Indian National Astronomy Olympiad – 2008

Junior Category
Model Solutions

Roll Number: ☐

INAO – 2008
Duration: **Three Hours**

Date: 2nd February 2008
Maximum Marks: 100

Please Note:

- The examination consists of three parts. This question booklet containing parts A and B should be returned to invigilators at the end of 2.5 hours. At that time, second question booklet containing part C of the paper will be given to you. You will get 30 minutes to solve part C.
- In part A and part C, there are 20 multiple choice questions each. For each question, only one of the four alternatives is correct. Mark the correct answer on the answer sheet provided separately. Each correct answer adds +3 marks to your score. **In part A, every wrong answer carries penalty of -1 marks.** There is no negative marking in part C.
- In part B, there are 4 analytical questions of 10 marks each. The answer to each question must be written in the blank space provided below each question.
- For the rough work, use the page(s) marked as rough sheet.
- Only non-programmable calculators are allowed.
- Return BOTH the question paper booklets and the answer sheet to the invigilator. DO NOT TAKE THIS BOOKLET BACK WITH YOU.

Please fill in all the data below correctly. The contact details provided here would be used for all further correspondence.

Full Name (BLOCK letters) Ms. / Mr.: _____

_____

Male / Female Date of Birth (dd/mm/yyyy): _____

Name of the school / junior college: _____

_____

Class: VIII / IX / X / XI Board: ICSE / CBSE / State Board / Other

Full Residential address (include city and PIN code): _____

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HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
Tata Institute of Fundamental Research
V. N. Purav Marg, Mankhurd, Mumbai, 400 088

Instructions for using the answersheet:

- Write the name at the top of the answer sheet.
- On the left side there is space provided for roll number. Write your INAO roll number in the squares with exactly one digit per square.
- Below each of the digits of roll number, mark corresponding digit by a cross mark ('X'). i.e. if your roll number is 40001, then you will put X on 4, 0, 0, 0 and 1 in the corresponding columns.
- Below the roll number, you should mark your preference for Either Astronomy camp or Junior Science Camp by putting a cross mark ('X') in the corresponding box. **Mark only one box indicating your 1^{st} preference**. You will be automatically considered for the second preference if the 1^{st} choice is not available.
- Use only black or blue pen to put 'X' marks on the answersheet. **Do not use any other ink or pencil.**

Useful Physical Constants

Mass of Earth	M_E	$\approx$	5.97×10^{24} kg
Radius of Earth	R_E	$\approx$	6.4×10^{6} m
Mass of Sun	$M_\odot$	$\approx$	1.99×10^{30} kg
Radius of Sun	$R_\odot$	$\approx$	7×10^{8} m
Speed of Light	c	$\approx$	3×10^{8} m/s
Astronomical Unit	1 A. U.	$\approx$	1.5×10^{11} m
Gravitational Constant	G	$\approx$	6.67×10^{-11} $m^3/(Kg\ s^2)$
Gravitational Acceleration	g	$\approx$	$9.8\ m/s^2$
Speed of Sound (at room temperature in air)	c_s	$\approx$	340 m/s

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Space for Rough Work

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Part A: Multiple Choice Questions

1. The unit on a graph paper is changed in scale from 1 cm to 1 inch. What will be the change in area of the unit cell?

   (a) 84% (b) 254% (c) **545%** (d) 645%

2. Of the Galilean Moons, which is the *farthest* from Jupiter?

   (a) Io (b) Europa (c) Ganymede (d) **Callisto**

3. When you stand on the ground, what is the distance of the horizon from you?

   (a) 500 km (b) **5 km** (c) 15 km (d) 50 km

4. A regular barometer is thrown from the top of a building.If the barometer is freely falling, what will be the height of the mercury column?

   (a) **100 cm** (b) 76 cm (c) 50 cm (d) 0 cm

5. P. Eclipses are not distributed evenly throughout the year, but happen only in certain months of a given year.
   Q. Orbit of the Moon (around the Earth) makes an angle of roughly 5 degrees to the orbit of Earth (around Sun).
   Which of the following options is correct?

