Sample Question Paper - 13
Chemistry (043)
Class- XII, Session: 2021-22
TERM II

Time allowed : 2 hours   *Maximum marks : 35*

General Instructions :

Read the following instructions carefully.

1. *There are 12 questions in this question paper with internal choice.*
2. *SECTION A - Q. No. 1 to 3 are very short answer questions carrying 2 marks each.*
3. *SECTION B - Q. No. 4 to 11 are short answer questions carrying 3 marks each.*
4. *SECTION C - Q. No. 12 is case based question carrying 5 marks.*
5. *All questions are compulsory.*
6. *Use of log tables and calculators is not allowed.*

SECTION - A

1. (a) What is electrode potential?

   (b) In an aqueous solution how does specific conductivity of electrolytes change with addition of water?

2. Write structures of different isomers corresponding to the molecular formula, C_3H_9N. Write IUPAC name of the isomers which will liberate nitrogen gas on treatment with nitrous acid.

3. Arrange the following in decreasing order of their acidic strength. Give explanation for the arrangement. C_6H_5COOH, FCH_2COOH, O_2NCH_2COOH

SECTION - B

4. (a) Predict which of the following will be coloured in aqueous solution? Ti^{3+}, V^{3+}, Cu^+, Sc^{3+}, Mn^{2+}, Fe^{3+} and Co^{2+}. Give reasons for each.

   (b) Explain briefly how +2 state becomes more and more stable in the first half of the first row transition elements with increasing atomic numbers?

<div align="center">OR</div>

   How would you account for the following?

   (a) Of the d^4 species, chromium(II) is strongly reducing while manganese(III) is strongly oxidising.

   (b) Cobalt(II) is stable in aqueous solution but in the presence of complexing reagents it is easily oxidised.

5. Write down the IUPAC name for each of the following complexes and indicate the oxidation state, electronic configuration and coordination number. Also give stereochemistry and magnetic moment of the complex :

   (a) $K[Cr(H_2O)_2(C_2O_4)_2].3H_2O$

   (b) $[Co(NH_3)_5Cl]Cl_2$

6. What are the differences between multimolecular and macromolecular colloids? Give one example of each. How are associated colloids different from these two types of colloids?

OR

Mention any three factors which influence the adsorption of a gas on a solid.

7. Account for the following :
   (a) pK_b of aniline is more than that of methylamine.
   (b) Ethylamine is soluble in water whereas aniline is not.
   (c) Aniline does not undergo Friedel–Crafts reaction.

8. (a) $[Cr(NH_3)_6]^{3+}$ is paramagnetic while $[Ni(CN)_4]^{2-}$ is diamagnetic. Why?
   (b) Arrange the following complexes in the increasing order of conductivity of their solution :
       $[Co(NH_3)_3Cl_3]$, $[Co(NH_3)_4Cl_2]Cl$, $[Co(NH_3)_6]Cl_3$, $[Cr(NH_3)_5Cl]Cl_2]$

   OR

   (a) Arrange following complex ions in increasing order of crystal field splitting energy (Δ_o) :
       $[Cr(Cl)_6]^{3-}$, $[Cr(CN)_6]^{3-}$, $[Cr(NH_3)_6]^{3+}$.
   (b) Why are low spin tetrahedral complexes not formed?
   (c) $CuSO_4.5H_2O$ is blue in colour while $CuSO_4$ is colourless. Why?

9. Predict the product of electrolysis in each of the following:
   (i) An aqueous solution of $AgNO_3$ with silver electrodes.
   (ii) An aqueous solution of $AgNO_3$ with platinum electrodes.
   (iii) A dilute solution of H_2SO_4 with platinum electrodes.

10. (a) Write the main product in the following equations :
    (i) $CH_3-\underset{\underset{O}{\|}}{C}-CH_3 \xrightarrow{LiAlH_4}$?

    (ii) [benzaldehyde with CHO group] $\xrightarrow[273-283K]{HNO_3/H_2SO_4}$?
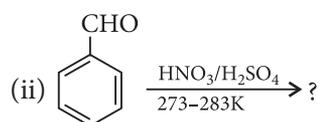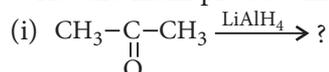
    (b) Write the structure of 2-methylbutanal.

    OR

    Describe the following:
    (a) Acetylation
    (b) Cannizzaro reaction
    (c) Decarboxylation

11. (a) Write chemical equations for the following reactions :
    (i) Propanone is treated with dilute $Ba(OH)_2$.
    (ii) Acetophenone is treated with Zn(Hg)/Conc. HCl
    (b) Draw the structure of hemiacetal of ethanol.

