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ESE 2024 : Prelims Exam
CLASSROOM TEST SERIES

GS & ENGINEERING APTITUDE

Test 3

Section A : Basics of Energy and Environment
Section B : Basic of Material Science
Section C : Engineering Mathematics + Reasoning & Aptitude

ANSWER KEY

1.	(c)	11.	(c)	21.	(d)	31.	(b)	41.	(b)
2.	(d)	12.	(b)	22.	(d)	32.	(b)	42.	(d)
3.	(c)	13.	(a)	23.	(a)	33.	(b)	43.	(d)
4.	(c)	14.	(a)	24.	(d)	34.	(c)	44.	(a)
5.	(d)	15.	(b)	25.	(b)	35.	(c)	45.	(b)
6.	(a)	16.	(b)	26.	(a)	36.	(a)	46.	(c)
7.	(a)	17.	(d)	27.	(d)	37.	(b)	47.	(a)
8.	(b)	18.	(c)	28.	(b)	38.	(c)	48.	(d)
9.	(c)	19.	(c)	29.	(a)	39.	(b)	49.	(d)
10.	(b)	20.	(a)	30.	(d)	40.	(d)	50.	(b)

DETAILED EXPLANATIONS

1.   **(c)**

- Ecotone is a zone of junction between two or more diverse ecosystems. For example, the mangrove forests represent an ecotone between marine and terrestrial ecosystem.
- It may be very narrow or quite wide, but not larger than a biome which is a much larger entity.
- Well-developed ecotones contain some organisms which are entirely different from that of the adjoining communities.

3.   **(c)**

Sources of pollution from POPs include the improper use and disposal of agrochemicals and industrial chemicals, elevated temperatures and combustion processes, and unwanted by-products of industrial processes or combustion.

4.   **(c)**

- Succession is a universal process of directional change in vegetation on an ecological time scale.
- Succession occurs when a series of communities replace one another due to large scale destruction either natural or manmade. This process continues – one community replacing another community, until a stable, mature community develops.

5.   **(d)**

- Primary microplastics include microbeads found in personal care products, plastic pellets (or nurdles) used in industrial manufacturing, and plastic fibres used in synthetic textiles (e.g., nylon). They enter the environment directly through any of various channels—for example, product use (e.g., personal care products being washed into wastewater systems from households), unintentional loss from spills during manufacturing or transport, or abrasion during washing (e.g., laundering of clothing made with synthetic textiles).
- Secondary microplastics form from the breakdown of larger plastics; this typically happens when larger plastics undergo weathering, through exposure to, for example, wave action, wind abrasion, and ultraviolet radiation from sunlight.

6.   **(a)**

- Biosparging is an in-situ remediation technique that supplies oxygen and nutrients to contaminated soils to promote aerobic biodegradation of contaminants.
- Bioaugmentation is defined as the introduction of cultured microorganisms into a contaminated environment in order to enhance bioremediation of pollutants.

10.   **(b)**

- Eutrophication is when a body of water becomes overly enriched with minerals and nutrients which induce excessive growth of algae. This process may result in oxygen depletion of the water body. One example is an algal bloom or great increase of phytoplankton in a water body as a response to increased levels of nutrients.
- Eutrophication is often induced by the discharge of nitrate or phosphate-containing detergents, fertilizers, or sewage into an aquatic system.

14. (a)
- Invasive alien species are animals, plants or other organisms that are introduced by humans, either intentionally or accidentally, into places outside of their natural range, negatively impacting native biodiversity, ecosystem services or human economy and well-being.
- The Kunming-Montreal Global Biodiversity Framework, which aims to halt and reverse biodiversity loss by 2030, was adopted in December 2022 at the 15th meeting of the Conference of the Parties to the Convention on Biological Diversity.

16. (b)
- Methane is one of the main drivers of climate change, responsible for 30 per cent of the warming since preindustrial times, second only to carbon dioxide.
- Over a 20-year period, methane is 80 times more potent at warming than carbon dioxide, according to a report by the United Nations Environment Programme.

