Chhatrapati Shahu Ji Maharaj
University, Kanpur

Answer Script Details
Barcode 5620089

Roll No. 24063001034
Total Mark 59/75.00

Exam M.SC-III_ODD_EXAM_NOV_2025
Subject B020903T - Solid State Chemistry (Elective)

Question wise Mark Summary

Q.No	Mark	Q.No	Mark	Q.No	Mark	Q.No	Mark
1A	4/5	8	0/15				
1B	4/5	9	0/15				
1C	4/5						
1D	4/5						
1E	4/5						
1F	4/5						
1G	4/5						
1H	4/5						
1I	4/5						
2A	6/7						
2B	6/7						
3	0/15						
4	0/15						
5A	0/7						
5B	0/7						
6	11/15						
7	0/15						

Chhatrapati Shahu Ji Maharaj University
Kanpur, Uttar Pradesh

PART-II

MARKS OBTAINED										
Q.	1	2	3	4	5	6	7	8	9	10
(a)										
(b)										
(c)										
(d)										
(e)										
(f)										
(g)										
(h)										
(i)										
(j)										
Total										
Total Marks in Figures									Max. Marks	
Total Marks in Words										

Date of Exam: 08/12/25 Shift: 3rd Room No.: 23

Paper Code: B020903T Subject: Chemistry Year/Sem.: 3rd

Name of Candidate: Riya Kumari Gupta

Roll No.: 2 4 0 6 3 0 0 1 0 3 4

Signature of Candidate: Riya Kumari Gupta

Signature of Invigilator

COE Facsimile

B 0 2 0 9 0 3 T
Paper Code

Signature of Evaluator

Course: Solid State Chemistry

Session: 2024-26 Year/Semester: 3rd

Subject Name: Chemistry

Medium: English ● Hindi ○

Paper Code: 0 2 0 9 0 3 T

Exam Date: 8 1 2 2 0 2 5

Name of Candidate: RIYA KUMARI GUPTA

Father's Name: HMBHUNATH PRASAD

परीक्षा केन्द्र का कोड
College Code: U N 0 1

परीक्षा केन्द्र का कोड
Exam Centre Code: U N 0 1

Type of Exam: Regular ● Ex-Student ○ Private ○ Back Paper Exam ○

ANSWER BOOKLET NO.: 5620089

B 0 2 0 9 0 3 T
Paper Code

Enrollement Number: C S J M A 2 4 0 0 0 0 6 3 1 7 1

परीक्षार्थी अनुक्रमांक संख्या Candidate's Roll Number: 2 4 0 6 3 0 0 1 0 3 4

प्रश्न पत्र Paper Code: B 0 2 0 9 0 3 T

Signature of Candidate

Signature of Invigilator

C S Facsimile

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नोट:- 1. परीक्षार्थी को निर्देशित किया जाता है कि आवरण पत्रे को पृष्ठ भाग पर अंकित सभी निर्देशों को सावधानी पूर्वक पढ़ें।
2. बॉक्स में भरी जाने वाली प्रविष्टियाँ बायीं तरफ से शुरू की जायें। 3. गोलों को काले या नीले बॉलपेन से भरा जायें।

INSTRUCTION TO THE CANDIDATE FOR FILLING PART-I

1. Read the instructions carefully given on the answer script and admit card.
2. Write Date of Exam, Shift, Paper Code & Name of Subject Correctly.
3. Write Name & Roll No. Correctly.
4. Write Semester & Branch Correctly.

INSTRUCTION TO THE CANDIDATE FOR FILLING PART-III

1. Use blue or black ball point pen for writing alphabets & numerals in ☐ boxes.
2. Carefully study the example before you start marking.
3. As shown in the example below, blacken thecircles completely.

Correct Method	Incorrect Method
① ● ③ ④	✓ ✗ ● ○

4. Make no Stray marks o n this sheet.
5. **DO NOT WRITE OR MARK ON THE BAR CODE.**

IN ORDER TO AVOD UFM (UNFAIR MEANS) :

1. The Roll No. and Answer Book no. found elsewhere or any other symbol found in the answer book will be treated as unfair means.
2. Any tempering of Bar Code and Booklet no shall be treated as Unfair Means.
3. Do Not bring the materials like slip of paper/mobile/digital diaries/ study material/ revision notes in examination hall. Possession of the mobiles/ digital diaries/electronic/digital/ watch and any other electronic gadget except memory less scientific calculator shall be considered as UFM case.
4. Do not keep or paste currency note in answer script it shall be consider as UFM.

