



UNIVERSITY OF NORTH BENGAL
B.Sc. Honours 3rd Semester Examination, 2019

GE-PHYSICS

Time Allotted: 2 Hours

Full Marks: 40

*The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.*

**The question paper contains GE3A and GE3B.
The candidates are required to answer any one from two courses.
Candidates should mention it clearly on the Answer Book.**

GE3A

MECHANICS

GROUP-A

- | | | |
|-----|--|---------|
| 1. | Answer any <i>five</i> questions from the following: | 1×5 = 5 |
| (a) | What is Geosynchronous orbit? | 1 |
| (b) | Define shearing stress. | 1 |
| (c) | What is solenoidal vector? | 1 |
| (d) | Explain the term 'Ether' in Michelson-Morley Experiment. | 1 |
| (e) | Define the term Resonance. | 1 |
| (f) | What is the difference between impulse of force and impulsive force? | 1 |
| (g) | Write the dimension of torque. | 1 |
| (h) | Write down the most general form of a homogeneous first order differential equation. | 1 |

GROUP-B

Answer any *three* questions from the following 5×3 = 15

- | | | |
|----|---|---------|
| 2. | (a) A linear harmonic oscillator is characterized by $y = a \cos \omega t$. Calculate the displacement at which K.E. is equal to its P.E. | 2 |
| | (b) What is damped vibration? How does it differ from free vibration? | 1+2 = 3 |
| 3. | (a) Show that the vectors $\vec{a} = \hat{i} - 2\hat{j} + 3\hat{k}$, $\vec{b} = -2\hat{j} + 3\hat{j} - 4\hat{k}$ and $\vec{c} = -\hat{j} + 2\hat{k}$ are coplanar. | 2 |
| | (b) Find the gradient of the scalar function $\phi(x, y, z) = 4e^{(2x-y+z)}$ at the point (1, 1, -1). | 3 |

4. (a) State Kepler's laws in connection with planetary motion. 3
 (b) A disc of mass 50 g and radius 2 cm is rolling down with linear velocity 5 cm/s. Find out its linear and rotational kinetic energy. 2
5. (a) Find the general solution of differential equation $\frac{d^2y}{dx^2} - 5\frac{dy}{dx} + 6y = 0$. 3
 (b) Establish the relation between total energy and momentum of a relativistically moving body. 2
6. (a) Derive an expression for the energy stored in an elastic body in the case of longitudinal strain. 2
 (b) The compressibility of water is 44×10^{-6} / atm, if 125 atm pressure is applied to 200 cc of water, then find the volume compressed. 3

GROUP-C

Answer any two questions from the following

10×2 = 20

7. (a) Write down Lorentz transformation equations. 2
 (b) On the basis of Lorentz transformation, discuss 'Time dilation'. 4
 (c) A spaceship of rest length 120 m passes an observer on earth in 4.5 μ s. Find the velocity of the spaceship with respect to the earth. 4
8. (a) A force $\vec{F} = 3\hat{i} + 2\hat{j} - 4\hat{k}$ is applied at the point (1, -1, 2). Find the moment of the force about the point (2, -1, 3). 3
 (b) Determine the height of the Geosynchronous Satellite from the earth surface. 4
 (c) Prove Newton's 3rd law of motion from the conservation principle of linear momentum. 3
9. (a) If the distance between the Sun and Earth is reduced to half of their present distance. What will be the length of the year? 3
 (b) If the length of a simple pendulum is increased by 75%. Find the percentage increase in its time period. 3
 (c) Prove that the resultant motion of two Simple Harmonic Motion's having same period and amplitude but a phase difference of $\pi/2$ is circular. 4
- 10.(a) Show that the torsional couple per unit twist of a wire is $\frac{\pi r^4}{2l}$, where the symbols are their usual meanings. 4

- (b) A wire of 50 cm length and 1 mm^2 cross-sectional area has Young's modulus of $1.24 \times 10^{12} \text{ dyne/cm}^2$. Find out workdone to increase its length by 1 mm. 3
- (c) Show that Poisson's ratio σ lies between -1 to $\frac{1}{2}$. 3

