INTERIM JOINT MATRICULATION BOARD
AHMADU BELLO UNIVERSITY
ZARIA

INTERIM JOINT MATRICULATION BOARD EXAMINATION 2016

SUBJECT:	CHEMISTRY PAPER I
DATE SCHEDULED:	THURSDAY 25TH FEBRUARY, 2016
TIME ALLOWED:	THREE HOURS (3 HRS)

INSTRUCTIONS:

i. Answer **ALL** questions in Section A and any **FOUR (4)** questions from Section B.

ii. Each question in Section A carries 5 marks while each question in Section B carries 25 marks.

iii. The use of scientific programmable calculator is **PROHIBITED.**

iv. Table of constants:

Gas constant,	R	=	$8.314 JK^{-1} mol^{-1}$
Molar volume of gas at STP,	V_m	=	$22.4 dm^3$
Avogadro's constant,	N_A	=	$6.023 \times 10^{23} mol^{-1}$
Faraday constant,	F	=	$96500 C mol^{-1}$
1 atomic mass unit (a.m.u) = 931.5 MeV		=	$1.602 \times 10^{-13} J$
Rydberg constant,	R_H	=	$109678 cm^{-1}$
1 atmospheric pressure = 760 mm Hg		=	$1.013 \times 10^5 Nm^{-2}$

Atomic masses of the following elements are: H = 1, N = 14, O = 16, Cu =63.5, Fe = 56, C = 12.

Atomic numbers of the following elements are: N= 7, Ca = 20, Mn = 25.

2016 IJMBE CHEMISTRY I contd.

SECTION A

1. Calculate the number of moles of copper formed when 20.50 g of Copper(II) oxide completely reacts with hydrogen gas.

2. a) Define molecular ion.
   b) How many atoms are there in (i) three moles of cobalt; (ii) 90g of water molecule; (iii) 10g of carbon?

3. State the type of force between the structural units of each of the following: a) diamond (b) neon (c) caesium chloride (d) iron (e) carbon(IV)oxide

4. When calcium reacted with a gas A, a compound B is formed. The compound B reacts with water to form a gas C which turns red litmus paper blue. (a) Identify A and B (b) Write the equation for the reaction of: (i) calcium with A; (ii) B with water.

5. a) Suggest one reasons why B^{3+} ions are rare but Al^{3+} ions are common in compounds formation.
   b) Give the names and chemical formulae of two important ores of aluminum.

6. In a Victor Meyer experiment, 0.52g of an organic liquid of molar mass 120g mol^{-1} was vaporized at temperature of 298K and pressure of $1.013x10^5 Nm^{-2}$. Calculate the volume (cm^3) of the air displaced (Given that saturated vapor pressure of water at 298K=$2.32 x10^3 Nm^{-2}$).

7. Predict the sign of Δs° for each of the following reactions:
   a) $CaCO_3(s) \longrightarrow CaCO(s) + CO_2(g)$
   b) $CS_2(l) \longrightarrow CS_2(g)$
   c) $2Hg(l) + O_2(g) \longrightarrow 2HgO(s)$
   d) $2Na_2O_2(g) + 2H_2O(l) \longrightarrow 4NaOH(aq) + O_2(g)$
   e) $CO(g) + H_2O(g) \longrightarrow CO_2(g) + H_2(g)$

8. Given that a certain gas is sealed up in a container, a) what happens to the average speed of the gas particles as the temperature decreases? b) Why does the pressure of a fixed volume of the gas decrease with decrease in temperature? c) What happens to the pressure of an ideal gas, if at the same temperature, its volume is doubled?

9. Consider the following elements in the second period of the periodic table: Li, Be, B, C, N, O, F and Ne.
   a) Which of these elements has the highest melting point?
   b) Which is the most electronegative? c) Which of these elements can form cation?

2016 IJMBE CHEMISTRY I contd.

d) Which of these exist as mono-atomic molecule at room temperature?

10. Calculate the oxidation number of:
    a) chlorine in ClO_3^- b) chlorine in ClO^- c) chlorine in ClO_4^-
    d) hydrogen in KH e) chromium in CrO_4^{2-}.

SECTION B

Answer any **FOUR (4)** questions in this section.

11. a) Explain the following observations:
    i) Nitrogen is inert at low temperature but reactive at high temperature.

    ii) The following compounds crystallized from water with the indicated number of water molecules: $MgI_2.8H_2O$; $NaI.2H_2O$ and CsI

    iii) Lead(II) oxide is more stable than lead(IV) oxide.

    iv) Heavier members of group 16 have +4 and +6 oxidation states but oxygen (first member of the group) has -2 as the highest oxidation state).

    v) The electron affinities of group 17 members decrease down the group but fluorine does not conform to the trend.

    b) What are isoelectronic ions? Give three examples of such ions.

12. a) Define phase diagram.
    b) Sketch phase diagram of each of the following:
    (i) water (ii) carbon(IV) oxide.
    c) Outline the essential features of diagram b(i).
    d) Explain the differences between the diagrams b(i) and b(ii) above.
    e) Calculate the pH of $8x10^{-3}$ mole dm^{-3} sodium hydroxide assuming the compound ionizes completely in water.

13. a) Differentiate between electrochemical and electrolytic cells. b) A solution of Copper(II) tetraoxosulphate(VI) was electrolyzed using inert electrodes.
    (i) Write balanced ionic equations for the reactions at the electrodes.
    (ii) Give the overall equation of the reaction.(iii) Calculate the volume of gas (if any) evolved at standard temperature and pressure, when a current of 2 amperes passed through the electrolyte for 2.5 hours.

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c) (i) What is metallic corrosion?
(ii) List 4 agents that can bring about the reaction in c (i)
(iii) Explain with relevant equation(s) the chemical processes involved in the rusting of iron.

14.a) What are ligands?
b) Give two IUPAC names each of (i) negatively charged ligands; (ii) positively charged complex ions; (iii) negatively charged complex ions and (iv) polydentate ligands.
c) Outline five special features of fluorine among group 17 of the periodic table.
d) List five uses each of the following group members of the periodic table (i) group 15; (ii) group 17.