अनुचित साधन से बचने हेतु :

1. उत्तर पुस्तिका के निर्दिष्ट स्थान को छोड़कर अनुक्रमांक एवं प्रश्नपुस्तिका का क्रमांक कहीं और न लिखें तथा कोई भी चिन्ह न बनायें क्योंकि यह अनुचित साधन प्रयोग की परिधि में आता है।
2. उत्तर पुस्तिका को फाड़कर अथवा उत्तर पुस्तिका सादा पर छेड़ छाड़ करने पर अनुचित साधन प्रयोग माना जायेगा।
3. परीक्षा कक्ष में भिन्न वस्तुएं साथ न लायें, जैसे लिखे हुए कागज के टुकड़ें, मोबाईल, डिजिटल डायरी, डिजिटल घड़ि, कॉपी, पुस्तक यह सभी वस्तुएं जो अनुचित साधन के अन्तर्गत आती है। केवल संबंधित प्रश्नपत्र में ही मेमोरी लेस साइंटिफिक कैलकुलेटर ले जाने की अनुमत्ता होगी।
4. उत्तर पुस्तिकाओं में लपेटे न लगे न ही उत्तर पुस्तिका में चिपकायें। ऐसा करना अनुचित साधन प्रयोग की परिधि में आता है।

परीक्षार्थियों के लिए निर्देश

1. प्रवेश पत्र एवं उत्तर पुस्तिका पर दिये गये निर्देशों को ध्यान से पढ़ें।
2. अपना पृष्ठ के दूसरी तरफ कुछ न लिखें।
3. उत्तर पुस्तिका के पृष्ठों पर दोनों तरफ लिखें।
4. प्रश्न पत्र पर अपने अनुक्रमांक के अतिरिक्त कुछ न लिखें।
5. प्रश्न पत्र कोड एवं प्रश्न पत्र ID सावधानी पूर्वक लिखें।
6. अपनी स्थिति स्पष्ट लिखें।
7. उत्तर पुस्तिका के पृष्ठों की संख्या देखें। अगर उत्तर पुस्तिका में पृष्ठ (1-24) से कम है या फटे हुए हैं, तो शुरू होने से पूर्व दूसरी उत्तर पुस्तिका ले लें।
8. प्रश्नपत्र को देख, यदि प्रश्नपत्र के विषय कोड, विषय का नाम तथा प्रश्न में कोई त्रुटि है तो उसके [illegible] होने के 30 मिनट के अन्दर उक्त विसंगति को लिखित सूचित करें, उसके बाद विश्वविद्यालय द्वारा को नहीं की जायेगी।
9. प्रश्नों के उत्तर लिखने के लिये पेंसिल का प्रयोग न करें।
10. दी जोगी या अतिरिक्त पत्रक नहीं दिया जायेगा।

INSTRUCTION TO THE CANDIDATE

1. Read the instructions carefully given on the Question Paper, Admit Card & Answer Script.
2. Do not write anything on back side of the cover page.
3. Write on both sides of pages of answer book.
4. Do not write anything on question paper except Roll Number.
5. Write Paper Code & Question Paper Id carefully.
6. CHECK the number of pages (1-24) or any other kind of damage in your answer script, if found than change the answer script immediately before commencement of examination.
7. CHECK the Question Paper for any kind of discrepancy e.g. Subject Code Name, and Question of the Question Paper during first THIRTY MINUTE commencement of the exam, so that it can be corrected in TIME. After tha corrections shall be entertained by the university.
8. Do not use pencil for answering the question.
9. Write status correctly e.g. those appearing in carry over papers should fill i as Carry Over. Those appearing as Ex- Students should fill in status as e
10. No supplementary answer book & graph paper will be provided.