SECTION - C

12. Read the passage given below and answer the questions that follow.

For the reaction : $3A_{(g)} + B_{2(g)} \rightarrow A_3B_{2(g)}$, the following data were collected. All the measurements were

Experiment No.	Initial $[A]$ (M)	Initial $[B_2]$ (M)	Initial rate of disapp. of B_2 (M/min)
1.	0.15	0.15	0.60
2.	0.15	0.30	1.20
3.	0.30	0.15	2.40
4.	0.25	0.25	?

(a) Predict the molecularity of above reaction.

(b) Determine the rate law expression of the given reaction.

(c) Determine the overall order of the reaction.

(d) What is the rate constant of the given reaction?

OR

What will be the initial rate of disappearance of B_2 in the fourth experiment?

1. (a) The electrical potential difference set up between the metal and its ions in the solution is called electrode potential. It is also defined as the tendency of an electrode to lose or gain electrons when it is in contact with solution of its own ions.

(b) Specific conductivity decreases because number of ions per unit volume decreases by addition of water or dilution.

2. In all, four structural isomers are possible. These are as follows :

Primary amines : $CH_3CH_2CH_2NH_2$
Propan-1-amine

$CH_3—CH—CH_3$
|
NH_2
Propan-2-amine
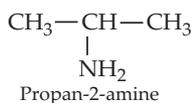
Secondary amines : $CH_3 — NH — C_2H_5$
N-Methylethanamine

CH_3
|
Tertiary amines : $CH_3 — N — CH_3$
N,N-Dimethylmethanamine

Only primary amines react with HNO_2 to liberate N_2 gas.

$CH_3CH_2CH_2NH_2 + HNO_2 \longrightarrow$
Propan-1-amine

$CH_3CH_2CH_2OH + H_2O + N_2$
Propan-1-ol
(major product)

$\underset{CH_3}{\overset{CH_3}{>}}CH—NH_2 + HNO_2 \longrightarrow \underset{CH_3}{\overset{CH_3}{>}}CHOH + N_2 + H_2O$
Propan-2-amine Propan-2-ol
(major product)
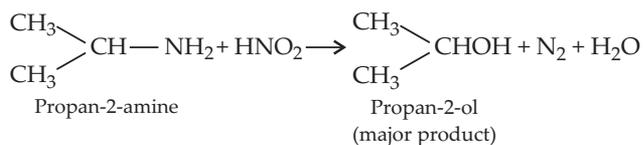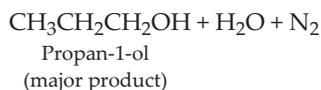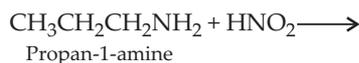
3. $O_2NCH_2COOH > FCH_2COOH > C_6H_5COOH$

An electron withdrawing group increases the acidic strength of acid by withdrawing electrons and making the release of proton easier.

$-I$-effect of $—NO_2$ is greater than $—F$ and $C_6H_5 —$ group has weak $-I$-effect

4. (a) The configuration of the given metal ions can be given as

Ti^{3+}	$– 3d^1 4s^0$	1 unpaired electron
V^{3+}	$– 3d^2 4s^0$	2 unpaired electrons
Cu^+	$– 3d^{10}4s^0$	No unpaired electron
Sc^{3+}	$– 3d^0 4s^0$	No unpaired electron
Mn^{2+}	$– 3d^5 4s^0$	5 unpaired electrons
Fe^{3+}	$– 3d^5 4s^0$	5 unpaired electrons
Co^{2+}	$– 3d^7 4s^0$	3 unpaired electrons

Out of these only Cu^+ and Sc^{3+} are colourless. All other ions are coloured due to presence of unpaired electrons.

(b) With increasing atomic number the effective nuclear charge increases after losing two electrons from s-orbital. The ionic size decreases which results in more stability. The stability is less in the beginning due to too few electrons to lose or share.

OR

(a) Both Cr^{2+} and Mn^{3+} have d^4 configuration, Cr^{2+} is reducing since its configuration is converted to d^3 from d^4. d^3 has half-filled t_{2g} configuration with higher stability. Mn^{3+} is oxidising since in changing from d^4 to d^5 the configuration becomes half filled which has extra stability.