15. a) State three postulates and two limitations of Bohr's theory of atom.
b) Calculate the wavelength of the radiation corresponding to the spectra line of the lowest line in Lyman series in hydrogen atom.
c) Explain the significance of *n*, *l*, *m* and *s* quantum numbers in the orbital arrangement of electrons in atoms.
d) Arrange the following equimolar solutions in order of decreasing pH: NH_4Cl, KOH, HCl, KCl, HCOOH, and HCOOK. Give reasons for your order of arrangement.

16. a) State the major contribution of each of the following scientists to the development of Modern Chemistry (i) J.J Thompson (ii) Mendeleev (iii) de Broglie (iv) Faraday (v) Millikan
b) Using defined rules or principles, illustrate how electrons are arranged in manganese.
c) The conversion of iron(II) to iron(III) can be carried out using acidified potassium tetraoxomanganate(VII).
(i) Write a balanced ionic equation to show how the reaction can be achieved.
(ii) What is the oxidation number of manganese in MnO_4^-?
(iii) What species is reduced and which is oxidized?
(iv) What is the role of acid in this reaction?
d) Define the term "*pollutant*".
e) Differentiate between biodegradable and non-biodegradable pollutants.

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INTERIM JOINT MATRICULATION BOARD EXAMINATION 2016

SUBJECT: CHEMISTRY PAPER II: ORGANIC
DATE SCHEDULED: TUESDAY 23RD FEBRUARY, 2016
TIME ALLOWED: TWO HOURS (2 HRS)

Instruction: Answer ALL questions in SECTION A, which carries a total of 50 marks. Answer any TWO (2) questions in SECTION B, each question carries 25 marks. The use of scientific non-programmable calculator is allowed.

C=12, H=1, O=16, N=14, Cl=35.5, S=32, Na=23

SECTION A: Answer ALL questions in this Section. Each question carries 5 marks.

1. List five (5) common techniques used for purification in organic chemistry.

2. Give the structure of the first member of the following homologous series:
   (a) Alkyne
   (b) Alkanone
   (c) Alkanoic acid
   (d) Alkanamide
   (e) Alkanol

3. Give the organic product of the following reactions or indicate 'no reaction' if no product is formed:
   (a) $2CH_3CH_2Br + Na \longrightarrow$
   (b) $CH_3CH_2CH_3 + LiAlH_4 \longrightarrow$
   (c) $CH_3CH{=}CHCH_2Cl + H_2/Pt \longrightarrow$
   (d) $CH_3CH_2CH_2Br + CH_3ONa \longrightarrow$
   (e) $(CH_3)_2CHCH_2CH_3 + Cl_2 \longrightarrow$

4. Classify the following statements as True or False:
   (a) Increase in molar mass leads to decrease in melting point of compounds in a homologous series.
   (b) Weak conjugate bases is obtained from strong acids.
   (c) The structure of a molecule does not affect its boiling point.
   (d) Polar compounds generally boils at higher temperature than non-polar compounds.
   (e) Water solubility of compounds generally increases with hydrogen bonding.

5. (a) Write the electron configuration of carbon in the: (i) ground state (ii) excited state
   (b) Which hybrid orbitals are involved in:
   (i) C – C bond
   (ii) C = C bond
   (iii) C ≡ C bond

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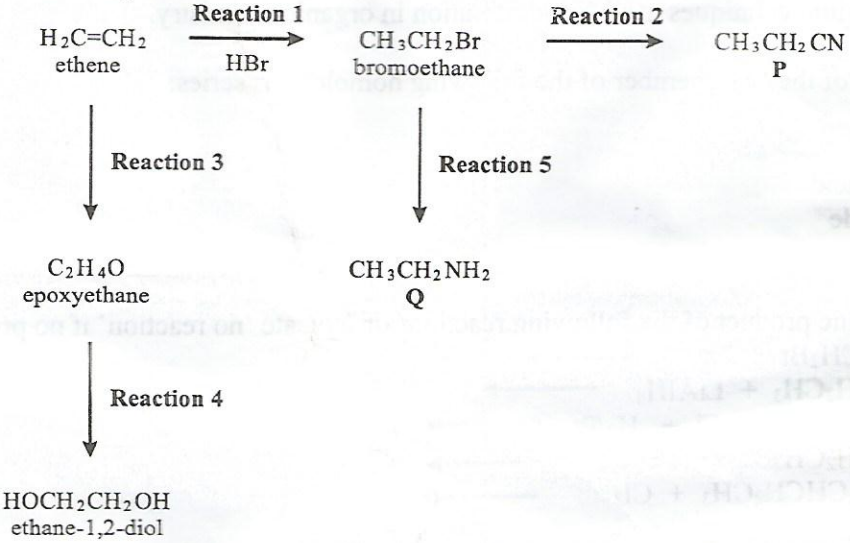
6. Define Resonance effect and Electrometric effect.

7. Give the name of five (5) structural isomers of pentenes.

8. Use formulae to illustrate the following:
   (a) tertiary amine
   (b) organometallic compound
   (c) quaternary ammonium salt
   (d) alkane triol
   (e) diazonium salt.

9. List Five (5) conversion processes in the refining of crude oil (petroleum).

10. Consider the following scheme of reactions.



(a) Identify a reagent for **Reaction 2**. Name the organic product, **P**.
(b) Identify a reagent for **Reaction 5**. Name the organic product, **Q**.
(c) Identify a reagent for **Reaction 3**.