18. (c)
- The '21' in Agenda 21 refers to the 21st century.
- Agenda 21 is a non-binding action plan of the United Nations with regard to sustainable development.
- It is a product of the Earth Summit (UN Conference on Environment and Development) held in Rio de Janeiro, Brazil, in 1992.

19. (c)
Biomagnification, also known as bioamplification or biological magnification, is the increasing concentration of a substance, such as a toxic chemical, in the tissues of tolerant organisms at successively higher levels in a food chain.

20. (a)
- The COP is the supreme decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC).
- All States that are Parties to the Convention are represented at the COP, at which they review the implementation of the Convention and any other legal instruments that the COP adopts and take decisions necessary to promote the effective implementation of the Convention, including institutional and administrative arrangements.
- A key task for the COP is to review the national communications and emission inventories submitted by Parties. Based on this information, the COP assesses the effects of the measures taken by Parties and the progress made in achieving the ultimate objective of the Convention.

22. (d)
Ocean acidification refers to a reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO_2) from the atmosphere. Nitrogenous compounds contribute fraction to ocean acidification.

26. (a)
- Coarse-grained materials exhibit better creep resistance than fine-grained ones, as fine-grained metals have a great amount of grain boundary materials and grain boundaries behave as a quasi-viscous material with a high tendency to flow at elevated temperatures.

- Resilience is the capacity of a material to absorb energy when it is elastically deformed and then upon unloading, to have the energy recovered.
- Statement 3 is correct for modulus of resilience.

27. (d)

Grey cast iron has high fluidity and ability to make sound castings, it possesses excellent casting qualities for producing simple and complex shapes.

28. (b)

Low carbon steel is an alloy of iron and carbon. The carbon content varies from 0.05 to 0.15% for dead mild steel and 0.15 to 0.3% for mild steel.

29. (a)

Austenitic stainless steels contains 0.03 to 0.25% C, 2 to 10% Mn, 16 to 26% Cr, 3.5 to 22% Ni and other elements. They possess the highest corrosion resistance among all the stainless steels. They retain ductility at temperature approaching absolute zero. They are useful in applications such as aircraft industry, chemical processing, food processing, household items, dairy industry, transportation etc.

30. (d)

Muntz metal is an alloy of 60% copper, 40% zinc and some traces of iron. The purpose of adding alloying elements to copper is to optimize the strength, ductility and thermal stability without inducing unacceptable loss in fabric ability, electrical/thermal conductivity or corrosion resistance.

31. (b)

Polymers have good corrosion resistance. They have poor mechanical properties. But it can however be improved by fibre reinforcement of plastics.

32. (b)

$$\text{Density of the metal, } \rho = \frac{n \times M}{a^3 \times N_A}$$

$$\text{or} \qquad n = \frac{\rho \times a^3 \times N_A}{M}$$

We have, $\rho = 8.4$ gm/cc, $a = 3.2 \times 10^{-8}$ cm, $N_A = 6.023 \times 10^{23}$, $M = 56$

$$\therefore \qquad n = \frac{8.4 \times \left(3.2 \times 10^{-8}\right)^3 \times 6.023 \times 10^{23}}{56}$$

$$= 2.96 \simeq 3$$

33. (b)

Magnetic susceptibility (X) and relative permeability (μ_r) are related as

$$X = \mu_r - 1$$

For diamagnetic materials, $\mu_r < 1$. Hence, the magnetic susceptibility can be negative also.

34. (c)
In semiconductor, current flow is due to drift and diffusion. Displacement current flows in a dielectric under alternating field.

35. (c)
- Quartz is a piezoelectric material used for high frequency oscillation. It's unique structure, allows it to generate a high level of electric charge in response to mechanical stress.
- ZnO is a piezoelectric material as well as a wide band gap semiconductor.

36. (a)
Polystyrene has highest dielectric strength among all the given options.