GE3B

THERMAL PHYSICS AND STATISTICAL MECHANICS

GROUP-A

1. Answer any *five* questions from the following: 1×5 = 5
- (a) State the principle of equipartition of energy. 1
- (b) What is the change of internal energy in a reversible cycle? 1
- (c) State Wien's displacement law. 1
- (d) What is the dimension of the entropy? 1
- (e) State the Carnot theorem. 1
- (f) What is the reflective power of a perfect black body? 1
- (g) Write down the expression for "pressure of radiation". 1
- (h) What is the value of $\ln 10!$ according to the Stirling's formula? 1

GROUP-B

Answer any *three* questions from the following 5×3 = 15

2. (a) What is free expansion? Is it an adiabatic process? 1+1
- (b) Show that for an ideal gas, the internal energy depends only on the temperature not on pressure and/or volume. 3
3. (a) What is the meaning of mean free path of the molecules of a gas? Show that it is equal to $\frac{1}{\pi n d^2}$, where n is the number of molecules per unit volume and d is the diameter of each molecules. 1+3
- (b) Write down the relation between the coefficient of viscosity and thermal conductivity of a gas? 1
4. (a) What are bosons? Give examples. 1+1
- (b) Discuss the difference between the Fermi-Dirac and the Bose-Einstein statistics. 3
5. (a) Mention the physical significance of the Gibb's potential. 2
- (b) Show that the ratio of the adiabatic to isothermal elasticity is γ . 2
- (c) Write down the Clausius-Clapeyron equation of state. 1

- | | |
|--|---|
| 6. (a) State Kirchoff's law of radiation. | 1 |
| (b) Using dimensional analysis establish the Stefan-Boltzmann law. | 3 |
| (c) What is the limitation of Newton's law of cooling? | 1 |

GROUP-C

Answer any two questions from the following

10×2 = 20

- | | |
|---|---|
| 7. (a) Distinguish between extensive and intensive variables. Give examples. | 2 |
| (b) Represent (i) an isobaric process and (ii) an isochoric process on a P-V diagram. | 2 |
| (c) Show that for an adiabatic process $TV^{\gamma-1} = \text{constant}$, where the symbols have their usual meaning. | 3 |
| (d) Find the work done in compressing 1 gm of air adiabatically at NTP (initially) to half of its original volume. The density of air at NTP = 0.00129 gm/cc and $\gamma = 1.4$. | 3 |
| 8. (a) If ' αdt ' be the probability of a gas molecule making a collision in the time interval ' dt ', then find the probability of a molecule experiencing no collision during the interval ' t '. | 3 |
| (b) At what temperature will average speed of molecules of hydrogen gas be double the average speed of oxygen at 300 K. | 3 |
| (c) Calculate the degrees of freedom of a linear triatomic molecule. | 2 |
| (d) Show that $\gamma = 1 + \frac{2}{f}$, where the symbols have their usual meaning. | 2 |
| 9. (a) Calculate the change in entropy when 2 gm of ice melt's into water at the same temperature. The latent heat of ice 80 cal/gm. | 3 |
| (b) Using Maxwell's thermodynamical relation, prove that for a Van der Waals gas | 4 |
| $C_p - C_v = R \left(1 + \frac{2a}{RTV} \right)$ | |
| (c) Give two statements of second law of thermodynamics and show that they are equivalent. | 3 |
| 10.(a) Discuss on the conditions for the application of Maxwell-Boltzmann statistics. | 2 |
| (b) The Fermi velocity of the electron in a metal is 0.7×10^6 m/s. Calculate the Fermi velocity. | 3 |
| (c) Show that adiabatic curves are steeper than the isothermal ones. | 2 |
| (d) Using Maxwell's thermodynamic relations show that the ratio of adiabatic to isobaric volume expansivity is $\frac{1}{1-\gamma}$. | 3 |

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UNIVERSITY OF NORTH BENGAL
B.Sc. Programme 3rd Semester Examination, 2019

DSC-PHYSICS (PAPER-III)

THERMAL PHYSICS AND STATISTICAL MECHANICS

Time Allotted: 2 Hours

Full Marks: 40

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GROUP-A / বিভাগ-ক / विभाग-क

1×5 = 5

1. Answer any *five* questions from the following:

নিম্নলিখিত যে-কোন পাঁচটি প্রশ্নের উত্তর দাও:

कुनै पाँच प्रश्नहरूको उत्तर दिनुहोस् –

(a) State Zeroth law of thermodynamics.