SECTION B : Attempt Any TWO (2) Questions in this Section

11. (a) Write the expected product(s) of the reaction between ethyl ethanoate ($CH_3CO_2C_2H_5$) and the following reagents –
   (i) H^+, H_2O, heat
   (ii) NaOH, H_2O
   (iii) aqueous NH_3, heat
   (iv) $LiAlH_4$ followed by H_3O^+ (8 marks)

2016 IJMBE CHEMISTRY II contd.

(b) The reaction of Grignard reagent (e.g. CH_3MgBr) with carbonyl compounds is an important synthetic route to primary, secondary & tertiary alkanols. Use appropriately named starting materials to write balanced equations to justify this statement. The appropriate name of the products should be indicated. (9 marks)

(c) Briefly describe the fermentation process of starch. (8 marks)

12. (a) A carbonyl compound has a relative molar mass of 86 and contain 69.8 % carbon and 11.6 % hydrogen.
(i) What is the molecular formula of this compound?
(ii) Write out ALL the possible chemical formulae of the compound. (13 marks)

(b) Write an equation to illustrate the oxidation of each of the following compounds using CrO_3 with aqueous H_2SO_4 in acetone as reagent. Give the name of the organic products.
(i) 3-Pentanol (ii) Pentanol
(iii) Pentanal (iv) 3-Pentanone (12 marks)

13. (a) Write chemical equations to illustrate an industrial process to make a detergent (**D**) which involve the following reaction steps
(i) tetramerisation of propene to give the starting alkene (**X**)
(ii) acid catalysed reaction of the alkene (**X**) with benzene to give product, **Y**.
(iii) sulphonation of the product, **Y**, with concentrated tetraoxosulphate (VI) acid gave product, **Z**.
(iv) sodium hydroxide neutralization of product, **Z**, gave the detergent, **D**. (12 marks)

(b) Give the name of the detergent, **D**, and calculate its percentage elemental composition. (9 marks)

(c) Outline two (2) similarities and two (2) differences between detergents and soaps. (4 marks)

14. (a) Draw the condensed structure of the following compounds:
(i) 2-bromo-3-chloro-4,4-dimethylpentanal
(ii) 2,3-dihydroxybutan-1-ol
(iii) 3-amino-2-methoxypentanoic acid
(iv) 4-methylhex-2-ene
(v) 2,4,6-tribromophenol. (10 marks)

(b) Explain the following scientific observations:
(i) ethanol is miscible with water in all proportions but phenol is only sparingly soluble in water.
(ii) propan-2-one in the presence of trace acid gives positive test for both carbonyl and hydroxyl groups. (10 marks)

(c) Give the name of the monomer(s) of the following polymers:
(i) protein
(ii) natural rubber
(iii) Nylon 6,6
(iv) Dacron or Terylene
(v) Starch. (5 marks)

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INTERIM JOINT MATRICULATION BOARD EXAMINATION 2016

SUBJECT: 'A' LEVEL MATHEMATICS PAPER I
DATE SCHEDULED: SATURDAY 20TH FEBRUARY, 2016
TIME ALLOWED: TWO HOURS (2 HRS)

Instructions:
(i) Unless otherwise restricted, the use of mathematical tables is PERMITTED.
(ii) Use of SCIENTIFIC calculator is ALLOWED.
(iii) Marks for each question are indicated at the end.
(iv) Do not spend more than HALF (1/2) HOUR on section A.
(v) Attempt ALL questions in section A; and FOUR (4) questions from other sections, choosing at least
ONE (1) question from each of sections B and C.

SECTION A (20%)

1. Given that $\sin 30^0 = \frac{1}{2}$, obtain in surd form $\tan 15^0$. [04marks]

2. Express $\frac{\sqrt{3}+\sqrt{2}i}{\sqrt{3}-\sqrt{2}i}$ in the form $x+iy$. [04marks]

3. Obtain the quadratic equation whose roots are the reciprocals of the roots of the equation $ax^2+x+c=0$. [04marks]

4. What is the remainder when the polynomial $3x^3-2x^2+6x-1$ is divided by $(x+1)$? [04marks]

5. Show that $\sin\phi = \frac{2\tan\frac{\phi}{2}}{1+\tan^2\frac{\phi}{2}}$ [04marks]

SECTION B: ALGEBRA

6. (a) Prove by mathematical induction that

(i) $1^3+2^3+3^3+\ldots+n^3 = \frac{n^2(n+1)^2}{4}$

(ii) $4^{2n}-1$ is a multiple of 5. [10marks]

(b) The polynomial px^3+3x^2+3x+q has a remainder $19x-11$ when divided by x^2-3x+2. Find thevalues of p and q. With these values of p and q factorize the polynomial into linear factors. [10marks]

7. (a) Solve the inequality $\frac{(x-1)(x+3)}{x+2} \geq 0$ [12marks]

(b) If the roots of the quadratic equation $cx^2+ax-b=0$ are α and β, obtain the quadratic equation whose roots are $\frac{\alpha^2}{\beta}, \frac{\beta^2}{\alpha}$. [08marks]

8. (a) Given that $A=\begin{pmatrix}1 & 0 & 0\\ 2 & 1 & 0\\ 3 & 2 & 1\end{pmatrix}$ and $B=\begin{pmatrix}1 & -1 & 2\\ 0 & 1 & -1\\ 0 & 0 & 1\end{pmatrix}$, show that $(A+B)^2 \neq A^2+2AB+B^2$. [11marks]

(b) Resolve $\frac{x^2+1}{x(x-1)(x+1)}$ into partial fractions. Hence obtain its binomial expression up to term in x^3. [09marks]

SECTION C: TRIGONOMETRY AND COMPLEX NUMBERS

9. (a). Find roots of the equation $Z^5-1=0$ where $Z=x+iy$ [10marks]

(b).Express $\tan 3\theta$ in terms of $\tan\theta$. [10marks]

10. (a) If $\cos(x+\theta)=\cos(x-\phi)$, find $\cot x$ in terms of θ and ϕ. [08marks]

(b). If $\sin A=\frac{-4}{5}$ and $\cos B=\frac{12}{13}$ where A and B are both in quadrant IV, find without using tables, the values of (i) $\cos(A+B)$; (ii) $\sin(A-B)$. [12marks]

11. (a) Describe the locus defined by $|Z+i|=2|3Z+i|$ where $Z=x+iy$. [12marks]