(b) Co(II) gets oxidised to Co(III) in presence of complexing agent because Co(III) is more stable than Co(II). Most of the strong field ligands cause pairing of electrons forming diamagnetic octahedral complexes which are very stable due to very large crystal field stabilization energy.

5. (a) $K[Cr(H_2O)_2(C_2O_4)_2]\cdot3H_2O$

Potassiumdiaquadioxalatochromate(III) hydrate

Oxidation state = +3

C.N. = 6,

Configuration = t_{2g}^3
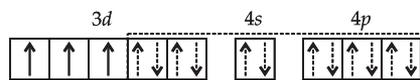
d^2sp^3 hybridisation, octahedral shape, paramagnetic in nature

$\mu = \sqrt{n(n+2)} = \sqrt{3\times5} = \sqrt{15} = 3.87$ B.M.

(b) $[Co(NH_3)_5Cl]Cl_2$

Pentaamminechloridocobalt(III) chloride

$Co(27) : 3d^7 4s^2$

$Co^{3+} : 3d^6 4s^0$
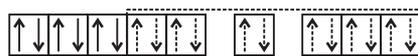
d^2sp^3 hybridisation, octahedral, diamagnetic in nature

The oxidation state of Co = +3

C.N. = 6

Configuration = t_{2g}^6

$\mu = 0$ B.M.

6. Depending upon the type of particles of the dispersed phase, colloids are classified as : multimolecular, macromolecular and associated colloids.

(i) **Multimolecular colloids:** On dissolution, a large number of atoms or smaller molecules of a substance aggregate together to form species having size in the colloidal range (diameter < 1 nm). The species thus formed are called multimolecular colloids. For example, a gold sol may contain particles of various sizes having many atoms. Sulphur sol consists of particles containing a thousand or more of S_8 sulphur molecules.

(ii) **Macromolecular colloids:** Macromolecules in suitable solvents form solutions in which the size of the macromolecules may be in the colloidal range. Such systems are called macromolecular colloids. These colloids are quite stable and resemble true solutions in many respects. Examples of naturally occurring macromolecules are starch, cellulose, proteins and enzymes; and those of man-made macromolecules are polythene, nylon, polystyrene, synthetic rubber, etc.

(iii) **Associated colloids (Micelles):** There are some substances which at low concentrations behave as normal strong electrolytes but, at higher concentrations exhibit colloidal behaviour due to the formation of aggregates. The aggregated particles thus formed are called micelles. These are also known as associated colloids. The formation of micelles takes place only above a particular temperature called Kraft temperature and above a particular concentration called critical micelle concentration (CMC). On dilution, these colloids revert back to individual ions. Surface active agents such as soaps and synthetic detergents belong to this class. For soaps, the CMC is 10^{-4} to 10^{-3} mol L^{-1}. These colloids have both lyophobic and lyophilic parts. Micelles may contain as many as 100 molecules or more.

OR

Factors affecting adsorption of a gas on solids are (any three) :

Nature of the adsorbent : The same gas is adsorbed to different extents by different solids at the same temperature. Also, greater the surface area of the adsorbent, more is the gas adsorbed.

Nature of the adsorbate : Different gases are adsorbed to different extents by different solids at the same temperature. Higher the critical temperature of the gas, greater is its amount adsorbed.

Temperature : Since adsorption is an exothermic process, applying Le Chatelier's principle, we can find out that adsorption decreases with an increase in temperature.

Specific area of the adsorbent : Surface area available for adsorption per gram of the adsorbent increases the extent of adsorption. Greater the surface area, higher would be the adsorption therefore, porous or powdered adsorbents are used.

Pressure : At constant temperature, the adsorption of gas increases with pressure.

Activation of adsorbent : It means increasing the adsorbing power of an adsorbent by increasing its surface area. It is done by

(i) making the adsorbent's surface rough

(ii) removing gases already adsorbed

(iii) subdividing the adsorbent into smaller pieces.

7. (a) If the pK_b value of any base or compound is higher than that of another, it implies that the former is a weaker base than the latter. In aniline, the N-atom is attached to the benzene ring and therefore the lone pair on N is delocalised over the entire benzene ring. As a result, it cannot accept a proton or any other electrophile.
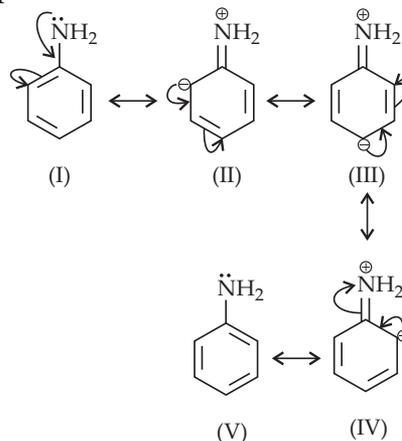
This is why it has a lower K_b value (lower basic strength) and high corresponding pK_b value.

