ROUGH WORK

SA

KVPY QUESTION PAPER –STREAM SA
October 31, 2010

PART A

MATHEMATICS

1 A student notices that the roots of the equation $x^2+bx+a=0$ are each 1 less than the roots of the equation $x^2+ax+b=0$. Then $a+b$ is

A. possibly any real number
B. -2
C. -4
D. -5

2 If x, y are real numbers such that

$$3^{x+1}-3^{x-1}=24,$$

then the value of $(x+y)/(x-y)$ is

A. 0 B. 1 C. 2 D. 3

3 The number of positive integers n in the set $\{1, 2, 3, \ldots, 100\}$ for which the number $\dfrac{1^2+2^2+3^2+\cdots+n^2}{1+2+3+\cdots+n}$ is an integer is

A. 33 B. 34 C. 50 D. 100

4 The three different face diagonals of a cuboid (rectangular parallelopiped) have lengths 39, 40, 41. The length of the main diagonal of the cuboid which joins a pair of opposite corners is

A. 49 B. $49\sqrt{2}$ C. 60 D. $60\sqrt{2}$

5 The sides of a triangle ABC are positive integers. The smallest side has length 1. Which of the following statements is true?

A. The area of ABC is always a rational number
B. The area of ABC is always an irrational number
C. The perimeter of ABC is an even integer
D. The information provided is not sufficient to conclude any of the statements A, B or C above

6 Consider a square $ABCD$ of side 12 and let M, N be the midpoints of AB, CD respectively. Take a point P on MN and let $AP=r$, $PC=s$. Then the area of the triangle whose sides are $r, s, 12$ is

A. 72 B. 36 C. $\frac{rs}{2}$ D. $\frac{rs}{4}$

7 A cow is tied to a corner (vertex) of a regular hexagonal fenced area of side a metres by a rope of length $5a/2$ metres in a grass field. (The cow cannot graze inside the fenced area.) What is the maximum possible area of the grass field to which the cow has access to graze?

A. $5\pi a^2$ B. $\frac{5}{2}\pi a^2$ C. $6\pi a^2$ D. $3\pi a^2$

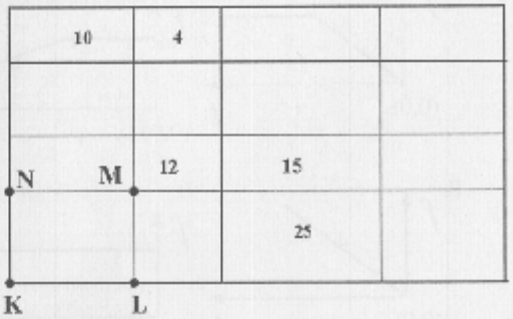
8 A closed conical vessel is filled with water fully and is placed with its vertex down. The water is let out at a constant speed. After 21 minutes, it was found that the height of the water column is half of the original height. How much more time in minutes does it require to empty the vessel?

A. 21 B. 14 C. 7 D. 3

9 I carried 1000 kg of watermelon in summer by train. In the beginning, the water content was 99%. By the time I reached the destination, the water content had dropped to 98%. The reduction in the weight of the watermelon was

A. 10 kg B. 50 kg C. 100 kg D. 500 kg

10 A rectangle is divided into 16 sub-rectangles as in the figure; the number in each sub-rectangle represents the area of that sub-rectangle. What is the area of the rectangle KLMN?



A. 20 B. 30 C. 40 D. 50

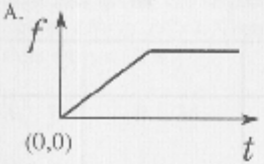
PHYSICS

11 A hollow pendulum bob filled with water has a small hole at the bottom through which water escapes at a constant rate. Which of the following statements describes the variation of the time period (T) of the pendulum as the water flows out?

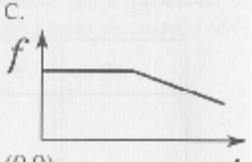
A. T decreases first and then increases
B. T increases first and then decreases
C. T increases throughout
D. T does not change

12 A block of mass M rests on a rough horizontal table. A steadily increasing horizontal force is applied such that the block starts to slide on the table without toppling. The force is continued even after sliding has started. Assume the coefficients of static and kinetic friction between the table and the block to be equal. The correct representation of the variation of the frictional force, f, exerted by the table on the block with time t is given by

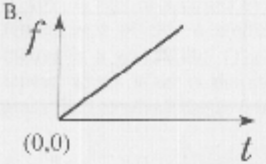
A.



