Properties of Solids and Liquids JEE Main PYQ - 2

Total Time: 25 Minute **Total Marks:** 40

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Properties of Solids and Liquids

1. A metal ball of mass $0.1\,kg$ is heated upto $500^{\circ}C$ and dropped into a vessel of heat capacity $800\ JK^{-1}$ and containing $0.5\,kg$ water. The initial temperature of water and vessel is $30^{\circ}C$. What is the approximate percentage increment in the temperature of the water ? [Specific Heat Capacities of water and metal are, respectively, $4200\ Jkg^{-1}K^{-1}$ and $400\ JKg^{-1}K^{-1}$] **(+4, -1)**

[11 Jan. 2019 II]

a. 30%

b. 20%

c. 25%

d. 15%

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2. A pendulum clock loses $12\,s$ a day if the temperature is $40^{\circ}C$ and gains $4\,s$ a day if the temperature is $20^{\circ}C$. The temperature at which the clock will show correct time, and the co-efficient of linear expansion (α) of the metal of the pendulum shaft are respectively : **(+4, -1)**

a. $25^{\circ}C; \alpha = 1.85 \times 10^{-5}/^{\circ}C$

b. $60^{\circ}C; \alpha = 1.85 \times 10^{-4}/^{\circ}C$

c. $30^{\circ}C; \alpha = 1.85 \times 10^{-3}/^{\circ}C$

d. $55^{\circ}C; \alpha = 1.85 \times 10^{-2}/^{\circ}C$

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3. A rod, of length L at room temperature and uniform area of cross section A, is made of a metal having coefficient of linear expansion $\alpha/^{\circ}C$. It is observed that an external compressive force F, is applied on each of its ends, prevents any change in the length of the rod, when its temperature rises by $\Delta T K$. Young's modulus, Y, for this metal is : **(+4, -1)**

[9 Jan. 2019 I]

a. $\frac{F}{2A\alpha\Delta T}$

b. $\frac{F}{A\alpha(\Delta T-273)}$

c. $\frac{F}{A\alpha\Delta T}$

d. $\frac{2F}{A\alpha\Delta T}$

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4. A steel rail of length $5\,m$ and area of cross section 40 cm^2 is prevented from expanding along its length while the temperature rises by $10°C$. If coefficient of linear expansion and Young?s modulus of steel are $1.2 \times 10^{-5}\,K^{-1}$ and $2 \times 10^{11}\,Nm^{-2}$ respectively, the force developed in the rail is approximately : **(+4, -1)**

[Online April 9,2017]

a. $2 \times 10^7 N$

b. $1 \times 10^5 N$

c. $2 \times 10^9 N$

d. $3 \times 10^{-5} N$

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5. A thermometer graduated according to a linear scale reads a value x_0 when in contact with boiling water, and $x_0/3$ when in contact with ice. What is the temperature of an object in $0°C$, if this thermometer in the contact with the object reads $x_0/2$? **(+4, -1)**

[11 Jan. 2019 II]

a. 35

b. 25

c. 60

d. 40

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6. A uniform cylindrical rod of length L and radius r, is made from a material whose Young's modulus of Elasticity equals Y. When this rod is heated by temperature T and simultaneously subjected to a net longitudinal compressional force F, its length remains unchanged. The coefficient of volume expansion, of the material of the rod, is (nearly) equals to : **(+4, -1)**

[12 April 2019 II]

a. $F/\left(3\pi r^2 YT\right)$

b. $3F/\left(\pi r^2 YT\right)$

c. $6F/\left(\pi r^2 YT\right)$

d. $9F/\left(\pi r^2 YT\right)$

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7. An experiment takes $10\,min$ to raise the temperature of water in a container from $0°C$ to $100°C$ and another $55\,min$ to convert it totally into steam by a heater supplying heat at a uniform rate. Neglecting the specific heat of the container and taking specific heat of water to be $1\,cal/g°C$, the heat of vaporisation according to this experiment will come out to be **(+4, -1)**

[Online April 11, 2015]

a. 530 cal/ g

b. 540 cal/g

c. 550 cal/g

d. 560 cal/g

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8. Ice at $-20°C$ os added tp $50\,g$ of water at $40°C$. When the temperature of the mixture reaches $0°C$, it is found that $20\,g$ of ice is still unmelted. The amount of ice added to the water was close to (Specific heat of water = $4.2\ J/g/°C$) Specific heat of Ice = $2.1\ J/g/°C$ Heat of fusion of water at $0°C = 334\ J/g$) **(+4, -1)**