INSTRUCTION TO-THE CANDIDATE FOR FILLING PART-IV

1. Use blue or black ball point pen for writing alphabets & numerals in ☐ Boxes
2. Use blue or black ball point pen for filling the circles

	1	8	1	5	4	3	2	1	6	9
0	0	0	0	0	0	0	0	0	0	0
1	●	1	●	1	1	1	1	●	1	1
2	2	2	2	2	2	2	●	2	2	2
3	3	3	3	3	3	●	3	3	3	3
4	4	4	4	4	●	4	4	4	4	4
5	5	5	5	●	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	●	6
7	7	7	7	7	7	7	7	7	7	7
8	8	●	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	●

Note- If your Roll No. is of 10 digits. Please leave first three colum

Paper Code
B 0 2 0 9 0 3 T

1

Section A.

(A) Co-precipitation is a wet-chemical technique used to prepare highly homogeneous solid precursors for solid-state synthesis. In this method, two or more desired metal ions are simultaneously precipitated from a solution by adding a precipitating agent (such as OH^-, CO_3^{2-}, or oxalate). Because all ions precipitate together, the resulting solid contains them uniformly mixed at the molecular level.

Co-precipitation is used before solid-state Reaction:-

Solid-state reactions usually occur between metal powders but diffusion in solids is very slow. If the reactants are not well mixed the reaction requires high temperatures and takes long time.

Co-precipitation solves this by forming a single, homogeneous precursor where the cations are already close to each other. On heating the precursor decomposes to yield a fine, intimately mixed oxide or mixed metal-solid. This material then reacts faster and at lower temperatures compared to conventional solid mixing.

Advantages:-

- Atomic level homogeneity → improves the purity of the final solid.
- Small particle size → enhances diffusion & lowers reaction temperature.

Do Not Write anything in this Portion

(B) A magnetic domain is a small region inside a magnetic material in which the magnetic moments of atoms are aligned in the same direction.

Domains form because the material tries to minimize its overall energy. If all the atomic spins in the entire crystal were aligned in one direction, the material would create a very large external magnetic field, which is energetically unfavourable.
To reduce this energy, the material breaks into many small domains with different orientations, so their fields cancel out.

Behaviour in different magnetic materials:-

- Ferromagnetic materials (Fe, Co, Ni) :- these mat domains. In the unmagnetized state, domains point randomly, so the material shows no overall magnetic
- Ferrimagnetic & antiferromagnetic materials :- these have more complex domain structures due to unequal or opposing spins.

Effect of an external magnetic field:-

When an external magnetic field is applied:-

1. Domain aligned with the field grow in size.
2. Other domains shrink or rotate.
3. Eventually, most domains align in the direction of

(c) Recent research (2023–2025) has led to the discovery of several new classes of superconductors that go beyond traditional cuprates and conventional BCS materials. One of the most significant advances is the emergence of nickelate superconductors, such as $SmNiO_2$, which show high-temperature superconductivity (~40K) without copper.

These nickelates are important because they mimic cuprate-like behavior yet offer new chemical flexibility and can be stabilized at ambient pressure using lattice strain.

Another major development is in 2-D and twisted material, particularly magic-angle graphene systems, where unconventional superconductivity arises from electron correlation effects. Recently, graphene-based superconductors have even shown co-existence of superconductivity and magnetism, challenging the idea that these two properties are incompatible.

Overall, new superconductors are expanding the field by offering higher critical temperatures, stable pairing mechanisms and stability under practical conditions, and making them promising for future applications in quantum devices, power systems and advanced electronics.

Do Not Write anything in this Portion

(D) A colour centre (also called a F-centre) is a type of point defect in a crystal that causes the material to develop colour. Normally, ionic crystals like NaCl or KCl are colourless, but when certain defects trap electrons or create vacancies, the crystal absorb specific wavelengths of light and appears coloured.

Reasons:-
Colour centres generally arise due to:-

1. Anion vacancies (missing negative ions)
2. Impurities or irradiations.
3. Electrons trapped in empty lattice sites.

These trapped e⁻ absorb visible light and the remaining wavelengths are transmitted giving the crystal a colour

Types of Colour Centres:-

1. F-centre

- Formed when an anion vacancy traps an electron
- The e⁻ in the vacant site absorbs visible light and the crystal becomes coloured.

e.g. NaCl turns yellow when heated in sodium vapour

2. V-centre.

- A hole (positive charge) trapped at an anion site (e.g. missing electron in an O^{2-}).

