27(0.001)^4$

$= 27(10^{-3})^4$

$K_{sp} = 27 \times 10^{-12}$

SECTION – E

The following questions are long answer type and carry 5 marks each. All questions have an internal choice.

31 (a) Calculate the enthalpy change for the process :- (3+2)

$$CCl_4\,(g) \rightarrow C\,(g) + 4\,Cl\,(g)$$

$\Delta_{vap}H^o(CCl_4) = 30.5\ kJ\ mol^{-1}$ ($\Delta_{vap}H^o$ is enthalpy of vaporisation)

$\Delta_f H^o\,(CCl_4) = -135.5\ kJ\ mol^{-1}$ ($\Delta_f H^o$ is enthalpy of formation)

$\Delta_a H^o\,(C) = 715.0\ kJ\ mol^{-1}$ ($\Delta_a H^o$ is enthalpy of atomisation)

$\Delta_a H^o\,(Cl_2) = 242\ kJ\ mol^{-1}$

Answer

The chemical equations implying to the given values of enthalpies are:

(i) $CCl_{4(l)} \longrightarrow CCl_{4(g)}\ \Delta_{vap}H^\theta = 30.5\ kJ\ mol^{-1}$

(ii) $C_{(s)} \longrightarrow C_{(g)}\ \Delta_a H^\theta = 715.0\ kJ\ mol^{-1}$

(iii) $Cl_{2(g)} \longrightarrow 2Cl_{(g)}\ \Delta_a H^\theta = 242\ kJ\ mol^{-1}$

(iv) $C_{(g)} + 4Cl_{(g)} \longrightarrow CCl_{4(g)}\ \Delta_f H = -135.5\ kJ\ mol^{-1}$

Enthalpy change for the given process $CCl_{4(g)} \longrightarrow C_{(g)} + 4Cl_{(g)}$, can be calculated using the following algebraic calculations as:

Equation (ii) + 2 × Equation (iii) – Equation (i) – Equation (iv)

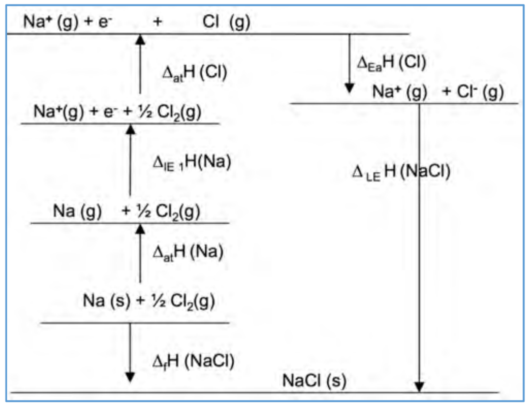
$\Delta H = \Delta_a H^\theta(C) + 2\Delta_a H^\theta(Cl_2) - \Delta_{vap}H^\theta - \Delta_f H$

$= (715.0\ kJ\ mol^{-1}) + 2(242\ kJ\ mol^{-1}) - (30.5\ kJ\ mol^{-1}) - (-135.5\ kJ\ mol^{-1})$

$\therefore \Delta H = 1304\ kJ\ mol^{-1}$

(b) Draw the born haber cycle of NaCl (s)

Answer



OR

(a) Calculate the standard enthalpy of formation of methanol from the given data:

Standard enthalpy of Combustion of methanol = - 726 kJ mol^{-1}

Standard enthalpy of formation of carbon dioxide = -393 kJ mol^{-1}

Standard enthalpy of formation of water = -286 kJ mol^{-1}.

Answer

The reaction that takes place during the formation of $CH_3OH_{(l)}$ can be written as:

$C_{(s)} + 2H_2O_{(g)} + \frac{1}{2}O_{2(g)} \longrightarrow CH_3OH_{(l)}$ (1)

The reaction (1) can be obtained from the given reactions by following the algebraic calculations as:

Equation (ii) + 2 × equation (iii) – equation (i)

$\Delta_f H^\theta [CH_3OH_{(l)}] = \Delta_c H^\theta + 2\Delta_f H^\theta [H_2O_{(l)}] - \Delta_r H^\theta$

$= (-393 \text{ kJ mol}^{-1}) + 2(-286 \text{ kJ mol}^{-1}) - (-726 \text{ kJ mol}^{-1})$