(b). Express $12\sin\theta-5\cos\theta$ in terms of $R\sin(\theta-\alpha)$ and hence solve the equation $12\sin\theta-5\cos\theta=6.5$ for $0\leq\theta\leq 360^0$. [08marks]

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INTERIM JOINT MATRICULATION BOARD EXAMINATION 2016

SUBJECT: 'A' LEVEL MATHEMATICS PAPER II
DATE SCHEDULED: TUESDAY 16TH FEBRUARY, 2016
TIME ALLOWED: TWO HOURS (2 HRS)

Instructions:
(i) Unless otherwise restricted, the use of mathematical tables is PERMITTED.
(ii) Use of SCIENTIFIC calculator is ALLOWED.
(iii) Marks for each question are indicated at the end.
(iv) Do not spend more than HALF (1/2) HOUR on section A.
(v) Attempt ALL questions in section A; and FOUR (4) questions from other sections, choosing at least
ONE (1) question from each of sections B and C.

SECTION A (20%)

1. Differentiate $\cos^{-1}\left(\frac{1-x}{1+x}\right)$. You may simplify your answer. [04marks]

2. Evaluate $\lim_{x\to 9}\left(\frac{x-9}{\sqrt{x}-3}\right)$. [04marks]

3. Find the values of β such that $\beta\mathbf{i}-2\mathbf{j}-\beta\mathbf{k}$ is perpendicular to $\beta\mathbf{i}+4\mathbf{j}-\beta\mathbf{k}$. [04marks]

4. Solve the equation $\frac{dy}{dt}=t^2(1+y)$. [04marks]

5. Evaluate $\int_0^2 \frac{7x}{10+x^2}dx$. [04marks]

SECTION B: CALCULUS

6. (a). Find $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ at $(1,1)$ if $\frac{(x-h)^2}{a^2}+\frac{(y-k)^2}{b^2}=1$. [10marks]

(b). If $y=e^{5x}\sin 4x$, show that $y''-10y'+41y=0$. [10marks]

7. (a). Differentiate from first principle $y=100+3x-5x^3$. [10marks]

(b). Find $\int \frac{(x^2+1)dx}{x(x-1)(x+1)}$. [10marks]

8. (a). If $y = \sinh(k\sin^{-1}x)$, show that $(1-x^2)y'' - xy' - k^2y = 0$. [06marks]

(b). Using integration by parts, show that $nI_n = \sin x\cos^{n-1}x + (n-1)I_{n-2}$, given that $I_n = \int \cos^n x dx$. Hence evaluate $\int_0^{\frac{\pi}{2}} \cos^5 x dx$. [14marks]

SECTION C: DIFFERENTIAL EQUATIONS AND VECTORS

9. (a). Solve the equation $(2x-y)dx - ydy = 0$. [12marks]

(b). The vertices of ΔABC are represented by the vectors $2\mathbf{i}+\mathbf{j}+\mathbf{k}$, $\mathbf{i}-2\mathbf{j}+\mathbf{k}$ and $\mathbf{i}+\mathbf{j}-2\mathbf{k}$, respectively. Show that ΔABC is an isosceles triangle and obtain its area. [08marks]

10. (a). Calculate the unit vector in direction of the sum of the vectors $\mathbf{a} = 3\mathbf{i}-\mathbf{j}+3\mathbf{k}$ and $\mathbf{b} = 3\mathbf{i}+\mathbf{j}-\mathbf{k}$. Hence obtain the angle between it and vectors $\mathbf{a}$. [10marks]

(b). Solve the equation $y\frac{dy}{dx} = xe^{x^2-3y^2}$. [10marks]

11. (a). Solve the equation $(x+2)\frac{dy}{dx} - 2y = (x+2)^{-1}$. [10marks]

(b).Given that $\mathbf{p} = \mathbf{i}+3\mathbf{j}+2\mathbf{k}$ and $\mathbf{q} = \mathbf{i}-3\mathbf{j}-3\mathbf{k}$, find the projection of the vector $\mathbf{p}-2\mathbf{q}$ on $2\mathbf{p}+\mathbf{q}$. [10marks]

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INTERIM JOINT MATRICULATION BOARD EXAMINATION 2016

SUBJECT: 'A' LEVEL MATHEMATICS PAPER III
DATE SCHEDULED: THURSDAY 18TH FEBRUARY, 2016
TIME ALLOWED: TWO HOURS (2 HRS)

Instructions:
(i) Unless otherwise restricted, the use of mathematical tables is PERMITTED.
(ii) Use of SCIENTIFIC calculator is ALLOWED.
(iii) Marks for each question are indicated at the end.
(iv) Do not spend more than HALF (1/2) HOUR on section A.
(v) Attempt ALL questions in section A; and FOUR (4) questions from other sections, choosing at least
ONE (1) question from each of sections B and C.

SECTION A (20%)

1. Find the equation of a straight line which passes through the point of intersection of the lines $3x - y = 0$ and $2x + 3y = 0$ and perpendicular to the line $x - 5y = 2$. [04marks]
2. Calculate the value of k and mean of the distribution with probability density function $f(x) = ke^{-3x}$ where $0 \le x \le \infty$. [05marks]
3. Calculate $P(A \cup B)$ where $P(A) = 0.4, P(B) = 0.42$ if A and B are mutually exclusive events. [03marks]
4. Find the equation of a circle whose centre is at $(1,-2)$ and radius $\sqrt{13}$. [04marks]
5. Find the eccentricity and foci of the hyperbola $\frac{x^2}{36} - \frac{y^2}{25} = 1$. [04marks]

SECTION B: CO ORDINATE GEOMETRY

6. (a). Show that the equation $x^2 - 8y - 6x + 1 = 0$ represents a parabola. Find the coordinates of its vertex, focus and the equations of its directrix, axis and lactus rectum. Hence sketch the curve. [14marks]
(b). Find the equation of a straight line which is parallel to PQ with $P(2,5), Q(-1,2)$ and bisects, the line joining the points $A(-2,2)$ and $B(4,6)$. [06marks]