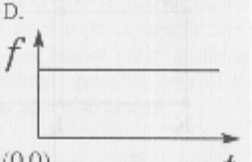
C.



B.



D.



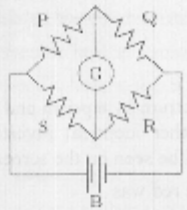
13 A soldier with a machine gun, falling from an airplane gets detached from his parachute. He is able to resist the downward acceleration if he shoots 40 bullets a second at the speed of 500 m/s. If the weight of a bullet is 49 gm, what is the weight of the man with the gun? Ignore resistance due to air and assume the acceleration due to gravity $g = 9.8\ ms^{-2}$.

A. 50 kg B. 75 kg C. 100 kg D. 125 kg

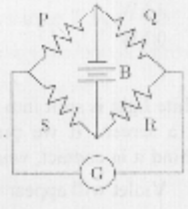
14 A planet of mass m is moving around a star of mass M and radius R in a circular orbit of radius r. The star abruptly shrinks to half its radius without any loss of mass. What change will be there in the orbit of the planet?

A. The planet will escape from the star
B. The radius of the orbit will increase
C. The radius of the orbit will decrease
D. The radius of the orbit will not change

15 Figure (a) below shows a Wheatstone bridge in which P, Q, R, S are fixed resistances, G is a galvanometer and B is a battery. For this particular case the galvanometer shows zero deflection. Now, only the positions of B and G are interchanged, as shown in figure (b). The new deflection of the galvanometer



(a)



(b)

A. is to the left
B. is to the right
C. is zero
D. depends on the values of P, Q, R, S

16 12 positive charges of magnitude q are placed on a circle of radius R in a manner that they are equally spaced. A charge $+Q$ is placed at the centre. If one of the charges q is removed, then the force on Q is

A. zero

B. $\frac{qQ}{4\pi\varepsilon_0 R^2}$ away from the position of the removed charge

C. $\frac{11qQ}{4\pi\varepsilon_0 R^2}$ away from the position of the removed charge

D. $\frac{qQ}{4\pi\varepsilon_0 R^2}$ towards the position of the removed charge

17 An electric heater consists of a nichrome coil and runs under 220 V, consuming 1kW power. Part of its coil burned out and it was reconnected after cutting off the burnt portion. The power it will consume now is

A. more than 1 kW
B. less than 1 kW, but not zero
C. 1 kW
D. 0 kW

18 White light is split into a spectrum by a prism and it is seen on a screen. If we put another identical inverted prism behind it in contact, what will be seen on the screen?

A. Violet will appear where red was
B. The spectrum will remain the same
C. There will be no spectrum, but only the original light with no deviation
D. There will be no spectrum, but the original light will be laterally displaced

19 Two identical blocks of metal are at 20°C and 80°C, respectively. The specific heat of the material of the two blocks increases with temperature. Which of the following is true about the final temperature T_f when the two blocks are brought into contact (assuming that no heat is lost to the surroundings)?

A. T_f will be 50°C
B. T_f will be more than 50°C
C. T_f will be less than 50°C
D. T_f can be either more than or less than 50°C depending on the precise variation of the specific heat with temperature

20 A new temperature scale uses X as a unit of temperature, where the numerical value of the temperature t_X in this scale is related to the absolute temperature T by $t_X = 3T + 300$. If the specific heat of a material using this unit is 1400 J $kg^{-1}X^{-1}$ its specific heat in the S.I. system of units is

A. 4200 J $kg^{-1}K^{-1}$
B. 1400 J $kg^{-1}K^{-1}$
C. 466.7 J $kg^{-1}K^{-1}$
D. impossible to determine from the information provided