$= (-393 - 572 + 726) \text{ kJ mol}^{-1}$

$\therefore \Delta_f H^\theta [CH_3OH_{(l)}] = -239 \text{ kJ mol}^{-1}$

(b) Find out the internal energy change (ΔU) for the reaction A (l) → A (g) at 373 K. Heat of vaporisation (ΔH) is 40.66 kJ/mol. (R= 8.3 J K^{-1} mol^{-1})

Answer :

$A(l) \rightarrow A(g)$

so, $\Delta n_g = n_p - n_r = 1 - 0 = 1$

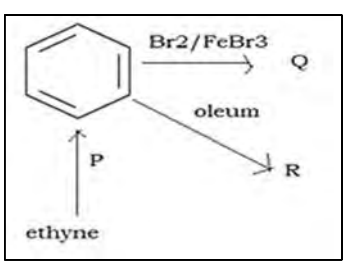
$\Delta H = \Delta U + \Delta n_g RT$

$\Delta U = \Delta H - \Delta n_g RT$

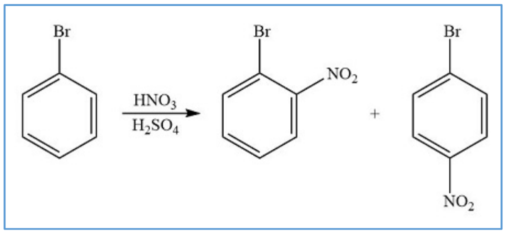
$= 40660 - 1 \times 8.3 \times 373 = 40660 - 3095.9 = 37564$ J/mol

$\Delta U = 37.56$ kJmol^{-1}

32 (a) Identify the variables P, Q and R. What product is obtained when Q is treated with nitrating mixture? 2+1+2



Answer : P is red hot Fe tube at 873 K, R is benzene sulphonic acid and Q is bromobenzene reaction of Q with nitrating mixture-



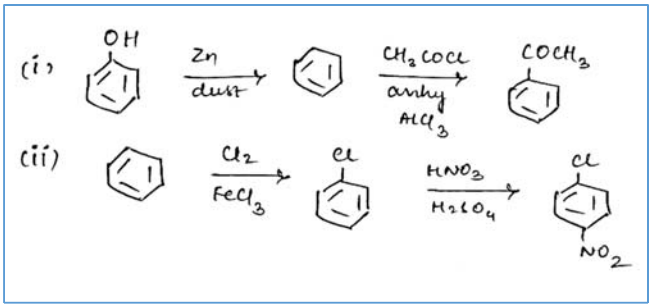
(b) On addition of HBr to Propene, Z is formed as a major product. Identify Z and give the reaction.

Z is 2-bromopropane.

(c) Convert

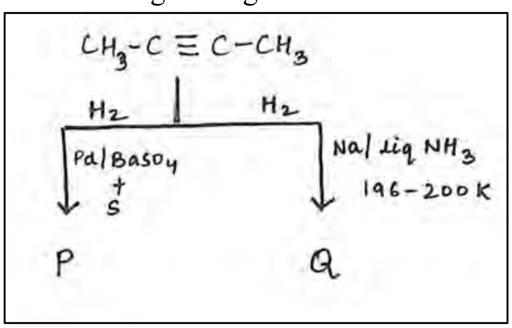
(i) Phenol to acetophenone

(ii) Bezene to para-chloronitrobenzene



OR

(a) Consider the reaction in given figure and answer the following questions:



(i) Identify the variables P and Q.

P is cis-But-2-ene and Q is trans-But-2-ene

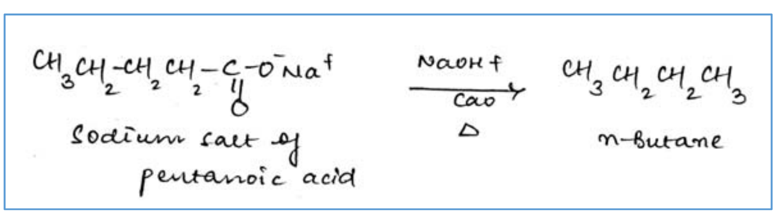
(ii) P and Q show what type of stereoisomerism?