2016 IJMBE A/L MATHEMATICS III contd.

7. (a). Show that the equation $9x^2+16y^2-18x-32y-119=0$ represents an ellipse. Find the co-ordinates of its centre, foci and the equations of its directries and axes. Hence sketch the ellipse. [14marks]

(b). Show that $r=\frac{3}{1-\cos\theta}$ is a polar form of a parabola. [06marks]

8. (a). Find the condition for which the line $y=mx+c$ touches the parabola $y^2+12x=0$. Hence obtain theequation of the tangent whose slope is 3. [10marks]

(b). Sketch the curve $r=2(1-\cos\theta)$ in polar form. [10marks]

SECTION C: STATISTICS

9. (a) For a Binomial distribution with 5 trials and p = 0.4, find the probability that:
(i) six trials are successful (ii) only two are successful (iii) None ofthe trials is successful
(iv) Exactly four are successful [12marks]

(b). If a card is randomly selected from a deck of cards, find the probability that it is
(i) A red card or a heart. (ii) A Queen or a spade. [08marks]

10. (a) Three balls are drawn at random without replacement from a bag containing 18 blue, 9 Redand 13 yellow balls. Find the probability that:
(i) the balls are of different coluors (ii) 2 of the balls are yellow and one is red. [10marks]

(b) The death rate in a certain village follows a poison distribution with an average death of 2 per annum.What is the probability that in a certain year there will be
(i) no death, (ii) at least 4 deaths and (iii) exactly 6 deaths? [10marks]

11. (a) The following are marks obtained by ten students out of a maximum of 10 marks for each subject in a test:

Commerce X	10	9	8	8	7	7	6	6	5	4
Economics Y	6	6	7	7	8	8	9	9	10	10

(i) Calculate $\bar{x}$ and $\bar{y}$
(ii) Calculate the correlation coefficient r.
(iii) Interpret the value of this coefficient.
(iv) Calculate Spearman's rank correlation coefficients.
(v) Interpret the values of the coefficient
(vi) Do the values in (ii) and (iv) above show any correspondence? [14marks]

(b). If $X \approx N(60, 6.25)$ Find: (i) $P(X \le 58)$, (ii) $P(X \ge 64)$ and (iii) $P(54 \le X \le 62)$. [06marks]

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INTERIM JOINT MATRICULATION BOARD EXAMINATION 2016

SUBJECT: PHYSICS PAPER I

DATE SCHEDULED: SATURDAY 13TH FEBRUARY, 2016

TIME ALLOWED: THREE HOURS (3 HRS)

INSTRUCTIONS:

i. Answer **ALL** the questions in Section A and **ONE (1)** question from each of Section B and D, and **TWO (2)** questions from Section C.

ii. Non-Programmable electronic calculators can be used.

Useful constants:

Mean Radius of earth, R_E	=	6.371×10^6 m
Speed of light (free space), c	=	3.0×10^8 ms^{-1}
Universal gravitational constant, G	=	6.67×10^{-11} Nm^2 kg^{-2}
Stefan Boltzmann's constant, σ	=	5.7×10^{-8} Jm^{-2} K^{-4} s^{-1}
Acceleration due to gravity, g	=	10ms^{-2}
Density of water,	=	1.0×10^3 kgm^{-3}
Viscosity of water at 10 °C,	=	1.3×10^9 Nm^{-2}s
Speed of sound (air)	=	340 ms^{-1}
Emissivity of the earth	=	1.0
Specific heat capacity of water, C_w	=	4200 Jkg^{-1} K^{-1}
Latent heat of vaporisation of water L_w,	=	2.2×10^6Jkg^{-1}
Atmospheric pressure, P_{atm}	=	1.0×10^5Nm^{-2}

40+4 = 44

SECTION A

Answer All the questions in this section

1. a. Convert 2.5 gmm^{-2} to kgm^{-2}.

b, Determine if the formula $T = 2\pi\sqrt{\frac{m}{F/x}}$ is dimensionally correct. Where T is time period, m is mass, F is force and x is distance.

2, a. State the conditions for two vectors to be equal. Give any four examples of the term "magnitude" as applied to vector and scalar quantities.

b. Two vectors having equal magnitudes f make an angle θ with each other. Find the magnitude of the resultant.

3,A particle of mass 40g executes a simple harmonic motion of amplitude 2. 0 cm. If the time period is 0.20 s, find the total mechanical energy of the system.

4. A load of 4.0 kg is suspended from a ceiling through a steel wire of radius 2.0 mm. Find the tensile stress developed in the wire at equilibrium.

5. a. What is a fluid? Give two examples.

b. Define the terms adhesion and cohesion

6.Consider the wave $y = 5\sin(x - 60t)$. In terms of π, Find the wave number, the frequency, wavelength and velocity of the wave.

7. Define the term entropy. A Carnot engine working between 27 ^{0}C and 127 ^{0}C takes up 800J of heat from the reservoir in one cycle. Calculate the work done by the engine and efficiency of the engine.

8. Calculate the energy radiated per second by a sphere (assumed to be a blackbody radiator) of radius 10 cm maintained at a constant temperature of 727^{0}C.

9. A particle of mass 20 g is projected vertically upwards with a speed of 10 ms^{-1}. Find the work done by the force of gravity during the time the particle goes up.

10. A platinum resistance thermometer reads 0°C when its resistance is 80 Ω and 100°C when its resistance is 90Ω. Find the temperature at the platinum scale at which the resistance is 86Ω.

The vector must be in the same direction.

SECTION B MECHANICS

Answer ONE question only from this section

11. a. (i) Distinguish between the terms *"conservative force and nonconservative force"*, give one example for each.

(ii). A simple pendulum of length l, and mass m oscillates through an angle θ. Derive the expressions for its potential energy.