B. H- centre

- Extra anion located in an interstitial site.

4. M-centre.

- Two adjacent F-centres.

(E) Doping is the process of intentionally adding small amount of impurities to a pure semiconductors (like Si or Ge) to increase the amount of dopant can drastically change the electrical properties.

1) n-type Doping :-

- Done by adding pentavalent impurities (group 15 elements)
- P, As, Sb.
- These atoms have 5 valence electrons ; four form covalent bonds with Si and the extra electron becomes free for conducting electrons.
- Thus electrons are the majority carriers, holes are minority carriers.
- Conductivity increases due to rise in electron concentration.

2) p-type Doping :-

- Done by adding trivalent impurities (group 13 elements)

Do Not Write anything in this Portion

- These atoms have 3 valence electrons; one electron is missing thus creating a hole.
- Holes act as positive charge carriers.
- Holes become the majority carriers, electrons are minority.

Effects of Doping :-

- Reduces resistivity by many order of magnitude.
- Shifts the Fermi Level upward in n-type and downward in p-type.
- Forms the basic of diodes, transistors, solar cells, etc.

(f) A p-n junction diode is a semiconductor device formed by joining a p-type semiconductor with an n-type semiconductor. It allows current to flow in one direction only making it a key component in rectifiers, photodetectors.

Formation of p-n junction diodes:-

When a p-type and n-type material are joined:

- Electrons from the n-region diffuse into p-region.
- Holes from the p-region diffuse into the n-region.
- These charges recombine near the junction, leaving behind immobile ions and forming a depletion region.
- The depletion region has no free charge carriers and acts as an insulator.
- An internal potential barrier is created.

Paper Code

7

Biasing of p-n-junction:

1) Forward Bias:-

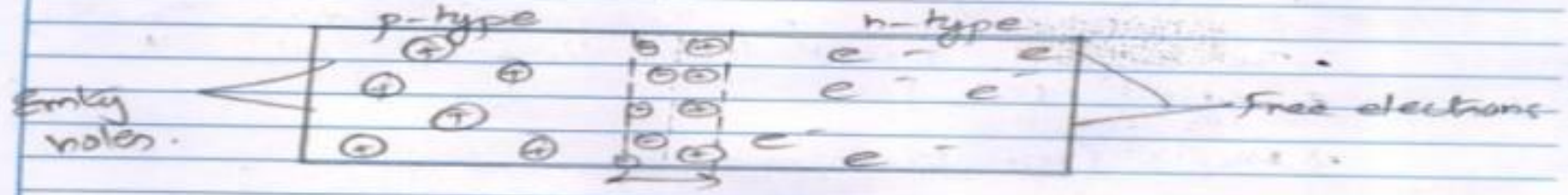
- p-side connected to positive terminal, n-side connected to negative terminal.
- Depletion layer becomes narrow.
- Barrier potential decreases.

2) Reverse Bias

- p-side connected to negative terminal, n-side to positive terminal.
- Depletion layer becomes broad.
- Barrier potential increases.

Applications:-

- Rectifiers (AC to DC conversion).
- Clipping and clamping circuits.
- LED, photodiodes.



Do Not Write anything in this Portion

(6) Dislocations are line defects in a crystal lattice that play an important role in determining the mechanical properties of solids, especially metals.

⇒ Edge Dislocation:

- Formed when an extra half-plane of atoms is inserted into a crystal.
- The dislocation line is perpendicular to the direction of atomic displacement.
- Characterized by a Burgers vector that is perpendicular to dislocation line.
- Produces compressive stress above the extra plane and tensile stress below it.
- Represented by the symbol ⊥.

⇒ Screw Dislocation:

- Formed by a shearing deformation that shifts part of the crystal by one atomic spacing.
- The dislocation line is parallel to the direction of atomic displacement.
- Burgers vector is parallel to the dislocation line.
- The lattice around the dislocation forms the shape of a spiral (screw).

⇒ Mixed Dislocation

- Most real dislocations are a combination of edge and screw components.

Paper Code

9

Q1) Silicon is most widely used material in solar cells because of several ideal physical, chemical & economic properties.