তাপগতিবিদ্যা সংক্রান্ত জিরোথ (Zeroth)-এর সূত্রটি বিবৃত কর।

ऊष्म प्रवैगिकी को जेरोथ नियमहरू कथन गर्नुहोस्।

(b) What is cyclic process?

आवर्त (Cyclic) प्रक्रिया बलते की बोवा ?

चक्रीय प्रक्रिया भनेको के हो ?

(c) Which one has greater slope between the two curves – isothermal or adiabatic?

रुद्धताप (Adiabatic) এবং समोष्म (isothermal) प्रक्रिया दुটির मध्ये कौनটির नति (Slope) বেশি ?

समतापयी वा रुद्धोष्म वक्रहरू बीच कुन वक्रको ढलान ठूलो हुन्छ ?

(d) State the principle of equipartition of energy.

समशक्तिर नीति (Equipartition of energy)-টি विवृत कर।

उर्जाको समविभाजनको सिद्धान्त कथन गर।

(e) Write down the Stefan-Boltzmann's Law.

स्टीफन-बोल्जमान (Stefan-Boltzmann)-এর সূত্রটি লেখ।

स्टीफन-बोल्जमानको नियम लेख्नुहोस्।

(f) Name one particle that follows Bose-Einstein Statistics.

बोस-आइन्स्टाइन परिसंख्यान (Bose-Einstein Statistics) मने चले এমন একটি कणार नाम उल्लेख कर।

बोस-आइन्स्टेन तथ्याङ्क पालन गर्ने एउटा कणको नाम दिनुहोस्।

(g) What is thermodynamic probability?

तापगतिय सञ्भावना (Thermodynamic probability) काके बले ?

ऊष्मागतिकत सम्भावना भनेको के हो ?

GROUP-B / विभाग-ब / विभाग-ख

Answer any three questions from the following

5×3 = 15

निम्नलिखित ये-केन तिनटि प्रश्नर उत्तर दाओ

कुनै तीन प्रश्नहरूको उत्तर दिनुहोस्

2. (a) What is a Carnot engine? 1
 कार्ण्टि (Carnot) इंजिन (engine) बलाते की बोधा ?
 कार्ण्ट कल भनेको के हो ?
- (b) Calculate the work done at different stages of a Carnot cycle. 4
 कार्ण्टि चक्र (Carnot cycle)-एर विभिन्न भाषेपर क्षेत्रे कृतकार्य बेर करे सेखाओ।
 कार्ण्ट घक्रको विभिन्न चरणहरूमा गरिएको कार्य-उर्जाको गणना गर्नुहोस्।
3. (a) What is Enthalpy of system? 1
 कोनो संस्था (System)-र एन्थाल्पि (enthalpy) बलाते की बोधा ?
 प्रणालीको तापीय धारिता भनेको के हो ?
- (b) Write down the four equations of Maxwell in thermodynamics. 2
 तापगतिविद्या (Thermodynamics) संक्रांत म्याक्सवेल (Maxwell)-एर चारटि सूत्र लेख।
 ऊष्म प्रवैगिकीमा भएको म्याक्सवेलको चारवटा समीकरणहरू लेख्नुहोस्।
- (c) What is Joule-Thomson effect? 2
 जूल (Joule)-थम्पसन (Thompson) क्रिया (effect) संक्षेपे व्याख्या कर।
 जूल-थमसन प्रभाव भनेको के हो ?
4. (a) Define root mean square (r.m.s.) velocity of gas molecule. 1
 ग्यासेर अणुदेर क्षेत्रे गड़ वर्ग बेग (r.m.s. velocity) बलाते की बोधा ?
 ग्यास अणुको मूल-औसत-वर्ग वेग (r.m.s.) परिभाषित गर्नुहोस्।
- (b) Using Kinetic Theory of gases, show that pressure of a gas $P = \frac{1}{3} \rho c^2$ 4
 Where ρ is the density of the gas and c is r.m.s. velocity of gas molecules.
 ग्यासेर गतीर तत्व (Kinetic Theory of gas) थेके प्रमाण कर एकटि ग्यासेर धारा प्रदत्त चाप
 $P = \frac{1}{3} \rho c^2$, येथाने ρ हल ग्यासटिंर घनत्व (density) एवंग c ग्यासेर अणुत्तिंर गड़ वर्ग वेग (r.m.s. velocity)
 ग्यासहरूको गतिज सिद्धान्त प्रयोग गरेर ग्यासको दबाव $P = \frac{1}{3} \rho c^2$ हो भनेर देखातनुहोस्।
 यहाँ ρ ग्यासको घनत्व हो र c प्रकाशको वेग हो।
5. Write down the expression of Planck's black body radiation, hence derive the Wien's displacement law from it. 1+4
 कृष्णवस्तु विकिरण (Blackbody radiation) सम्पर्कित प्लांक (Planck)-र सूत्रटि लेख एवंग सेथान थेके
 व्वाइन (Wien)-एर सरण-सूत्र (displacement law)-टिंर प्रतिष्ठा कर।
 प्लांकको कृष्णवस्तु विकिरणको राशिगाला लेख्नुहोस्, यसैले यसबाट वियनको डिस्प्लेसमेन्ट नियम निकाल्नुहोस्।