Geometrical isomerism

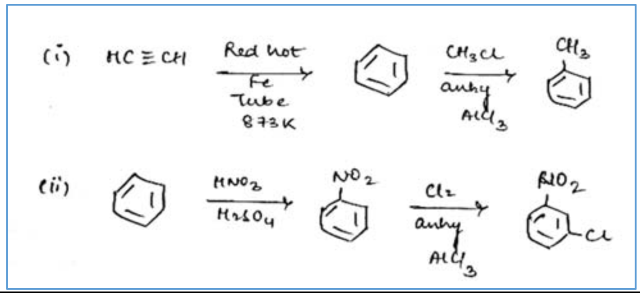
(iii) Out of P and Q, which one has a higher boiling point and why?

Boiling point of cis-But-2-ene is higher than trans isomer because cis isomers are polar and hence they have strong intermolecular forces between the molecules.

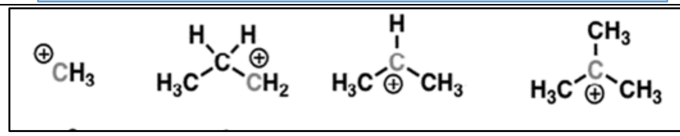
(b) Sodium salt of which acid will produce n-butane using decarboxylation method? Give reaction.



(c) Convert
(i) Ethyne to Toluene
(ii) Benzene to meta-chloronitrobenzene

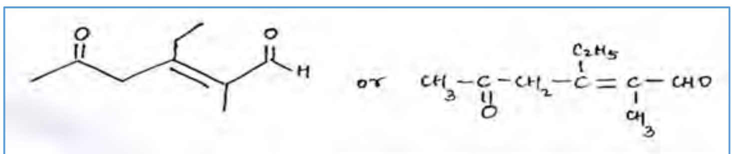


33 (a) Arrange the following carbocations in decreasing order of stability. Explain the reason using inductive effect. 2+1+2

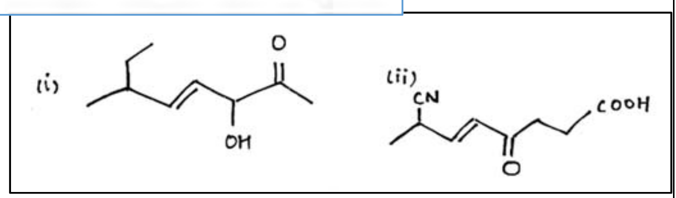


$(CH_3)_3C^+$ > $(CH_3)_2CH^+$ > $(CH_3)CH_2^+$ > CH_3^+
As the tertiary carbocations are more stabilized due to +I effect. The methyl groups increase the electron density on the carbon atom having positive charge, thus making it more stabilized.

(b) Draw the structure of 3-ethyl-2-methyl-5-oxo hex-2-enal.



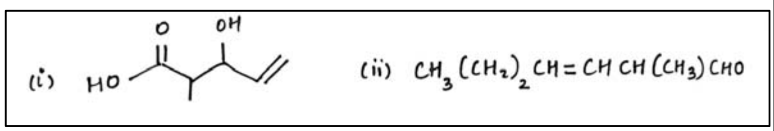
(c) What is the IUPAC name of the given organic compounds-



(i) 3-Hydroxy-6-methyloct-4-en-2-one
(ii) 7-Cyano-4-oxooct-5-en-1-oic acid

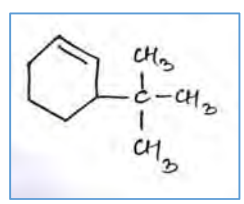
OR

(a) What is the IUPAC name of the given organic compounds -

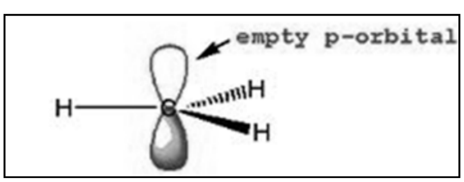


(i) 3-Hydroxy-2-methylpent-4-en-1-oic acid
(ii) 2-Methylhept-3-en-1-al

(b) Draw the structure of 3-tert-butylcyclohex-1-ene.



(c) Identify and give any one characteristic property of the given species:



What happens to the stability of above species if one H is replaced by methyl group.

The given species is methyl carbocation i.e. CH_3^+. The shape of this species is trigonal planar.
If one of the H atom is replaced with methyl group then the stability of the resulting species will be increased due to inductive effect.