37. (b)
x_m is negative for diamagnetic material and as long as the electronic structure of the material is independent of temperature, the diamagnetic susceptibility is also essentially independent of temperature.

38. (c)
- Soft magnetic materials are used in making electromagnets because they are easy to magnetize and demagnetize. This is because they have a low coercivity, which is the ability of a ferromagnetic material to withstand an external magnetic field without becoming demagnetized.
- Hard magnetic materials have a high coercive field.

39. (b)
Let

$$\text{Total population} = x$$

$$\text{Then, number of males} = \frac{5}{9}x$$

$$\text{Married males} = 30\% \text{ of } \frac{5}{9}x = \frac{x}{6}$$

$$\text{Married females} = \frac{x}{6}$$

$$\text{Number of females} = x - \frac{5}{9}x = \frac{4x}{9}$$

$$\text{Unmarried females} = \frac{4x}{9} - \frac{x}{6} = \frac{5x}{18}$$

$$\therefore \quad \text{Required percentage} = \left(\frac{5x}{18} \times \frac{1}{x} \times 100\right)\% = 27\frac{7}{9}\%$$

40. (d)
Let Sunita's present age be x years.

$$\text{Then, Reena's present age} = 2x \text{ years}$$

$$\text{Three years ago, Sunita's age} = (x - 3) \text{ years and}$$

$$\text{Reena's age} = (2x - 3) \text{ years}$$

So,
$$(2x - 3) = 3(x - 3)$$
$$2x - 3 = 3x - 9$$
$$x = 6$$

$$\therefore \quad \text{Reena's present age} = 2x = 12 \text{ years}$$

41.   **(b)**

The number must be in form

(L.C.M of 3, 4, 5, 6)x + 1 i.e. (60x + 1) and a multiple of 7.

Clearly for x = 5, the number is multiple of 7.

So, the number is 301.

42.   **(d)**

$$\frac{2.32^3 + 1.44^3 + 2.88^3 - 3 \times 2.32 \times 1.44 \times 2.88}{2.32^2 + 1.44^2 + 4 \times 1.44^2 - 2 \times 1.44^2 - 2.32 \times 1.44 - 2.32 \times 2.88}$$

$$= \frac{2.32^3 + 1.44^3 + 2.88^3 - 3 \times 2.32 \times 1.44 \times 2.88}{2.32^2 + 1.44^2 + 2.88^2 - 2.88 \times 1.44 - 2.32 \times 1.44 - 2.32 \times 2.88}$$

$$\Rightarrow \qquad \frac{a^3 + b^3 + c^3 - 3abc}{a^2 + b^2 + c^2 - ab - bc - ca} \;=\; a + b + c$$

$$= 2.32 + 1.44 + 2.88 \;=\; 6.64$$

43.   **(d)**

Let equal sides of the isosceles triangle be x,

Then $\qquad\qquad\qquad\qquad x^2 + x^2 \;=\; 10^2$

$$x \;=\; 5\sqrt{2} \text{ cm}$$

So, $\qquad\qquad$ Final area $= 8 \times \left(\dfrac{1}{8} \times \pi \times 10^2 - \dfrac{1}{2} 5\sqrt{2} \times 5\sqrt{2} \right)$

$$= \pi \times 10^2 - 4 \times 25 \times 2$$

$$= 100\pi - 200$$

$$\text{Area} \;=\; 114.16 \text{ cm}^2$$

44.   **(a)**

Given: $z = 4 - i$

$$\left| \frac{z-2}{z+1} \right| \;=\; \left| \frac{4-i-2}{4-i+1} \right| = \left| \frac{2-i}{5-i} \right| = \left| \frac{(2-i)(5+i)}{(5-i)(5+i)} \right|$$

$$= \left| \frac{10 + 2i - 5i - i^2}{25 - i^2} \right| = \left| \frac{11 - 3i}{26} \right| = \frac{\sqrt{11^2 + 3^2}}{26}$$

$$= \frac{\sqrt{130}}{26} = \sqrt{\frac{5}{26}}$$

45.   **(b)**

Tossing a fair coin n times is a binomial experiment.