In methylamine, CH_3NH_2, the electron density on nitrogen is greater than that in case of aniline. This is because $-CH_3$ group in methylamine, by virtue of its $+I$ effect, increases electron density on N, which is more available for protonation.

(b) Any compound capable of forming hydrogen bonds with water, dissolves in it. Ethylamine is able to do the same and hence it is soluble.
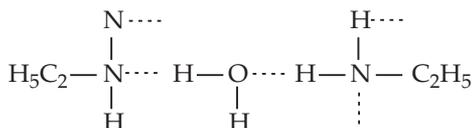
However, in aniline, the bulky hydrocarbon part $-C_6H_5$ prevents the formation of effective hydrogen bonding and therefore it is not soluble.

(c) During Friedel–Crafts reaction, anhydrous $AlCl_3$ is used as a Lewis acid for generation of the electrophile from the electrophilic reagent.

$$CH_3\ddot{\underset{..}{C}l:} + AlCl_3 \rightarrow \overset{\oplus}{C}H_3 + [AlCl_4]^{\ominus}$$
electrophile
generated
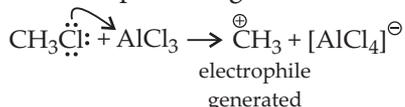
But when this reaction is carried out with aniline, no electrophile generation takes place. The reason being the presence of aniline as a base.

Aniline is a Lewis base, reacts with $AlCl_3$ and hence deactivates it. The Lewis acid is therefore no more available for electrophile generation and hence reaction does not take place.
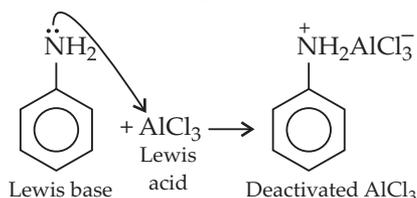

8. (a) $[Cr(NH_3)_6]^{3+}$:
$Cr(24) : [Ar] 4s^1 3d^5$, $Cr^{3+}(21) : [Ar] 4s^0 3d^3$

$d^2 sp^3$ hybridisation
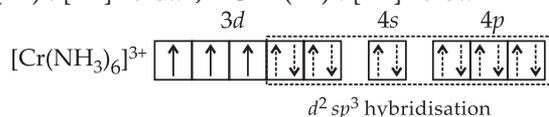
It is paramagnetic due to presence of unpaired electrons

$[Ni(CN)_4]^{2-} : Ni(28) : 4s^2 3d^8$, $Ni^{2+} : 4s^0 3d^8$

dsp^2 hybridisation
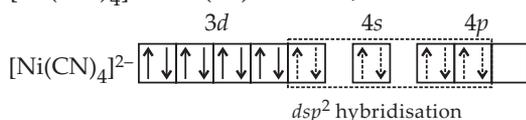
It has square planar shape and is diamagnetic due to absence of unpaired electrons.

(b) $[Co(NH_3)_3Cl_3] < [Cr(NH_3)_4Cl_2]Cl <$
$\qquad [Co(NH_3)_5Cl]Cl_2 < [Co(NH_3)_6]Cl_3$

Conductivity depends on the number of ions produced in the solution. In the order the complexes produce 1, 2, 3 and 4 ions respectively.

OR

(a) CFSE increases in the order of
$[Cr(Cl)_6]^{3-} < Cr(NH_3)_6]^{3-} < [Cr(CN)_6]^{3-}$ depending upon the strength of the field.

(b) Low spin tetrahedral complexes are not formed because for tetrahedral complexes the CFSE is lower than pairing energy hence, pairing of electrons does not take place.

(c) In $CuSO_4 \cdot 5H_2O$, water acts as ligand and causes crystal field splitting. Hence, d-d transition takes place and hydrated $CuSO_4$ shows colour. In anhydrous $CuSO_4$ there is no ligand hence, crystal field splitting is not possible and it is colourless.