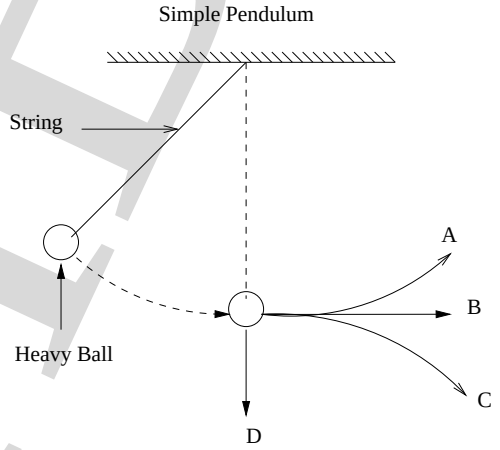
   (a) Statement 'P' is correct but 'Q' is incorrect.

   (b) Statement 'P' is incorrect but 'Q' is correct.

   (c) **Both the statements are correct and 'Q' is the correct reason of 'P'.**

   (d) Both the statements are correct and 'Q' is not the reason of 'P'.

6. When the ball at the end of the string swings to its lowest point, the string is cut by a sharp knife as shown. Assuming no air resistance, what will be the path of the ball?



(a) A (b) B (c) C (d) D

The answer is **(c)**.

7. If we ever make contact with aliens, which of our fundamental units is likely to match theirs? (In other words, which of these units is universally fundamental?)

   (a) Kelvin (b) Light year (c) a.m.u. (Atomic Mass Unit) (d) **None of these**

8. If the person beats drum on the Earth and an astronaut beats an identical drum in *space*, what will be the differences in the effects?

   (a) There will be no vibration in the drum in space.

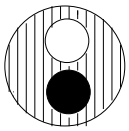
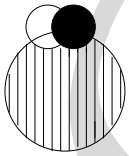
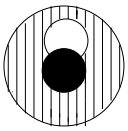
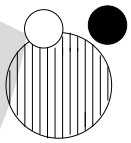
   (b) **There will be vibration in space but no sound.**

   (c) The drum on Earth will vibrate for a longer time than the one in space.

   (d) There will be no difference in terms of the vibrations or sound.

9. Which of the following Venn diagrams would be BEST suited to represent the three categories of animals?

   - Animals that give us *MEAT*
   - Animals that give us *EGGS*
   - Animals that give us *MILK*

   (a)  (b)  (c)  (d)  The answer is **(a)**.

10. P: Gravitational force exerted by Saturn on a human being is approximately same as that exerted by another human being standing a few cm away.
    Q. Saturn has very low density.
    (Additional data: Mass of Saturn $= 5 \times 10^{26}$ kg, Distance of Saturn $= 1.4 \times 10^{9}$ km)

    (a) Statement 'P' is correct but 'Q' is incorrect.

    (b) Statement 'P' is incorrect but 'Q' is correct.

    (c) Both the statements are correct and 'Q' is the correct reason of 'P'.

    (d) **Both the statements are correct and 'Q' is not the reason of 'P'.**

11. For the Earth, if the perihelion were 147 million km, approximately what will be the aphelion for the Earth?
    Aphelion: Point farthest from the Sun in the orbit of a body about the Sun.
    Perihelion: Point nearest from the Sun in the orbit of a body about the Sun.

    (a) About 2 times the Perihelion, 300 million km

    (b) About 3 times the Perihelion, 450 million km

    (c) **Slightly more than the perihelion, about 155 million km**

    (d) Exactly the same as the perihelion, 147 million km

12. A star is seen rising from Kolkata (23.5 °N 92 °E) at 7:00 pm IST, at what time IST will it be seen to rise from Mumbai (19 °N 72 °E)?