CHEMISTRY

21 The boiling points of 0.01 M aqueous solutions of sucrose, NaCl and $CaCl_2$ would be

A. the same
B. highest for sucrose solution
C. highest for NaCl solution
D. highest for $CaCl_2$ solution

22 The correct electronic configuration for the ground state of silicon (atomic number 14) is

A. $1s^2 2s^2 2p^6 3s^2 3p^2$
B. $1s^2 2s^2 2p^6 3p^4$
C. $1s^2 2s^2 2p^4 3s^2 3p^6$
D. $1s^2 2s^2 2p^6 3s^1 3p^5$

23 The molar mass of $CaCO_3$ is 100 g. The maximum amount of carbon dioxide that can be liberated on heating 25 g of $CaCO_3$ is

A. 11 g B. 5.5 g C. 22 g D. 2.2 g

24 The atomic radii of the elements across the second period of the periodic table

A. decrease due to increase in atomic number
B. decrease due to increase in effective nuclear charge
C. decrease due to increase in atomic weights
D. increase due to increase in the effective nuclear charge

25 Among NH_3, BCl_3, Cl_2 and N_2, the compound that does **NOT** satisfy the octet rule is

A. NH_3 B. BCl_3 C. Cl_2 D. N_2

26 The gas produced on heating MnO_2 with conc. HCl is

A. Cl_2 B. H_2 C. O_2 D. O_3

27 The number of covalent bonds in C_4H_7Br, is

A. 12 B. 10 C. 13 D. 11

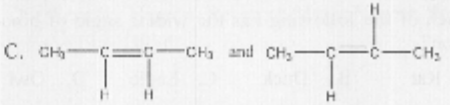
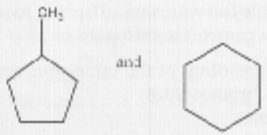
28 An aqueous solution of HCl has a pH of 2.0. When water is added to increase the pH to 5.0, the hydrogen ion concentration

A. remains the same
B. decreases three-fold
C. increases three-fold
D. decreases thousand-fold

29 Consider two sealed jars of equal volume. One contains 2 g of hydrogen at 200 K and the other contains 28 g of nitrogen at 400 K. The gases in the two jars will have

A. the same pressure
B. the same average kinetic energy
C. the same number of molecules
D. the same average molecular speed

30 Identify the stereoisomeric pair from the following choices.

A. $CH_3CH_2CH_2OH$ and $CH_3CH_2OCH_3$
B. $CH_3CH_2CH_2Cl$ and $CH_3CHClCH_3$
C.  and
D.  and

BIOLOGY

31 Which of the following is a water-borne disease?

A. Tuberculosis
B. Malaria
C. Chickenpox
D. Cholera

32 In his seminal work on genetics, Gregor Mendel described the physical traits in the pea plant as being controlled by two 'factors'. What term is used to define these factors today?

A. Chromosomes
B. Genes
C. Alleles
D. Hybrids

33 A majority of the tree species of peninsular Indian origin fruit in the months of

A. April – May
B. August – September
C. December – January
D. All months of the year

34 In frogs, body proportions do not change with their growth. A frog that is twice as long as another will be heavier by approximately

A. Two-fold
B. Four-fold
C. Six-fold
D. Eight-fold

35 Which of the following has the widest angle of binocular vision?

A. Rat B. Duck C. Eagle D. Owl

36 The two alleles of a locus which an offspring receives from the male and female gametes are situated on

A. Two different homologs of the same chromosome
B. Two different chromosomes
C. Sex chromosomes
D. A single chromosome

37 Ants locate sucrose by

A. Using a strong sense of smell
B. Using a keen sense of vision
C. Physical contact with sucrose
D. Sensing the particular wavelength of light emitted/reflected by sucrose

38 The interior of a cow-dung pile kept for a few days is quite warm. This is mostly because

A. Cellulose present in the dung is a good insulator
B. Bacterial metabolism inside the dung releases heat
C. Undigested material releases heat due to oxidation by air
D. Dung is dark and absorbs a lot of heat

39 Which one of these is the correct path for a reflex action?

A. Receptor-Motor Neuron-Spinal Cord-Sensory Neuron-Effector
B. Effector-Sensory Neuron-Spinal Cord-Motor Neuron-Receptor
C. Receptor- Sensory Neuron-Spinal Cord-Motor Neuron-Effector
D. Sensory Neuron- Receptor-Motor Neuron-Spinal Cord-Effector

40 Insectivorous plants digest insects to get an essential nutrient. Other plants generally get this nutrient from the soil. What is this nutrient?

A. Oxygen
B. Nitrogen
C. Carbon dioxide
D. Phosphates