9. (i) Electrolysis of aqueous solution of $AgNO_3$ with silver electrodes,

$AgNO_{3(s)} + aq \longrightarrow Ag^+_{(aq)} + NO^-_{3(aq)}$
$H_2O \rightleftharpoons H^+ + OH^-$
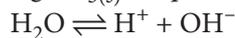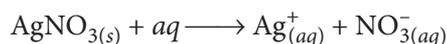
At cathode: Ag^+ ions have lower discharge potential than H^+ ions. Hence, Ag^+ ions will be deposited as Ag in preference to H^+ ions.

At anode: As Ag anode is attacked by NO^-_3 ions, Ag of the anode will dissolve to form Ag^+ ions in the solution.

$\qquad Ag \longrightarrow Ag^+ + e^-$
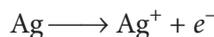
(ii) Electrolysis of aqueous solution of $AgNO_3$ using platinum electrodes,

At cathode: Ag will be deposited.

At anode: As anode is not attacked, out of OH^- and NO^-_3 ions, OH^- ions have lower discharge potential. Hence, OH^- ions will be discharged in preference to NO^-_3 ions, and OH^- will then decompose to give out O_2.

$OH^-_{(aq)} \longrightarrow OH + e^-$,
$4OH \longrightarrow 2H_2O_{(l)} + O_{2(g)}$
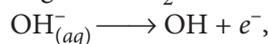
(iii) Electrolysis of dilute H_2SO_4 with platinum electrodes,

$H_2SO_{4(aq)} \longrightarrow 2H^+_{(aq)} + SO^{2-}_{4(aq)}$
$H_2O \longrightarrow H^+ + OH^-$
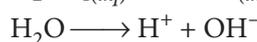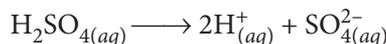
At cathode: $H^+ + e^- \longrightarrow H$,
$H + H \longrightarrow H_{2(g)}$
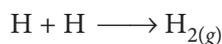
At anode: $OH^- \longrightarrow OH + e^-$,
$4OH \longrightarrow 2H_2O + O_{2(g)}$
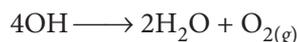
Thus, H_2 is liberated at the cathode and O_2 at the anode.

10. (a)

(i)

(ii)

Benzaldehyde $\qquad$ m-Nitrobenzaldehyde

(b)
$$\overset{4}{CH_3}-\overset{3}{CH_2}-\overset{2}{CH}\overset{\overset{\displaystyle CH_3}{|}}{-}\overset{1}{C}=O$$
with H below the C=O

2-Methylbutanal
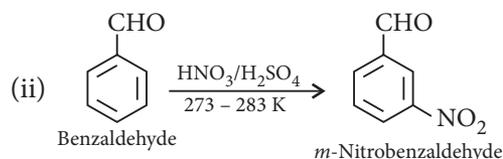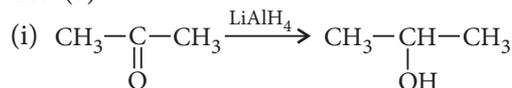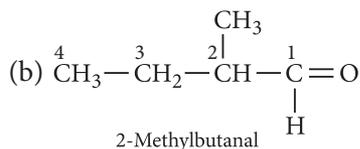
OR

(a) **Acetylation :** Acetylation is the process of introducing an $R-\overset{\overset{\displaystyle O}{||}}{C}-$ group in compounds that contain a replaceable hydrogen atom. The best example of acetylation is Friedel-Crafts acylation reaction where RCO group is introduced on the benzene ring. Reagents employed for the purpose of acylation are acyl chloride, acid anhydride etc. *e.g.,* Friedel-crafts acylation:

Benzene + CH_3COCl $\xrightarrow[\text{Acetyl chloride } AlCl_3]{\text{Anhyd.}}$ Acetophenone (COCH₃)

$CH_3COCl + C_2H_5OH \xrightarrow{\text{Pyridine}} CH_3COOC_2H_5 + HCl$
Ethyl acetate
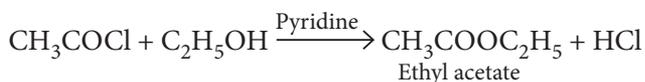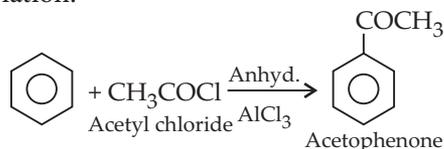
(b) **Cannizzaro reaction :** Cannizzaro reaction is undergone by aldehydes or ketones that lack an a-hydrogen atom. Such carbonyl compounds in the presence of conc. NaOH and heat undergo disproportionation reaction to produce the corresponding carboxylate ion and alcohol.