The probability of getting a head, $p = \dfrac{1}{2}$.

The probability of not getting a head, $q = \dfrac{1}{2}$

Probability of getting no heads in n tosses,

$$p(x = 0) = {}^nC_0 p^0 q^n$$

$$\therefore \qquad {}^nC_0 p^0 q^n > 0.1$$

$$\left(\frac{1}{2}\right)^n > 0.1$$

$$2^n < 10$$

46. (c)

$$\vec{A} \cdot \vec{B} = |A||B|\cos\theta$$

Since, $\cos\theta \le 1$, hence dot product is less than or equal to the product of magnitudes of two vectors.

47. (a)

Characteristic equation $|A - \lambda I| = 0$

$$\begin{vmatrix} 2-\lambda & 1 & 1 \\ 0 & 1-\lambda & 0 \\ 1 & 1 & 2-\lambda \end{vmatrix} = 0$$

$$(2 - \lambda)[(1 - \lambda)(2 - \lambda)] - 1(0) + 1(0 - 1 + \lambda) = 0$$

$$\lambda^3 - 5\lambda^2 + 7\lambda - 3 = 0$$

$$\lambda_1 = 1, \lambda_2 = 1 \text{ and } \lambda_3 = 3$$

For the matrix, $A^3 - 5A^2$, eigen values are obtained as

$$\lambda_1^1 = \lambda_1^3 - 5\lambda_1^2 = 1 - 5 = -4$$

$$\lambda_2^1 = \lambda_2^3 - 5\lambda_2^2 = 1 - 5 = -4$$

$$\lambda_3^1 = \lambda_3^3 - 5\lambda_3^2 = 3^3 - 5(3)^2 = -18$$

Hence, $\qquad \left(\lambda_1^1\right)^2 + \left(\lambda_2^1\right)^2 + \left(\lambda_3^1\right)^2 = 16 + 16 + 324$

$$= 356$$

48. (d)

$$|A + B| \ne |A| + |B|$$

49. (d)

$$\int_{-\infty}^{\infty} f(x)\,dx = 1$$

$$\int_{-\infty}^{0} 0\,dx + \int_{0}^{2} A\left(2x - 3x^2\right)dx + \int_{2}^{\infty} 0\,dx = 1$$

$$A\int_{0}^{2}\left(2x - 3x^2\right)dx = 1$$

$$A\left[\frac{2x^2}{2} - \frac{3x^3}{3}\right]_0^2 = 1$$

$$A\left[x^2 - x^3\right]_0^2 = 1$$

$$A[4 - 8] = 1$$

$$A = -\frac{1}{4}$$

So,

$$f(x) = \begin{cases} \dfrac{(3x^2 - 2x)}{4}; & 0 \le x \le 2 \\ 0 & \text{Otherwise} \end{cases}$$

Hence, required probability

$$P(x > 1) = \int_1^2 \frac{(3x^2 - 2x)}{4} dx + \int_2^\infty 0\, dx$$

$$= \frac{1}{4}\left[x^3 - x^2\right]_1^2$$

$$= \frac{1}{4}\left[(8 - 1) - (4 - 1)\right]$$

$$= \frac{1}{4} \times 4 = 1$$

50.   (b)

$$\text{grad } \phi = \frac{\partial \phi}{\partial x}\hat{i} + \frac{\partial \phi}{\partial y}\hat{j} + \frac{\partial \phi}{\partial z}\hat{k}$$

$$\text{grad } \phi = yz^2\hat{i} + xz^2\hat{j} + 2xyz\hat{k}$$

$$\text{grad } \phi\big|_{\text{at }(1,\,0,\,3)} = 0\hat{i} + 9\hat{j} + 0\hat{k} = 9\hat{j}$$

$$\text{Greatest rate of increase of } \phi = \left|\nabla\phi\right| = \sqrt{9^2} = 9$$

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