(iii) Determine the potential energy of a simple pendulum of length 90 cm and mass 0.5 kg displaced at angle of 60^0.

b. (i). The heat (H) produced in a wire carrying an electric current depends on the current (I), the resistance (R) and the time (t). Assuming that, the dependence is related by the equation $H \alpha I^x R^y t^z$. Use dimensional analysis to determine the values of the indices (x, y, z). Hence, find the expression for H.

(ii) A solid object has a mass $(400.3 \pm 0.02)g$ and volume $(75.6 \pm 0.01)cm^3$. Calculate the density of the solid with the associated error.

12a. (i). Explain the terms *center of mass (CM) and center of gravity (CG)*. How do these related to the rigid body?

12a(ii) Three particles of masses 1.0 kg, 2.0 kg and 3.0 kg are placed at the corners A, B and C respectively of an equilateral triangle ABC of side 1 m as shown in figure 1. What is the center of mass of the system?

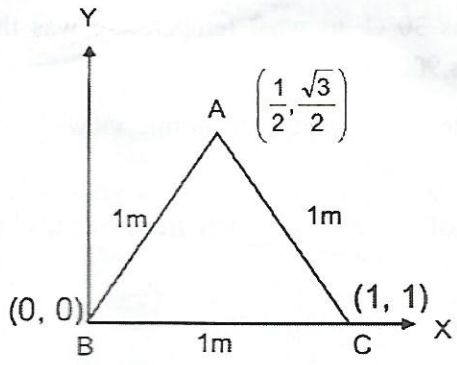

Figure 1.

12b(i). Two particles of masses 1 kg and 2 kg are placed at a separation of 50 cm. Calculate the force acting between them. Assuming that the only force acting on the particles are their mutual gravitation, find the initial accelerations of the each particle.

(ii). Calculate the escape velocity from the moon. The mass of the moon = 7.4×10^{22} kg and radius of the moon = 1740 km.

SECTION C: HEAT AND PROPERTIES OF MATTER

Answer TWO questions only from this section

13a.(i) Define the terms viscosity and coefficient of viscosity. State the SI unit and dimensions of coefficient of viscosity.

(ii). Write the mathematical expression for Stokes's law and state the meaning of each symbol.

(iii). Consider a metallic sphere of radius 'a' and density ρ to fall under gravity in a liquid of density σ. Sketch the forces acting on the sphere. Hence, Show that the terminal velocity is given by $v = \dfrac{2a^2(\rho - \sigma)g}{9\eta}$.

b(i). State two conditions for liquid to be ideal.

(ii). A liquid of mass m and volume V is flowing with velocity v, derive the expressions for its kinetic and potential energies per unit volume of the liquid in terms of ρ.

14.a(i). State the zeroth and first laws of thermodynamics.

(ii). An 0.050 kg block of Aluminum is heated and placed in a calorimeter containing 0.10 kg of water at 20°C. If the final temperature of the water was 30°C, to what temperature was the Aluminum heated? (Specific heat capacity of Aluminum is 900 $Jkg^{-1}K^{-1}$).

b. **(i).** State and briefly explain the three phases of matter with respect to atomic view. What causes the phase changes in matter?

(ii). How much heat is required to raise the temperature of 0.015 kg of water from −25.0°C to 125.0°C?

15a(i). Distinguish between the terms *Heat transfer and thermal conductivity.*

(ii). State and explain all the mechanisms of heat transfer.

(iii). A piece of brass is 5.0 mm thick and has a cross-sectional area of 0.010 m^2. If the temperature on one side of the metal is 65°C and the temperature on the other side is 25°C, how

much heat will be conducted through the metal in 30 s? The coefficient of thermal conductivity for brass is $120 WK^{-1}m^{-2}$.

15b. When a metallic bar is heated from 0^0C to 100^0C, its length increases by 0.05%. Obtain

(i) The coefficient of linear expansion of the metal.

(ii) The percentage increase of the volume of the bar.

16a (i) State the quantity that remains constant for each of the following thermodynamic processes.

(A) *Isobaric process* **B).***Isochoric process* **C)** *Isothermal process* **D)** *Adiabatic process.*

(ii) Show that, for a monatomic ideal gas undergoing an adiabatic process, $PV^{\frac{5}{3}} = \text{constant}$.

b(i) Write down (without proof) the efficiency for a Carnot cycle as a function of the:

A) *Heat that flows to and from the reservoirs and*

B) Temperatures of the two reservoirs.

(ii) A wire 10 m long and cross sectional area of $20\ mm^2$ is stretched 2,5cm by a 20 kg lead block when attached to it, find:

(A). The tensile stress (B) tensile strain (C) Young modulus of the wire.

(iii) The internal energy of a gas is given by $U = 1.5pV$. It expands from $100cm^3$ to $200cm^3$ against a constant pressure of 1.0×10^5 Pa. Calculate the heat absorbed by the gas in the process.

SECTION D: VIBRATION AND WAVES

Answer any ONE question from this section

17a(i). State any three differences and one similarity each of standing and travelling waves.

(ii). Two travelling waves of equal amplitudes and equal frequencies move in opposite directions along a string. They interfere to produce standing waves having the equation:

$y_1 = A\sin(\omega t - kx)$ *and* $y_2 = A\sin(\omega t + kx)$.

(A). Find the resultant when these waves superposed.
(B) What is the nature of amplitude of the resultant wave?
(C) Find the smallest points for node and antinode to be formed of the resultant wave.

b(i). White light is a mixture of light of wavelengths between the limits $400nm$ and $700nm$, When white light passes through water, what are the limits of the wavelength? Refractive index of water is 1.33.

b. (ii) A steel wire of length 64 cm weighs 5 g. If it is stretched by a force of 8 N, what would be the speed of a transverse wave passing on it?

18a(i). Define the following terms *pitch, resonance and Doppler effect* as applied to sound waves.

(ii) An ultrasound signal of frequency 50 kHz is sent vertically into sea water. The signal gets reflected from the ocean bed and returns to the surface 0.80 s after it was emitted. The speed of sound in sea water is 1500 ms^{-1}. Find the depth of the sea and the wavelength of this signal in water.

b(i). Two trains move towards each other at a speed of 90 kmh^{-1} relative to the earth's surface. One gives a 520 Hz signal. Find the frequency heard by the observer on the other train. The speed of sound wave in air is $350ms^{-1}$.