e.g., Benzaldehyde-CHO $\xrightarrow[\Delta]{\text{Conc. } \bar{O}H}$ Benzyl alcohol-CH₂OH
Benzaldehyde (No α-H) → Benzyl alcohol
+ $\langle O \rangle$-COO$\bar{}$Na$^+$
Sodium benzoate
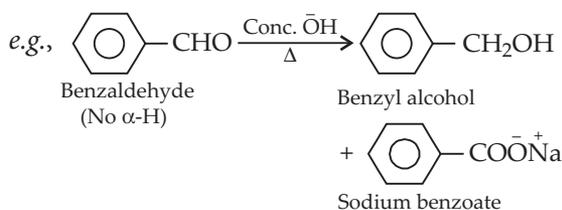
(c) **Decarboxylation :** Carboxylic acids lose carbon dioxide to form hydrocarbons when their sodium salts are heated with sodalime (NaOH and CaO in the ratio of 3 : 1). The reaction is
$R-COONa \xrightarrow[\text{Heat}]{NaOH+CaO} R-H + Na_2CO_3$

11. (a)

(i) $2\,\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{>}}C=O \xrightarrow{Ba(OH)_2} CH_3-\overset{\overset{\displaystyle OH}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}}-CH_2COCH_3$

4-Hydroxy-4-methyl-pentane-2-one

(ii) (COCH₃ benzene) + 4[H] $\xrightarrow{Zn(Hg)/Conc.HCl}$ (CH₂CH₃ benzene) + H_2O
Acetophenone → Ethylbenzene

(b)
$\overset{\displaystyle CH_3C}{\underset{\displaystyle H}{>}}C=O + C_2H_5OH \underset{}{\overset{HCl_{(g)}}{\rightleftharpoons}} \overset{\displaystyle H_3C}{\underset{\displaystyle H}{>}}C\overset{\displaystyle OC_2H_5}{\underset{\displaystyle OH}{<}}$
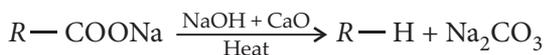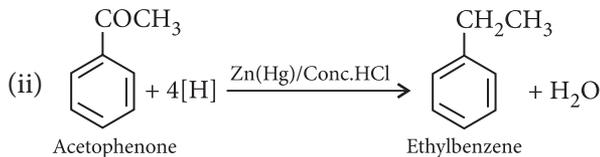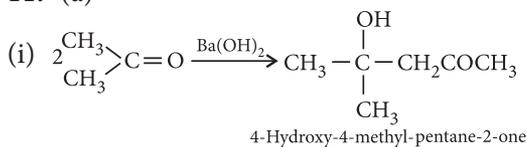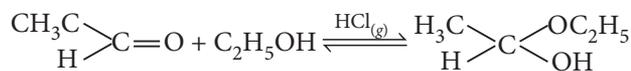
12. (a) $3A + B_2 \longrightarrow A_3B_2$
Molecularity = 4

(b) Let the rate of this reaction, $r = k[A]^m[B_2]^n$

then $\dfrac{r_1}{r_2} = \dfrac{0.60}{1.20} = \dfrac{k(0.15)^m(0.15)^n}{k(0.15)^m(0.30)^n}$

or, $\dfrac{1}{2} = \left(\dfrac{1}{2}\right)^n \Rightarrow n = 1$

Again from $\dfrac{r_2}{r_3} = \dfrac{1.20}{2.40} = \dfrac{k(0.15)^m(0.30)^n}{k(0.30)^m(0.15)^n}$

or $\dfrac{1}{2} = \left(\dfrac{1}{2}\right)^m \cdot \dfrac{2}{1}$ or $\dfrac{1}{4} = \left(\dfrac{1}{2}\right)^m \Rightarrow m = 2$

Hence, expression for rate law is
$r = k[A]^2[B_2]^1$

(c) As the order *w.r.t.* A is 2 and order *w.r.t.* B_2 is 1, hence the overall order is 3.

(d) Substituting the values of experiment 1 in rate law expression
$0.60\ M\ min^{-1} = k(0.15\ M)^2(0.15\ M)^1$

or $k = \dfrac{0.60\ M\,min^{-1}}{0.0225 \times 0.15\ M^3} = 177.77\ M^{-2}\ min^{-1}$

OR

$r = 177.7\ M^{-2}\ min^{-1} \times (0.25\ M)^2 (0.25\ M)$
$= 2.77\ M\ min^{-1}$