    (a) 5:40 pm (b) 7:00 pm (c) 7:20 pm (d) **8:20 pm**

13. To separate various components of air, the principle that different gases have different ..... can be used.

    (a) **Boiling Points** (b) Density (c) Color (d) Molecular weight

14. How many zeros will be as the ending digits of 120! ? ($120! = 1 \times 2 \times ..... \times 119 \times 120$)

    (a) 25 (b) 26 (c) 27 (d) **28**

    Note: In the original paper, the choices given had typographical errors. Thus, the correct answer 28 was not listed amogst the options. As a result the said question was removed from evaluation.

15. A nutty professor discovers a way to shrink objects in size using lasers and mistakenly shrinks his three teenage kids by a factor of 100. These kids then stray away into the garden where they see their pet dog. How many of the kids can climb onto the dog to get a ride home if the dog can bear a weight of 20 kg?

    (a) **None** (b) One (c) Two (d) All

16. Which of the following is true?

    (a) $\cos 80^\circ = -\sin 10^\circ$

    (b) $\cos 120^\circ = -\cos 240^\circ$

    (c) $\sin 135^\circ = -\sin 270^\circ$

    (d) $\sin 330^\circ = \sin 210^\circ$

    The answer is **(d)**.

17. A battery is connected by wires to a bulb as shown below and the bulb glows. Through which points does the charge flow?

    (a) **1-2-3-4-1. Charge flows through the battery also.**

    (b) 1-2-3-4. Charge flows through the wires and bulb only.

    (c) 2-3.Charge flows only through the bulb.

    (d) There is no flow of the charge in the circuit.

18. Every object exerts gravitational force on every other object - The *force* exerted by an object is higher if its *mass* is higher. Consider 2 magnets - a bigger magnet P and a smaller one Q. Which of the following will be true?

(a) Magnet P will exert a greater magnetic force than Q.

(b) **The magnetic forces exerted by P and Q will be the same.**

(c) Magnet Q will exert a greater magnetic force than P.

(d) We cannot tell from the sizes, as gravity and magnetism are unrelated.

19. What is the value of 'F' in the following equation if A, B, C, D, E and F are non-zero numbers?
ABCDEF $\times$ 6 = DEFABC

(a) 1 (b) 3 (c) 5 (d) **7**

20. On a cold winter day, if I stand on the edge of a carpet with one foot on the carpet and one on the smooth granite floor surface, which foot is likely to feel colder and why?

(a) **The foot on the granite as it will absorb heat away from the foot more quickly.**

(b) The foot on the carpet as it will absorb heat away from the foot more quickly.

(c) The foot on the granite because the granite is at a lower temperature.

(d) The foot on the carpet because the carpet is at a lower temperature.

Part B: Analytical Questions

21. A year in Solar calendar consists of 365 days and the same in Lunar calendar consists of 354 days. The additional days in Solar calendar are kept as balance every year. Whenever the number of balance days exceeds 30, an additional month of 30 days is added to the lunar year to offset the difference. The cycle goes on. Anwesh, whose birthday falls on 1st January, noticed that in the year 2008, his birthday coincided with the start of the lunar year. In which earliest future year, his birthday will again coincide with the start of the lunar year? (Ignore leap days.)

Solution: Every year the Solar year lags by 11 days.
Intercalary days are compensated by a month whenever they exceed 30 days.
Thus, one has to finde L.C.M. of 11 and 30.
L.C.M. is 330. i.e. after 330 intercalary days are introduced, both calenders will match.
i.e. they will match after 30 years.
Thus, his birthday in **2038** will again mark start of the lunar calander.

Note: Brute force method should not be given more than 7 marks.

22. When R_1 and R_2 are connected in *series*, the current in the circuit is 2A. When R_1 and R_2 are connected in *parallel*, the current in the circuit is 4A. Find the values of R_1 and R_2.

Solution: For a given V,

$$\begin{aligned} V &= I_A(R_1+R_2) \\ &= I_B\frac{R_1R_2}{(R_1+R_2)} \\ 2(R_1+R_2) &= 4\frac{R_1R_2}{(R_1+R_2)} \\ (R_1+R_2)^2 &= 2R_1R_2 \\ R_1^2+R_2^2 &= 0 \end{aligned}$$

The said conditions cannot be true.
Note: Problem is solvable if one assumes non-zero internal resistance for the battery. Those who reach till previous step, get 9 out of 10. Last point is reserved for those who take internal resistance into account.