6. (a) Write down the Maxwell's velocity distribution of gas molecules. Explain it graphically. 3
 ग्यासेर अणु गतिर बिस्तार संक्रान्त म्यान्-बोल्ट्जम्यान सूरति लेख एवं लेखचित्रेण साहाय्ये व्याख्या कर।
 ग्यास अणुहरूको लागि मैक्सवेलको वेग वितरण लेख्नुहोस्। यसलाई चित्रमय रूपमा वर्णन गर्नुहोस्।
- (b) Discuss the limitations of Maxwell-Boltzmann's statistics. 2
 म्यान्-बोल्ट्जम्यान परिसंख्यानेर सीमाबद्धतागुलि उल्लेख कर।
 मैक्सवेल-बोल्ट्जम्यानको तथ्याङ्कको सीमितता छलफल गर्नुहोस्।

GROUP-C / विभाग-ग / विभाग-ग

Answer any two questions from the following

10×2 = 20

निम्नलिखित ये-कोन दुट्टि प्रश्नेर उत्तर दाओ

कुनै दुईवटा प्रश्नहरूको उत्तर दिनुहोस्

7. (a) Explain why there are two different specific heats of a gas and establish the relation between them. 2+3
 কোনো ग्यासेर दु'ट्टि आपेक्षिक ताप (Specific heat) থাকे केन व्याख्या कर एवं तादेर मध्ये सम्पर्क স্থাপन कर।
 ग्यासको किन दुईवटा अलग-अलग विशिष्ट तापहरूहुन्छ बुझाउनुहोस् अनि दुई विशिष्ट तापहरू बीच सम्बन्ध स्थापना गर्नुहोस्।
- (b) What do you mean by degree of freedom of a gas molecule? Hence show that $\gamma = 1 + \frac{2}{x}$, where x is the degree of freedom of the gas and γ is the ratio of the two specific heats of the gas. 2+3
 ग्यासेर अणु स्वधीनतार मात्रा (Degree of freedom) बलते की बोख ? प्रमाण कर, কোনো ग्यासेर अणु स्वधीनतार मात्रा x हले, $\gamma = 1 + \frac{2}{x}$, येथाने γ हल ग्यासटिर दु'ट्टि आपेक्षिक तापेर अनुपात।
 ग्यास अणुको स्वतंत्रताको कोटी भन्नाले के बुझिन्छ ? यसैले देखाउनुहोस् $\gamma = 1 + \frac{2}{x}$, जहाँ x ग्यासको स्वतंत्रताको कोटी हो र γ दुई विशिष्ट तापहरूको अनुपात हो।
8. (a) What do you mean by thermodynamic potential? 2
 तापगतिय बिभव (Thermodynamic potential) बलते की बोख ?
 ऊष्मा गतिकत सम्भावित भन्नाले के बुझिन्छ ?
- (b) Derive Clausius-Clapeyron's equation. 4
 क्लासियस-क्लापेयन (Clausius-Clapeyron)-एर समीकरणटि प्रतिष्ठा कर।
 क्लासियस-क्लापेयनको समीकरण व्युत्पन्न गर।
- (c) What are internal and external latent heat? Explain. 3
 অভ্যন্তরীণ (Internal) ও বাহ্যিক (external) লীনতাপ (latent heat) কাকে বলে ? ব্যাখ্যা কর।
 आन्तरिक र बाह्य अत्यक्त उत्ताप भनेको के हो ? बुझाउनुहोस्।

