# WEEKLY TEST MEDICAL PLUS -02 TEST - 10 Balliwala SOLUTION Date 15-09-2019

## [PHYSICS]

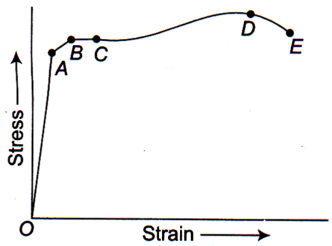
1. As stress is shown on $x$-axis and strain on $y$-axis

So we can say that $Y = \cot\theta = \frac{1}{\tan\theta} = \frac{1}{\text{slope}}$

So elasticity of wire $P$ is minimum and of wire $R$ is maximum.

2. In the region $OA$, the graph is linear showing that stress is proportional to the strain. Is proportional to the strain. Thus, in this region Hooke's law is obeyed.

The point $D$ on the graph is known as ultimate tensile strength.




The point $E$ on the graph is known as fracture point.

3. In ductile materials, yield point exist while in Brittle material, failure would occur without yielding.

4. $Y = \tan\theta$. According to figure $\theta_A > \theta_B > \theta_C$

i.e., $\tan\theta_A > \tan\theta_B > \tan\theta_C$

or $Y_A > Y_B > Y_C$

$\therefore$ $A$, $B$, and $C$ graph are for steel, brass and rubber respectively.

5. For a perfectly rigid body, both Young's modulus and bulk modulus is infinite.

6. From the given graph for a stress of $150 \times 10^6$ N m$^{-2}$ the strain is 0.002.

$\therefore$ Young's modulus $Y = \frac{\text{Stress}}{\text{Strain}}$

$$Y = \frac{150 \times 10^6}{0.002} \text{N m}^{-2} = 7.5 \times 10^{10} \text{N m}^{-2}$$

7. Initial length (circumference) of the ring = $2\pi r$
Final length (circumference) of the ring = $2\pi R$
Change in length = $2\pi R - 2\pi r$.

$$\text{Strain} = \frac{\text{change in length}}{\text{original length}} = \frac{2\pi(R-r)}{2\pi r} = \frac{R-r}{r}$$

Now Young's modulus $E = \frac{F/A}{l/L} = \frac{F/A}{(R-r)/r}$

$$\therefore \quad F = AE\left(\frac{R-r}{r}\right)$$

8. Tension in both string shall be same which can be observed by making FBD of string in figure (1)

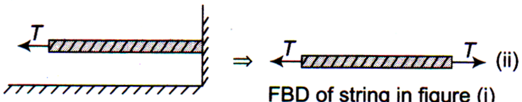


figure (i)
FBD of string in figure (i)

9. $Y = \frac{FL}{\pi r^2 l}$

$\therefore \quad l = \frac{FL}{\pi r^2 Y} \Rightarrow l \propto \frac{L}{r^2}$

$\therefore \frac{L}{r^2}$ is greatest for option $A$.

10. Let load put on the hanger is $F$, then stress in lower wire

$$S_1 = \frac{m_1 g + F}{0.003 \times 10^{-4}}$$

Let $S_1 = 8 \times 108\ \text{N/m}^2$, then

$$8 \times 10^8 = \frac{10 \times 10 + F}{3 \times 10^{-7}} \Rightarrow F = 140\ \text{N}$$

Let stress developed in upper wire is $S_2$, then

$$S_2 = \frac{(m_1 + m_2)g + F}{0.006 \times 10^{-4}}$$

11. Shearing strain $= \frac{\Delta x}{L}$

12. If coefficient of volume expansion is $\alpha$ and rise in temperature is $\Delta\theta$ then $\Delta V = V\alpha\Delta\theta \Rightarrow \frac{\Delta V}{V} = \alpha\Delta\theta$

Volume elasticity $\beta = \frac{P}{\Delta V/V} = \frac{P}{\alpha\Delta\theta} \Rightarrow \Delta\theta = \frac{P}{\alpha\beta}$