[11 Jan. 2019 I]

a. 50 g

b. 40 g

c. 60 g

d. 100 g

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9. A certain pressure ' P ' is applied to 1 litre of water and 2 litre of a liquid separately Water gets compressed to 0.01% whereas the liquid gets compressed to 0.03% The ratio of Bulk modulus of water to that of the liquid is $\frac{3}{x}$ The value of x is ________ **(+4, -1)**

[1-Feb-2023 Shift 1]

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10. A Spherical ball of radius $1\,mm$ and density $10.5\,g/cc$ is dropped in glycerine of coefficient of viscosity 9.8 poise and density $1.5\,g/cc$ Viscous force on the ball when it attains constant velocity is $3696 \times 10^{-x} N$. The value of x is_______. (Given, $g = 9.8\,m/s^2$ and $\pi = \frac{22}{9}$) **(+4, -1)**

[24-Jan-2023 Shift2]

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Answers

1. **Answer: b**

Explanation:

$0.1?400?(500 - T) = 0.5 \times 4200 \times (T - 30) + 800(T - 30)$
$\Rightarrow \; 40(500 - T) = (T - 30)(2100 + 800)$
$\Rightarrow \; 20000 - 40T = 2900T - 30?2900$
$\Rightarrow \; 20000 + 30 \times 2900 = T(2940)$
$T = 30.4^{\circ}C$
$\frac{\Delta T}{T} \times 100 = \frac{6.4}{30} \times 100$
$\simeq$ 20 %

Concepts:

1. **Thermal Properties of Matter:**

Anything that has mass or occupies space in the universe is commonly known as matter. There are five properties of matters namely chemical, mechanical, thermal, dimensional, and physical properties.

Read More: Thermal Properties of Matter

Heat Capacity:

The quantity of heat needed to change the temperature of the matter by 1° is known as the heat capacity of a material. The temperature is indicated in kelvin or Celsius and the amount of heat is shown in calories or joules. Specific heat capacity or molar heat capacity is used to calculate the heat capacity of the matter with the stated dimension.

Linear expansion is the situation when change takes place in one dimension or dimensional.

Thermal Expansion:

When heat is passed through the material, the change in the area, volume, and shape is recognized as the thermal expansion property of the material. The expansion of the railway tracks due to maximal heat which leads to accidents is an example of thermal expansion.

Thermal Conductivity:

This property is interconnected to the conductivity of heat. The amount of heat regulated by the material is directly proportional to the conductivity of the material. Not all objects have the capacity to conduct heat throughout their bodies. Insulators are such objects which do not have the property to conduct heat throughout their body.

Thermal Stress:

The stress due to thermal contraction or expansion of the body is known as thermal stress. The explosion of materials takes place due to thermal stress which is dangerous. The cracks on the truck tyres are caused by an outcome of thermal stress. Trucks at high speed generate heat which is caused by the friction of the truck tyres and the road surface.

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2. Answer: a

Explanation:

Time loss or gain is given by

$\Delta t = \left(\frac{\Delta T}{T}\right) t = \frac{1}{2}\alpha.\Delta\theta.t$

$\therefore\ 12 = \frac{1}{2}\alpha\left(40 - \theta_0\right) \times 1d$ .....(1)

$4 = \frac{1}{2}\alpha\left(\theta_0 - 20\right) \times 1d$ .....(2)

$\frac{(1)}{(2)}$ gives

$3 = \frac{(40-\theta_0)}{(\theta_0-20)}$

Solving $\theta_0 = 25^{\circ}C$ and putting in (2)

$\alpha = \frac{8}{5\times29\times60\times60} =$

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3. **Answer: c**

Explanation:

Young's modulus $y = \frac{\text{Stress}}{\text{Strain}}$
$= \frac{F/A}{(\Delta\ell/\ell)}$
$= \frac{F}{A(\alpha\Delta T)}$