23. You are given two lenses of focal lengths f_1 and f_2 respectively.

    (a) Is it possible to arrange them in such a way that both incident beam and emergent beam of light will be parallel beams for the following cases?

        1. One concave and one convex lens
        2. Both convex lenses

        Draw the ray diagrams.

    (b) Are the incident and emergent beams parallel to each other?

    (c) By observing the ray diagrams, state the condition on the distance 'd' between the two lenses in terms of f_1 and f_2.

Solution:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

d is the distance between the two lenses.
If the incident beam as well as the emerging beam are parallel beams, then $\frac{1}{f} = 0$ which gives the condition, $d = f_1 + f_2$
If one lens is concave and other convex, it will become, $d = f_1 - f_2$
Thus, it is only possible if focal length of the convex lens is more than that of the concave lens.
If both lenses are convex, d is always positive. Hence it is always possible.

Note: The ray diagrams should be such that above relations could be inferred by measuring respective lengths on the ray diagrams.

The two beams will be parallel to each other if both lenses are parallel to each other. Knowledge of the first equation is not expected. Students should inferr the $d = f_1 + f_2$ relation by purely observing ray diagrams.

24. If Aniket starts drawing a straight line with a brand new typical ball-point pen, how long line can be drawn before he finishes his refill? Explicitly state all the assumptions you make.

Solution: A typical ball pen refill has length of 12 cm.
(Acceptable 10-15 cm)
Typical refill diameter is 1 mm.
(Acceptable 0.5 - 2 mm)
Hence Total volume of ink is $\pi\, r^2\, h = \pi(0.05)^2 \times 12$ cc
$V \approx 0.1$ cc
Typical thickness of writing is of the size of finite number of molecules.
Size of one ink molecule can be taken to be 0.5 - 1nm.
Hence the thickness would be roughly 10nm.
(Acceptable 1-100 nm)
Typical width is half of refill diameter.
Thus, length,

$$l = \frac{V}{t\, d} = \frac{\pi\, r^2\, h}{2t\, r} = \frac{\pi \times 0.05 \times 12}{2 \times 10 \times 10^{-7}} cm$$

$l \approx 9.5$ km.

Note: Answer is not important for this order of magnitude estimation question. Approach to the problem should be judged for marks.

Part C: Multiple Choice Questions

Roll Number:

25. Resting membrane potential difference is a negative value which means:
    (a) No charge outside and negative charge inside of the membrane
    (b) **Positive charge outside and more negative charge inside of the membrane**
    (c) Zero charge inside and negative charge outside of the membrane
    (d) Positive charge inside and more negative charge outside of the membrane

26. Nerve impulse is...
    (a) Flow of electrons across the axon
    (b) **Change in ionic constitution across the membrane**
    (c) Flow of neuro-transmitters across the axon
    (d) Change in pressure across the axon

27. Bitter substances can be tasted in minute amounts but larger amounts are needed to taste sweet substances. Based on this observation which of the following reasons is more appropriate?
    (a) **The bitter receptors are more sensitive than the sweet receptors**
    (b) The bitter receptors are less sensitive than the sweet receptors
    (c) The bitter substances dissolve more easily than the sweet substances
    (d) There are more bitter receptors in mouth than the sweet receptors

28. Gustatory cells are stimulated by
    (a) **Dissolved chemicals**
    (b) Pressure
    (c) Temperature
    (d) Texture

29. The cornea of one person can be transplanted from one person to another with little or no possibility of rejection as it is beyond the reach of immune system because...
    (a) **The cornea has no blood vessels**
    (b) The cornea is a dead tissue
    (c) The cornea has no nerve endings
    (d) The cornea kills the cells of immune system