(ii) On a winter day, sound travels 336 meters in one second. Find the atmospheric temperature in ^0C. Speed of sound at $0°C = 332\ ms^{-1}$.

INTERIM JOINT MATRICULATION BOARD
AHMADU BELLO UNIVERSITY
ZARIA

INTERIM JOINT MATRICULATION BOARD EXAMINATION 2016

SUBJECT: PHYSICS PAPER II
DATE SCHEDULED: FRIDAY 19TH FEBRUARY, 2016
TIME ALLOWED: THREE HOURS (3 HRS)

INSTRUCTIONS:

i. Answer **ALL** the questions in Section A and **ONE (1)** question from each of Section B and D, and **TWO (2)** questions from Section C.

ii. Non-Programmable electronic calculators can be used.

Useful constant:

Charge on the electron	e	=	$-1.6 \times 10^{-19}C$
Electron volt	eV	=	$1.6 \times 10^{-19}J$
Mass of electron	M_e	=	$9.0 \times 10^{-31}Kg$
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}NA^{-2}$
Permittivity of free space	ε_0	=	$8.85 \times 10^{-12}Fm^{-1}$
Electrical constant of proportionality	K	=	$9 \times 10^{9}Nm^2C^{-2}$
Plank's constant	h	=	$6.6 \times 10^{-34}Js$
Velocity of light in free space	c	=	$3.0 \times 10^{8}ms^{-1}$
Avogadro's number	N	=	$6 \times 10^{23}mol^{-1}$
Atomic mass unit	1u	=	931Mev
Universal gravitational constant,	G	=	$6.67 \times 10^{-11}\ Nm^2\ Kg^{-2}$

SECTION A

Answer All the questions in this section

1(a). Write down one difference and one similarities of real and virtual images. Mention any two uses each of *plane mirror, concave and convex mirror.*

2. A ray of light travelling on a medium at an angle of $\cos^{-1}\left(\frac{1}{\sqrt{2}}\right)$ and refracted at an angle of $\sin^{-1}\left(\frac{1}{\sqrt{2}}\right)$ in the medium. Calculate the velocity of light in the medium.

3. A concave mirror has a focal length of 25.3 cm. An object, of height 1.45 cm is placed 46 cm in front of the mirror. Determine the: *the radius of curvature of the mirror, the image position, size and nature of the image.*

4. A charge of $1\mu C$ on a small sphere of mass $1\mu g$ is placed in a uniform electric field of $3NC^{-1}$. Calculate the acceleration produced by this filed.

5(a). Define the term Coulomb. Calculate the Coulombic force between two electrons situated at 1.6Å apart in vacuum.

6. A 2.5μF capacitor is connected in series with a non-inductive resistor of 300Ω across a mains of *rms* value 50 V, 1000/2πHz. .Calculate: the thermal values of the current in the circuit and the p.d across the capacitor.

7. Ten 1.5 V cells, each having an internal resistance of 0.2Ω, are connected in series to a load of 58 Ω. Determine the current flowing in the circuit and the p.d at the battery terminals.

8. Light is directed onto a metal surface for which the work function is 2eV. If the light's frequency is f such that $hf = 5eV$. What is the maximum speed of the emitted electrons?

9. State the Heisenberg Uncertainty Principle involving energy. What is the minimum uncertainty in the energy state of an atom if an electron remains in this state for 10^{-8}s?

10. Briefly explain the concepts of "insulators, semiconductors and conductors in terms of the forbidden energy gap. What is N-type semiconductor?

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SECTION B: GEOMETRIC OPTICS

Answer ONE question only from this section

11a (i). Explain how to differentiate between a plane mirror, a concave and a convex mirror, without touching them in terms of image formed.

(ii) Explain the following rules for ray diagram:

(A) A ray of light parallel to the principal axis.

(B) A ray of light passing through Centre of curvature of a mirror.

(C) A ray of light passing through the principal focus of a mirror.

(iii). Complete the table for the image formation by a concave mirror for different positions of the object. (1 to 8) in Table 1.

Position of object	Position of image	Size of image	Nature of image
At infinity	(1)	(2)	Real and inverted
At C	(3)	(4)	(5)
Between C and F	Beyond C	(6)	Real and inverted
At F	(7)	Highly enlarged	(8)

Table 1.

b(i). State the necessary conditions for the total internal reflection to occur. What are the factors on which the refractive index of a medium depends?

(ii) A 1.2 cm long pin is placed perpendicular to the principal axis of a convex mirror of focal length 12 cm, at a distance of 8 cm from it. Sketch the ray diagram and find the location, height and the nature of the image.

(iii) An astronomical telescope in normal use has an angular magnification of 8 and the lenses are at a distance of 45cm apart. What is the focal length of the lenses?

12a(i). State and give the geometrical interpretations of the laws of refraction using a rectangular glass prism. Hence, show that, $n_1 v_1 = n_2 v_2$ where v_1, v_2 velocities of light in medium 1 and 2 of refractive indices n_1 *and* n_2 respectively.

(ii) A ray of light making an angle of 30^0 with the normal, enters a glass plate 4 cm thick. Calculate the distance the light ray travels in the glass before it leaves the plate. What angles does the emergent ray make with the normal?

b. An object 4cm high is placed at a distance of 40cm from a converging lens of focal length 15cm. A diverging lens of focal length 10cm is placed a distance 30cm from the first lens. Find the position, size and the nature of the final image.

SECTION C : ELECTRICITY AND MAGNETISM

Answer TWO questions only from this section

13a(i). Explain in **details** the term "*capacitor*".

(ii). You are provided with three identical capacitors each of capacitances $2\mu F$. what are the maximum and minimum capacitance could you obtain with these capacitors? What arrangement of these capacitors would give a resultant capacitance of $3\mu F$? Sketch its diagram.

