PARLIAMENT OF INDIA
(JOINT RECRUITMENT CELL)

MAIN EXAMINATION FOR POST OF
SECURITY ASSISTANT GRADE- II (TECHNICAL)
IN
LOK SABHA SECRETARIAT

25th DECEMBER, 2010

PAPER-II: MATHEMATICS AND SCIENCE

INSTRUCTIONS : **Attempt six questions in all with two questions from each section.**

Time: 2 hours Marks: 100

PART - A: PHYSICS 40Marks

Note: Attempt any two questions from this part.

Q.1 Explain the construction of optical fibre with suitable diagram. Describe the mechanism of signal transmission through it. Derive the expression for critical angle θC of an optical fibre. State any four advantages of using optical fibre. Write any two reasons causing attenuation of signal in the fibre. (4+4+6+4+2=20)

Q.2 Explain the construction of a bipolar junction transistor stating the relative thicknesses and doping levels of each part. Describe the mechanism of current amplification in a BJT. Draw the circuit of common emitter biasing of an n-p-n transistor. Explain the input and output characteristics of this circuit. (4+6+4+6=20)

Q.3 Draw the diagram of von-Neumann architecture of a computer. Describe the function of each block in this diagram. Explain the difference between machine code language and assembly language of a computer. What is the function of an interpreter in a computer? Name any three network topologies used in computer networking. What is the advantage of Bluetooth in computer communication? (4+6+3+2+3+2=20)

Q.4 State the first law of thermodynamics. Write down the differential form of first law of TD for an electrical cell. Name the types of processes under the following conditions:

a) dQ=dU

b) dU=-dW

c) dQ=dW

What are the four processes involved in a Carnot cycle?

A Carnot engine is working between ice point (273 K) and liquid nitrogen temperature (77 K). Calculate its efficiency.

Is it possible to build a Carnot machine with efficiency = 1? Justify your answer.

(2+4+3+4+4+3=20)

PART - B: CHEMISTRY 30 Marks

Note: Attempt any two questions from this part.

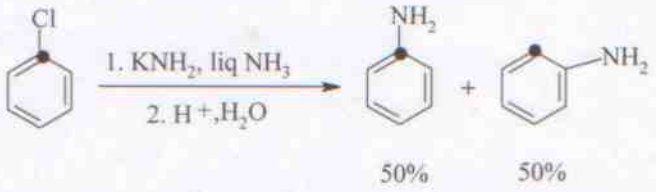
Q.5 i) Draw the phase diagram of water system indicating its triple point. ($2\frac{1}{2}$)

ii) Calculate the number of CsCl units in a unit cell. What is the coordination number of each type of ion? ($2\frac{1}{2}$)

iii) Arrange the following carboxylic acids in the increasing order of their acid strengths and give reason for your answer: ($2\frac{1}{2}$)

$HCOOH, ClCH_2COOH, CH_3COOH$

iv) When radioactively labeled chlorobenzene (^{14}C at Cl) is reacted with KNH_2 in liquid ammonia, a mixture of following products results: ($2\frac{1}{2}$)



Benzenamine -1- ^{14}C Benzenamine -2- ^{14}C

Explain the formation of above two products.

v) Explain the Van Arkel de Boer process of purification of metals. Name a metal purified by this method. $(2\frac{1}{2})$

vi) Which one of $K_3[FeF_6]$ and $K_4[Fe(CN)_6]$ is an outer orbital complex and shows paramagnetism ? Explain your answer. The atomic number of Fe is 26. $(2\frac{1}{2})$

Q.6 i) What is a standard hydrogen electrode ? Write its notation and give its utility. $(2\frac{1}{2})$

ii) Write the expression for the integrated rate law for the following first order reaction:

$$H_2O_2(l) \longrightarrow H_2O(l) + \tfrac{1}{2}\, O_2(g) \qquad (2\tfrac{1}{2})$$

iii) Draw the Newman projections for important conformations of butane and identify the most stable and least stable conformation. $(2\frac{1}{2})$

iv) Explain mutarotation by taking the example of D(+)- glucose. $(2\frac{1}{2})$

v) Explain the variation in first ionization enthalpy across the elements Li, Be, B, C, N, O, F, Ne. $(2\frac{1}{2})$

vi) Describe the splitting of *d*-orbitals in an octahedral crystal field. Calculate the crystal field stabilization energy of a high spin complex of a d^6 ion. $(2\frac{1}{2})$

Q.7 i) A reaction has a value of $\Delta H = -40$ kJ at 400 K. The reaction is spontaneous above 400 K but is not spontaneous below 400. Calculate ΔG and ΔS at 400 K. $(2\frac{1}{2})$

ii) What is the OH^- concentration of a 0.02 M solution of NH_3 ? ($K_b = 1.8 \times 10^{-5}$). $(2\frac{1}{2})$

iii) What are the limitations of Friedel–Crafts alkylation reaction ? Illustrate. $(2\frac{1}{2})$

iv) How is alanine synthesized from propanoic acid ? Write the reaction with appropriate reaction conditions. $(2\frac{1}{2})$

v) Give an example of a hydride having multicentre bonding. Explain its structure in brief. $(2\frac{1}{2})$