1) Suitable Band Gap:-

- Silicon has a band gap of 1.1 eV, which is ideal for absorbing a large portion of sunlight. It allows efficient conversion of photons into e^-

2) Abundant and Low Cost:-

- Silicon is the second most abundant element in Earth's crust.
- Easily extracted from sand (SiO_2) making it economical for large-scale solar production.

3) Forms High-Quality p-n junctions

- Silicon can be easily doped with elements like B and P.
- Produces stable and efficient p-n junctions necessary for photovoltaic action.

4) Good Thermal and Chemical Stability:-

- Silicon maintains its properties even at high temperatures and under sunlight exposure.

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(I) Curie law describes the temperature dependence of paramagnetic materials.

The magnetic susceptibility (χ) of a paramagnetic substance is inversely proportional to its absolute temperature (T).

$$\chi = \frac{C}{T}$$

where χ - magnetic susceptibility.
T - absolute temperature (Kelvin)
C - Curie constant.

As temperature increases, the thermal thermal motion randomizes magnetic moments, so paramagnetism decreases

Curie - Weiss Law

Curie-Weiss law is an extension of Curie law for material showing ferromagnetism or antiferromagnetism above the transition temperature.

Magnetic susceptibility is inversely proportional to $(T-\theta)$ where θ is the Weiss constant.

$$\chi = \frac{C}{T-\theta}$$

- For ferromagnets : $\theta > 0$
- For antiferromagnets : $\theta < 0$
- For ideal paramagnets : $\theta = 0$

Paper Code

11

Section B:

2(a) Hysteresis is the phenomenon in which the magnetization (M) of a ferromagnetic material lags behind the applied magnetic field (H) when the field is cycled. This produces a characterized hysteresis loop in the M-H or B-H graph.

Reason:

- Ferromagnetic materials consist of many magnetic domains.
- When an external field is applied, domains align in the direction of the field.
- When the field is removed domains do not return to their original random state immediately.
- Some alignment persists → giving residual magnetism.
- Reversing the field then requires extra energy to rotate the stubborn domains.

This lag between H and B/M is called hysteresis.

Key points of hysteresis loop:

- Initial magnetization Curve :- Starting from an unmagnetized state, B increases gradually until saturation as domains fully align.
- Saturation (Bs)
Point where almost all domains align; magnetization

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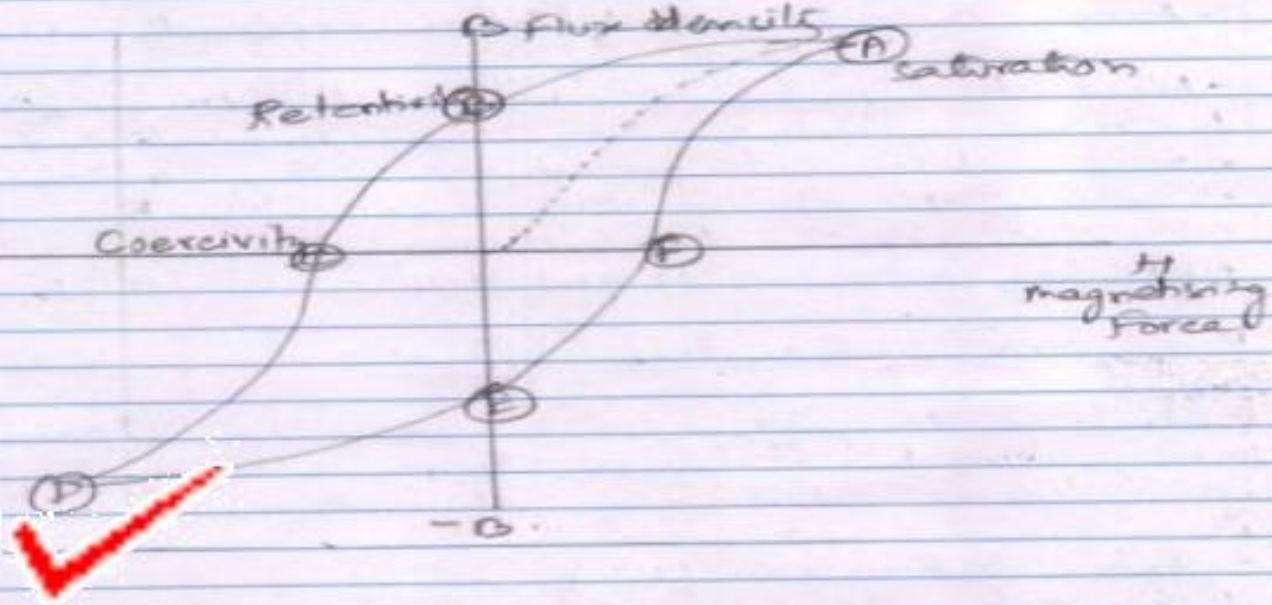
reaches maximum.