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4. **Answer: b**

Explanation:

$$F = yA \infty \Delta t$$
$$= 2 \times 10^{11} \times 40 \times 10^{-4} \times 1.2 \times 10^{-5} \times 10$$
$$= 9.6 \times 10^{4} = 1 \times 10^{5} \text{ N}$$

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5. **Answer: b**

Explanation:

$\Rightarrow T^\circ C = \frac{x_0}{6} \& \left(x_0 - \frac{x_0}{3}\right) = (100 - 0^\circ C)$

$x_0 = \frac{300}{2}$

$\Rightarrow T^\circ C = \frac{150}{6} = 25^\circ C$

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6. **Answer: b**

Explanation:

∴ Length of cylinder remains unchanged

so $\left(\frac{F}{A}\right)_{Compressive} = \left(\frac{F}{A}\right)_{Thermal}$

$\frac{F}{\pi r^2} Y\alpha T$

(α is linear coefficient of expansion)

$\therefore \ \alpha \frac{F}{YT\pi r^2}$

∴ The coefficient of volume expansion γ = 3α

$\therefore \ \gamma \ = \ 3\frac{F}{YT\pi r^2}$

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7. Answer: c

Explanation:

Let P be power of the heater
$P(10) = m \times 1 \times (100 - 0); P(55) = m\,L_v$
Dividing we get, $L_v = 550\,cal/g$

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8. **Answer: b**

Explanation:

Let amount of ice is m gm.
According to principal of calorimeter heat taken by ice = heat given by water
$\therefore\ 20 \times 2.1 \times m + (m - 20) \times 334$
$= 50 \times 4.2 \times 40$
376 m = 8400 + 6680
$m = 40.1$

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9. **Answer: 1 - 1**

Explanation:

The correct answer is 1.

B_{water} =(VΔV)−ΔP=1000.01−ΔP

B_{liquid} =1000.03−ΔP

$\frac{B_{liquid}}{B_{water}} = 3$

x=1

Concepts:

1. Mechanical Properties of Solids:

Mechanical properties of solids intricate the characteristics such as the resistance to deformation and their strength. Strength is the ability of an object to resist the applied stress, to what extent can it bear the stress.

Therefore, some of the mechanical properties of solids involve:

- **Elasticity:** When an object is stretched, it changes its shape and when we leave, it retrieves its shape. Or we can say it is the property of retrieving the original shape once the external force is removed. For example Spring
- **Plasticity:** When an object changes its shape and never attains its original shape even when an external force is removed. It is the permanent deformation property. For example Plastic materials.
- **Ductility:** When an object is been pulled in thin sheets, wires or plates, it will be assumed that it has ductile properties. It is the property of drawing into thin wires/sheets/plates. For example Gold or Silver
- **Strength:** The ability to hold out applied stress without failure. Many types of objects have higher strength than others.

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10. **Answer: 7 - 7**

Explanation:

The correct answer is 7.

$F_v = (mg - F_B)(\because a = 0)$

$= V\sigma_b g - V\rho_\ell g$

$= Vg(\sigma_b - \rho_\ell)$

$= \frac{4}{3}\pi(10^{-3})^3 \times 9.8(10.5 - 1.5) \times 10^3$

$= 3696 \times 10^{-7} N$

$So,\ x = 7$

Concepts:

1. Mechanical Properties of Fluid:

The science of the mechanical properties of fluids is called Hydrostatics. A fluid is a substance that relents to the slightest pressure. Fluids are categorized into two classes famed by the names of liquids, and elastic fluids or gases, which later comprehend the air of the atmosphere and all the different kinds of air with which chemistry makes us acquainted.

Streamline Flow:

A streamline is a curve the tangent to which at any point provides the direction of the fluid velocity at that point. It is comparable to a line of force in an electric or magnetic field. In steady flow, the pattern of the streamline is motionless or static with time, and therefore, a streamline provides the actual path of a fluid particle.

Tube of Flow:

A tubular region of fluid enclosed by a boundary comprises streamlines is called a tube of flow. Fluid can never cross the boundaries of a tube of flow and therefore, a tube of flow acts as a pipe of the same shape.

Surface Tension and Viscosity:

The surface tension of a liquid is all the time a function of the solid or fluid with which the liquid is in contact. If a value for surface tension is provided in a table for oil, water, mercury, or whatever, and the contacting fluid is unspecified, it is safe to consider that the contacting fluid is air.

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