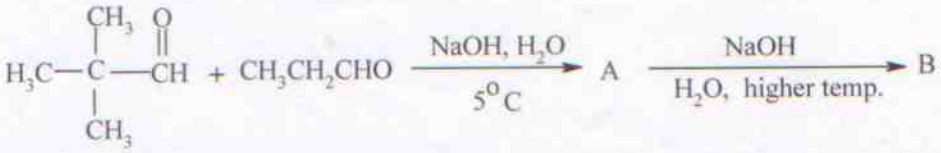
vi) What are lanthanides and what is lanthanide contraction ? Why is the separation of lanthanides so difficult ? $(2\frac{1}{2})$

Q.8 i) Express the critical constants in terms of van der Waals coefficients. $(2\frac{1}{2})$

ii) What is the condition for a molecule to show pure rotational spectrum? Which of the following molecules will show pure rotational spectrum ?

CO_2, H_2O, N_2, N_2O $(2\frac{1}{2})$

iii)



Write the structures of A and B formed in the above reaction. What is the name of the above reaction? $(2\frac{1}{2})$

iv) UV spectra of acetone shows λ_{max} at 280 and 190 nm whereas that of 3-buten-2-one shows λ_{max} at 324 and 219 nm. Explain this data and assign the transitions responsible for these bands. $(2\frac{1}{2})$

v) What are silicones ? Give one example each of a linear and a cross linked silicone polymer. $(2\frac{1}{2})$

vi) How does carbon monoxide behave as a σ- donor and a π-acceptor ligand ? Name the mononuclear metal carbonyl of a 3d metal, which does not obey 18 electron rule. $(2\frac{1}{2})$

PART - C: MATHEMATICS 30 Marks

Note: Attempt any two questions from this part.

Q.9 a) Let $f(x)=\begin{cases} 1+x & \text{for } 0\le x\le 2 \\ 3-z & \text{for } 2<x\le 3 \end{cases}$

Determine the form of g(x) = f(f(x)) and hence find the points of discontinuity of g, if any. (5)

b) Evaluate $\int_0^{\pi}\frac{x\,dx}{1+\cos\alpha\,\sin x}\ (0<\alpha<\pi)$ (5)

c) Let p be a prime number. Check whether $Q\left[\sqrt{P}\right]=\left\{a+b\sqrt{P}\,|a,b\in Q\right\}$ is a ring with respect to the operations of addition and multiplication on **R**. (5)

Q.10 a) Find the integral solution of the equation $(1-i)^n=2^n$. (3)

b) If $a^2+b^2=1$ and $m^2+n^2=1$, then prove that $|am+bn|\le 1$. (3)

c) An unbiased coin is tossed. If the result is a head, a pair of unbiased dice is rolled and the number obtained by adding the numbers on the two faces is noted. If the result is a tail, a card from a well shuffled pack of eleven cards numbered $2,3,4\cdots 12$ is picked and the number on the card is noted. What is the probability that the noted number is either 7 or 8? (4)

d) Solve the differential equation $\frac{dy}{dx}+\frac{xy}{1-x^2}=xy^{1/2}$. (5)

Q.11 a) Let $\mathbf{a}=\mathbf{q}+\mathbf{j}$ and $\mathbf{b}=2\mathbf{i}-\mathbf{k}$, then find the point of intersection of the lines $\mathbf{r}\times\mathbf{a}=\mathbf{b}\times\mathbf{a}$ and $\mathbf{r}\times\mathbf{b}=\mathbf{a}\times\mathbf{b}$ (4)

b) Find all the vectors **v** orthogonal to $\mathbf{a} = [1 \ \ 2 \ \ 0]^T$. Check whether they form a basis. Justify your answer.

c) Find out what type of conic section the following quadratic form represents and transform it to principal axes.

$$Q=17x_2\text{-}30x_1x_2+17x_2=128 \qquad (4)$$

d) Find the directional derivative of $f = e^x \cos y$ at $(2, \pi, 0)$ in the direction of $2\mathbf{i}+3\mathbf{j}$. (4)

Q.12 a) Prove that the centre of the sphere which touches the lines $y = mx, z = c; y = -mx, z = -c$ lie upon the conicoid $mxy + cz(1+m^2) = 0$. (5)

b) Let A be a subset of a metric space X. Then show that the following statements are equivalent.

i) A is non-dense in X.

ii) $\overline{A}$ contains no neighbourhood.

iii) $\left(\overline{A}\right)^{\cdot}$ is dense in X. (5)

c) Prove the following statement using induction:

If $p(x) = a_0 + a_1 x + a_2 x^2 + \ldots + a_n x^n$ is any polynomial of degree n with coefficients in a field F and a is any element of F, then p(x) can be written in the form

$b_0 + b_1 (x - a) + b_2 (x - a)^2 + \ldots + b_n (x - a)^n$, $b_i \in F$ $i = 0, \ldots, n$. (5)