- Remanence (Br) :- Even after removing the magnetic field, the material retains magnetism.
- Coercivity (Hc) :- The reverse magnetic field required to bring magnetization back to zero.
- Hysteresis loss :- Area enclosed by the loop represents energy lost (as heat) during one full magnetization cycle.



(b) Magnetic material used for data storage in (hard disks, magnetic disks) must clearly distinguish between two stable magnetic states (usually "0" and "1". For this purpose, the hysteresis loop of the material needs to be square or rectangular shaped.

Reasons:-

1) Clear and sharp switching between states:-

- A square hysteresis loop means the material switches suddenly from negative to positive magnetization between when the applied forces crosses the coercivity point.
- This produces well-defined magnetic states, reducing ambiguity between "0" and "1" in digital recording.

2) High Remanence (B_r):-

- A square loop has very high residual magnetization even after removing the external field.
- This ensures that the stored information remain stable for a long time.

3) High coercivity (H_c) to prevent accidental erasing:-

- A rectangular loop has large coercive force, meaning external stray magnetic fields cannot easily alter the storage information.

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A) Minimal energy loss during switching :-

- For digital memory, rapid and frequent switching is required.
- Square loops ensure efficient switching with practicable energy requirements.

B) Better signal to noise ratio :-

- A square loop produces a very clean, strong signal corresponding to each bit.
- Noise and partial magnetization are avoided, improving data accuracy.

Paper Code

15

Section - C.

6) A frenkel defect is a type of stoichiometric point defect in ionic crystals where...

- a cation (usually smaller ion) leaves its normal lattice site and.
- moves into an interstitial site, creating one vacancy + one interstitial defect.

Thus, the total number of positive and negative ions remain uncharged and electrical neutrality is maintained.

Features:-

- Involves cation vacancy and cation interstitial pair.
- Common in crystals with large anions and small cations.
- No change in density because ions are not lost, only displaced.
- Maintains stoichiometry of the crystal.

Conditions Favoring Frenkel Defects:-

- Large size difference between cation and anion.
- High polarizability of cation.
- Lower coordination number.

Examples:-

- AgCl, AgBr, ZnS, CaF_2 frequently show Frenkel defects.

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Number of Frenkel Defects:

Consider Frenkel defects as a whole:

N Ni n

$$W = \frac{N!}{(N-n)!\,n!} \times \frac{Ni!}{(Ni-n)!\,n!}$$

$$\Delta S = k \ln W$$

$$= k \ln \left[\frac{N!}{(N-n)!\,n!} \times \frac{Ni!}{(Ni-n)!\,n!} \right]$$

$$= k [\ln N! + \ln Ni! - \ln (N-n)! - \ln (Ni-n) - 2 \ln n!]$$

$$= k [N \ln N - N + Ni \ln Ni - Ni - (N-n) \ln (N-n) + N - n - (Ni-n) \ln (Ni-n) + Ni - n - 2 \ln n + 2n]$$

$$\Delta S = k [N \ln N + Ni \ln Ni - (N-n) \ln (N-n) - (Ni-n) \ln (Ni-n) - 2n \ln n] \quad (1)$$

$$\Delta H = n \Delta H$$

$$\Delta G = n \Delta H - T \Delta S$$

$$\Delta G = n \Delta H - Tk [N \ln N + \ldots \ln n]$$

$$\frac{\partial (\Delta G)}{\partial n} = 0 \quad - \Delta H - TRk [\ln (N-n) + 1 + \ln (Ni-n) + 1$$

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$$\Delta H - TK \ln\left[\frac{(N-n)(N_i-n)}{n^2}\right] = 0 \qquad n << N, N_i$$