30. Find out the mismatched pair in the following combinations.
    (a) Nearsightedness — longer than normal eyeball
    (b) Farsightedness — shorter than normal eyeball
    (c) **Myopia — loosened-up extrinsic eye muscles**
    (d) Astigmatism — cylindrical lens

31. Which sequence of events occur when a person looks at a star at night
    (a) pupils constrict → suspensory ligaments relax → lenses become less convex
    (b) **pupils dilate → suspensory ligaments become taut → lenses become less convex**
    (c) pupils dilate → suspensory ligaments become taut → lenses become more convex
    (d) pupils constrict → suspensory ligaments relax → lenses become more convex

32. Which nervous system conducts impulses from CNS to voluntary muscles?
    (a) **Motor division of PNS**
    (b) Sensory division of PNS
    (c) Sympathetic division
    (d) Parasympathetic division

33. The rate of a simple chemical reaction normally decreases as the reaction approaches completion. This is because
    (a) The reactant molecules individually become less active
    (b) With the progress of the reaction, the temperature goes down and hence the reaction slows down
    (c) The products inhibit the reaction
    (d) **The concentration of the reactants decreases**

34. **Froth flotation** is generally used for the ore dressing of
    (a) Oxide ores (b) Carbonate ores (c) Phosphate ores (d) **Sulfide ores**

35. The atomic property which is ***not*** periodic is
    (a) Atomic radius
    (b) **Mass number**
    (c) Electronegativity
    (d) Ionization energy

36. The largest number of molecules is present in 1 g of
    (a) CO_2 (b) H_2O (c) C_2H_5OH (d) N_2O_5
    The answer is **(c)**.

37. An isotope of the parent element is produced with the emission of
    (a) one α- and one β- particle
    (b) **one α- and two β- particles**
    (c) two α- and one β- particles
    (d) two α- and two β- particles

38. A compound was found to contain nitrogen and oxygen in the ratio nitrogen 28 g and oxygen 80 g. The formula of the compound is

    (a) NO (b) N_2O_3 (c) N_2O_5 (d) N_2O_4

    The answer is **(c)**.

39. Acetic acid is a weak electrolyte because

    (a) Its molecular mass is high

    (b) It is a covalent compound

    (c) It is highly unstable

    (d) **Its ionization is very small**

40. A certain current when passed through a $CuSO_4$ solution for 100 seconds, deposits 0.3175 g of copper. The current passed (in A) is

    (a) 4.83 (b) **9.65** (c) 0.965 (d) 0.483

41. For the redox reaction, the correct coefficients of the **reactants** for the balanced reaction are

$$MnO^{4-} + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$$

    (a) **2 5 16**

    (b) 16 5 2

    (c) 5 16 2

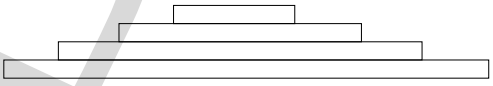
    (d) 2 16 5

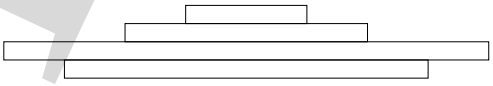
    Note: In the original paper, there were typographical errors in the chemical equation. Thus, the question was removed from evaluation.

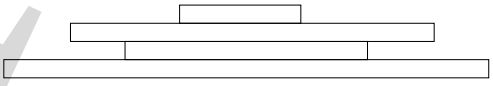
42. The pH of 0.1M CH_3COOH (dissociation constant of acetic acid is 1.80×10^5 at 25 ° C) will be

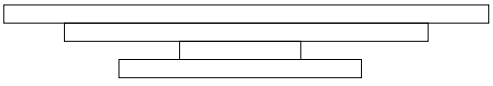
    (a) 1.0 (b) **2.9** (c) 1.8 (d) 0.2

43. Which kind of number pyramid will fit for the following example?
    Grass — Deer — Flea — Leptomonas (parasite of flea).

    (a) 

    (b) 

    (c) 

    (d) 

    The answer is **(d)**.