(d) What is mean free path?

1

ग्यासेर अणुन गड मुक्त पथ (mean free path)-एर संज्ञा लेख।

औसत स्वतंत्र मार्ग भनेको के हो ?

9. (a) A reversible engine converts one-sixth of heat into work. When the temperature of the sink is reduced by 62 K, its efficiency is doubled. Find the temperature of the source and sink.

4

एकटि प्रत्यावर्तक (Reversible) इञ्जिन तार 1/6 अंश तापके कार्ये परिणत करे। इञ्जिनटि सिंक (sink)-एर तापमात्रा 62 K ह्रास प्सेले तार दक्षता द्विगुण ह्य। इञ्जिनटि उत्रस (source) ओ सिंकेर तापमात्रा निर्णय कर।

एक उलटनीय यंत्रले तापको $\frac{1}{6}$ th भाग काममा रूपान्तरण गर्दछ। जब सिंकको तापमान 62 K घट्छ, उलटनीय यंत्रको दक्षता दोब्बर हुन्छ। स्रोत र सिंक को तापमान खोज्नुहोस्।

(b) What is entropy? What is the physical significance of it?

3

कोनो संस्तर अनैपि बलते की बोध ? एर जेत तापपर्य व्याख्या कर।

उत्क्रम-माप भनेको के हो ? यसको भौतिक महत्त्व के हो।

(c) Write down the third law of thermodynamics. What is its importance?

3

तापगतविद्यार तृतीय सूत्रटि लेख एवं व्याख्या कर।

ऊष्म प्रवैगिकी को तेस्रो नियम लेख्नुहोस्। यसको महत्त्व के हो।

10.(a) Define and explain the terms Macro- and Micro- state with suitable example.

3

उपयुक्त उदाहरणसह म्याक्रो (Macro) एर माइक्रो (Micro) दशा (State) कके बले बोधाओ।

उपयुक्त उदाहरणको साथ म्याक्रो र माइक्रो स्टेटको वर्णन साथै परिभाषित गर्नुहोस्।

(b) What is the difference between classical statistics and quantum statistics? Explain.

2

सनातन (Classical) ओ क्वाण्टम (quantum) परिसंख्यान (statistics)-एर मध्येकार मूल पार्थक्युलि व्याख्या कर।

शास्त्रीय र क्वाण्टम तथ्याङ्क बीच के भिन्नता छ व्याख्या गर्नुहोस्।

(c) Write down the distribution function of Fermi-Dirac distribution and plot the distribution function for different temperatures. From this plot, define Fermi-energy.

2+2+1

फेर्मि-डिराक (Fermi-Dirac) वा F-D वितरण (Distribution)-एर सूत्रटि लेख एवं विभिन्न तापमात्राय वितरण अपेक्षक (Function)-टि लेख (plot) अङ्कन कर। এই लेखटि थके फेर्मि शक्ति (Fermi-energy)-एर संज्ञा माओ।

फेर्मि-डिराक वितरणको वितरण प्रकार्य लेख्नुहोस् र विभिन्न तापमानहरूको लागि वितरण प्रकार्य आरेखांकन गर्नुहोस्। यस लेखाचित्रबाट फेर्मि-उर्जा परिभाषित गर्नुहोस्।

—x—