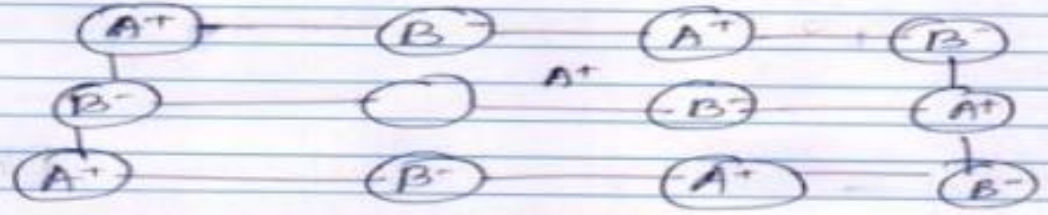
$$\Delta H - T k \ln\left[\frac{\sqrt{NN_i}}{n}\right]^2 = 0$$

$$\ln\left[\frac{\sqrt{NN_i}}{n}\right] = \frac{\Delta H}{2KT}$$

$$\frac{\sqrt{NN_i}}{n} = e^{(\Delta H/2KT)}$$

$$\frac{n}{\sqrt{NN_i}} = e^{(-\Delta H/2KT)}$$

$$\boxed{n = e^{(NN_i)^{1/2}} e^{(-\Delta H/2KT)}}$$



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Do Not Write anything in this Portion

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19

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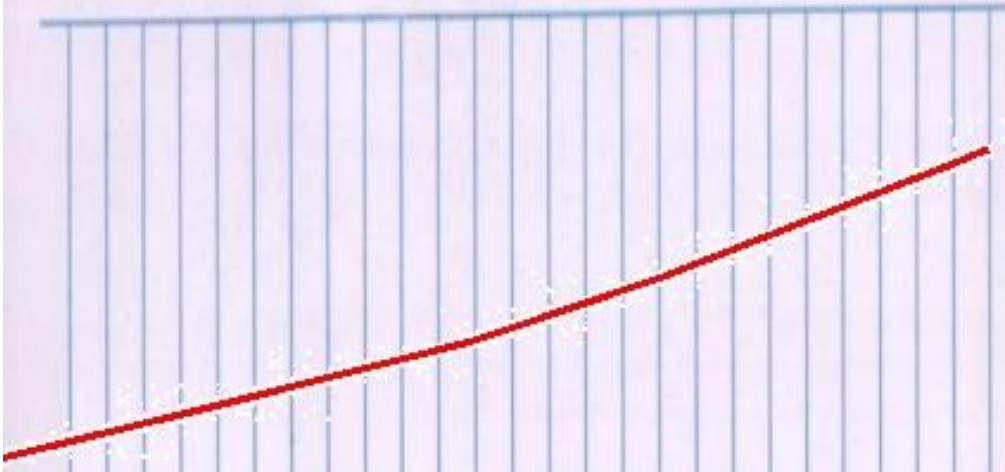