13b(i). Define the terms inductor and inductance of inductor.

(ii). Four inductors each of inductance 2mH, are connected in parallel across a 10A a.c

supply. Calculate the equivalent inductance and the energy stored.

14a(i). Define magnetic flux and magnetic flux density. State their possible units.

(ii). Assume the maximum working flux of a lifting magnet is 1.8T and the effective area of a pole face is circular in cross section. If the total magnetic flux produced is 0.353Wb. Calculate the radius of the pole.

14b(i). State the mathematical form of Gauss's law of electrostatic and state the meaning of each symbol in the equation.

(ii). Distinguish between resistance and reluctance. Calculate the permeance of reluctance $\frac{5}{9}$ *per* Hery.

(iii). Two wires of same material and length have resistances 5 Ω and 10 Ω respectively. Find the ratio of radii of the two wires.

15a (i). State the law of electromagnetic induction and derive its mathematical relations.

(ii). Calculate the mutual inductance between two coils when a current changing at $200As^{-1}$ in one coil induces an emf of 1.5V in the other.

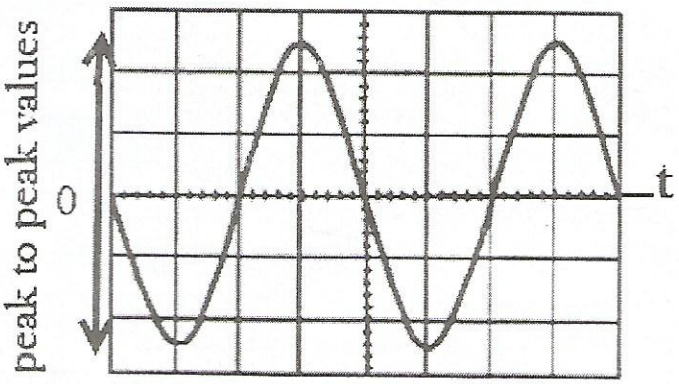

fig. 15.1

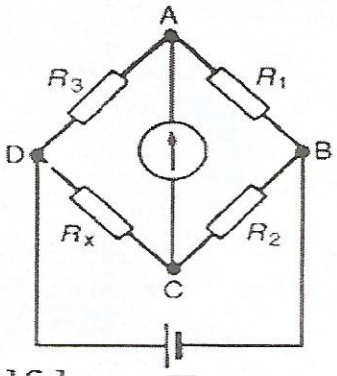

fig. 16.1

15.b(i). What do you understand by a cathode ray oscilloscope (c.r.o.)? A sinusoidal voltage trace displayed by a (c.r.o). is shown in Figure 15.1. If the 'time/cm' switch is on 500μs/cm and the 'volts/cm' switch is on 5 V/cm. Find, for the waveform: the frequency, the peak-to-peak voltage, the amplitude and the r.m.s value of voltage. Given that the width of one complete cycle is 4 cm.

16a(i). The arms of a Wheatstone bridge ABCD (fig. 16.1), have the following resistances: $AB: R_1 = 100\Omega \pm 1.0\%$, $BC: R_2 = 100\Omega \pm 0.5\%$, $CD: unkown\ resistance\ R_x$, $DA: R_3 = 432.5\Omega \pm 0.2\%$. Determine the value of the unknown resistance and its relative error.

16a(ii). A coil of copper wire has a resistance of 100Ω when its temperature is 0°C. Determine its resistance at 70 ^{0}C if the temperature coefficient of resistance of copper at 0°C is $0.0043°C^{-1}$.

16b(i). Calculate the effective resistance between points A and B in figure 16.2.

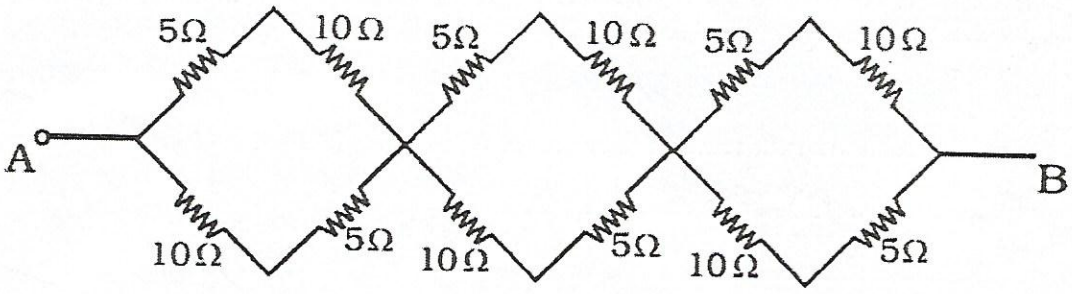

fig. 16.2

(ii). Briefly define the following terms*: ammeter, voltmeter, ohmmeter moving coil galvanometer, and current sensitivity of a galvanometer.*

(iii). Draw a circuit diagram to show, how the alternating voltmeter and ammeter connected in a circuit of load resistance 12.72kΩ with 210Va.c mains?

SECTION D: MODERN PHYSICS

Answer ONE question only from this section

17a(i). Explain in details the modes of production and action of a modern x-rays tube. (Labeled diagram is needed) and mention any two good characteristics of the target material in the productions of x- rays and one good characteristics of the anode.

(ii). Briefly explain the terms *hard and soft x-rays*. State five properties of x-rays.

(iii). A Coolidge tube operates at 24800 V. Determine the maximum frequency the radiation emitted from tube.

17(b)(i). State five Shortcomings of Bohr's theory?

(ii) If the Wavelength of Balmer first line is 6563Å. Calculate the wavelength of second line.

18a(i). State any four properties each of α, β, *and* γ, rays emitted by radioactive atoms.
(ii) State and derive the radioactive law of disintegration.
(iii) Calculate the time required for 60% of a sample of radon to completely decay. Given $T_{½}$ of radon = 3.8 days.

18(b). Show labeled sketches of PNP and NPN junction transistor and diode valves. Illustrate your answer with their respective circuit symbols.