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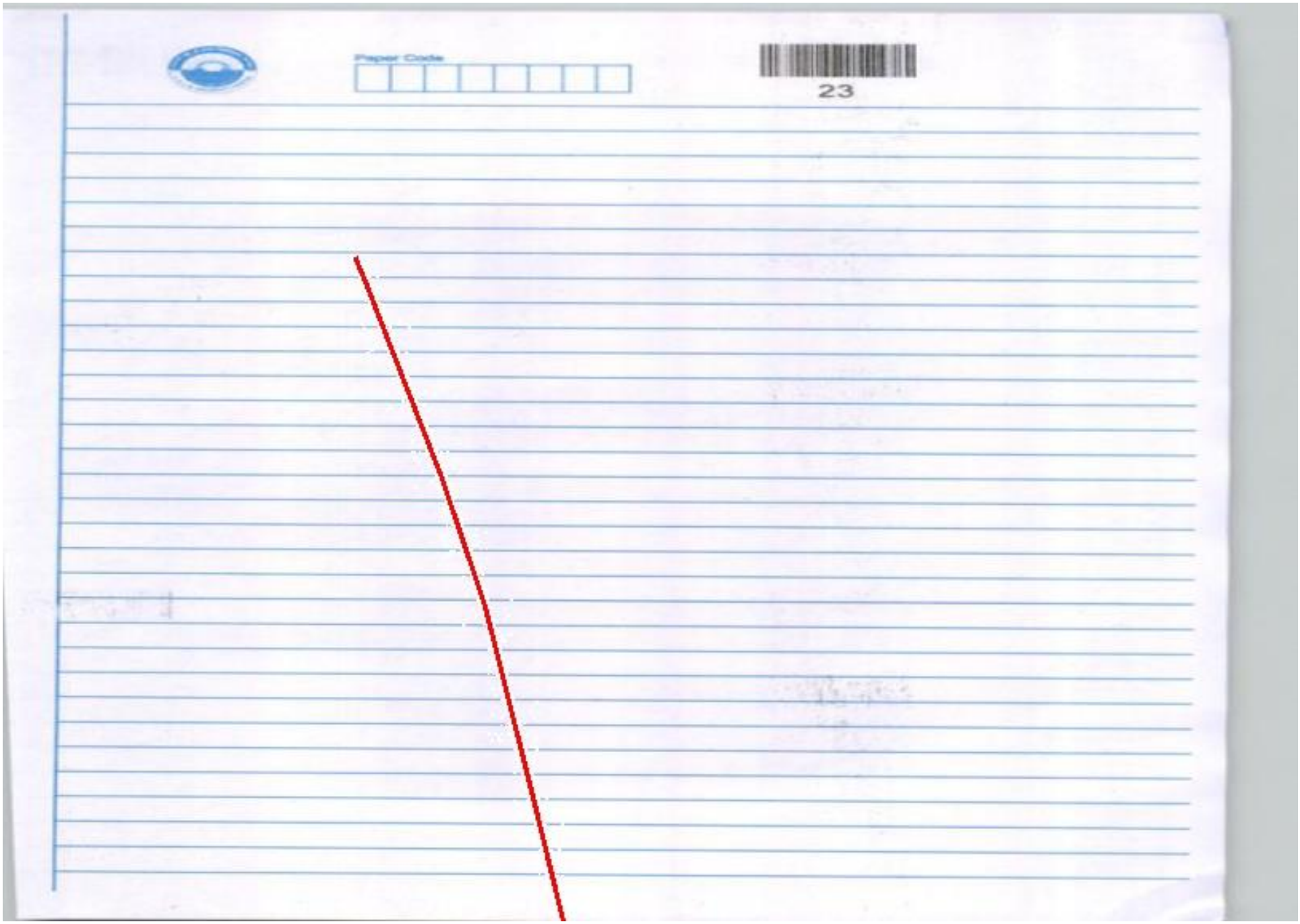
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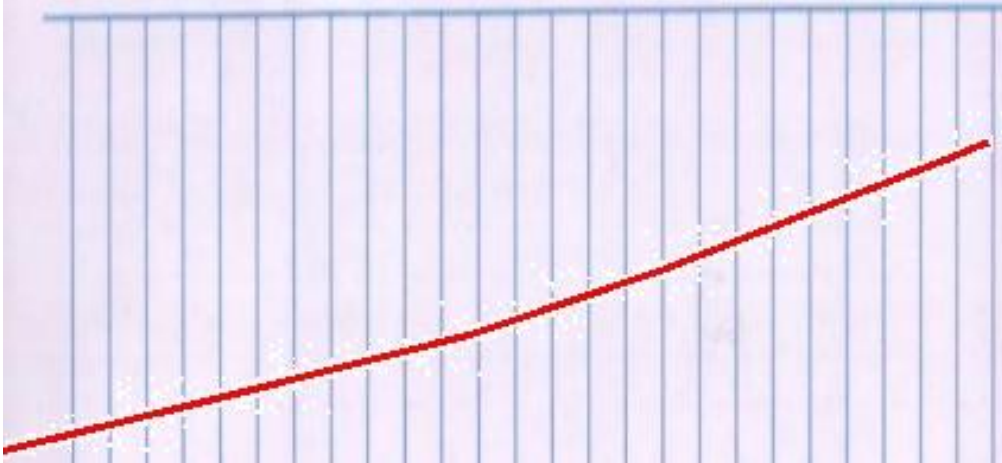

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