13. $\Delta V = 0.00004(200\text{ L}) = 0.008\text{ L}$

$$\Delta p = B\left(-\frac{\Delta V}{V}\right)$$

$$= (2100\text{ MPa})\left(\frac{0.008L}{200L}\right)$$

$$= 0.084\text{ MPa} = 84\text{ kPa}$$

14. If side of the cube is $L$ then $V = L^3 \Rightarrow \frac{dV}{V} = 3\frac{dL}{L}$

$\therefore$ % change in volume = 3 × (% change in length)

$$= 3 \times 1\% = 3\% \therefore \text{Bulk strain } \frac{\Delta V}{V} = 0.03$$

15. $B = \frac{\Delta p}{\Delta V/V} = \frac{h\rho g}{0.1/100} = \frac{200 \times 10^3 \times 9.8}{1/1000}$

$= 19.6 \times 10^8\text{ N/m}^2$

16. $K = \frac{\Delta p}{\Delta V/V} = \frac{(1.165 - 1.01) \times 10^5}{10/100} = \frac{0.155 \times 10^5}{1/10}$

$= 1.55 \times 10^5\text{ pa}$

17. Work done in stretching a wire .

$$W = \frac{1}{2}Fl = \frac{1}{2} \times 10 \times 0.5 \times 10^{-3} = 2.5 \times 10^{-3}\text{ J}$$

Work done to displace it through 1.5 mm

$$\text{W} = \text{F} \times \text{l} = 5 \times 10^{-3}\text{ J}$$

The ratio of above two work = 1 : 2

18. At extension $l_1$, the stored energy $= \frac{1}{2}Kl_1^2$

At extension $l_2$, the stored energy $= \frac{1}{2}Kl_2^2$

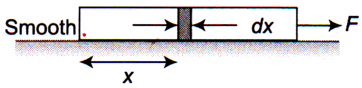
Work done in increasing its extension from $l_1$ to $l_2$

$$= \frac{1}{2}K(l_2^2 - l_1^2)$$

19. $U = \frac{1}{2} \times Y \times (\text{Strain})^2 = \frac{1}{2} \times 9 \times 10^{11} \times \left(\frac{1}{100}\right)^2$

$= 4.5 \times 10^7\text{ J}$

20. Tension, $T = \frac{F}{L_0} \cdot x\, x$




Stress, $\sigma = \frac{T}{A} = \frac{F}{AL_0} x$

$$dU = \frac{1}{2} \cdot \frac{\sigma^2}{Y} A dx = \frac{1}{2} \frac{F^2}{A^2 L_0^2} \cdot x^2 \frac{A}{Y} dx$$

or $$dU = \frac{F^2}{2A^2 L_0^2 Y} \cdot x^2 dx$$

$\Rightarrow$ $$U = \frac{F^2}{2AY L_0^2} \int_0^{L_0} x^2 dx$$

$$U = \frac{F^2}{2AY L_0^2} \cdot \frac{L_0^3}{3} = \frac{F^2 L_0}{6AY}$$

21. Work done in stretching the wire through 0.61 mm under the load of 3 kg wt.

$$W = \frac{1}{2} \text{ stretching force} \times \text{extension}$$

$$= \frac{1}{2} \times 3 \times 9.8 \times 0.61 \times 10^{-3}$$

$$= 8.967 \times 10^{-3} \text{ J}$$

Work done in stretching the wire through 1.02 mm under the load of 5 kg wt.

$$W_2 = \frac{1}{2} \times 3 \times 9.8 \times 1.02 \times 10^{-3}$$

$$= 34.99 \times 10^{-3} \text{ J}$$

Hence the work done in stretching the wire from 0.61 mm to 1.02 mm.

$$\Delta W = W_2 - W_1 = (24.99 - 8.961) \times 10^{-3}$$

$$= 16 \times 10^{-3} \text{ J}$$

22. The elastic potential energy per unit volume

$$= \frac{1}{2} \text{stress} \times \text{strain} = \frac{1}{2} Y \text{ strain} \times \text{strain}$$

$$= \frac{1}{2} Y (\text{strain})^2 = \frac{1}{2} Y \sigma^2$$

23. The energy stored per unit volume is

$$U = \frac{1}{2}\text{stress} \times \text{strain}$$

$$= \frac{1}{2}\text{stress} \times \frac{\text{strain}}{Y}$$

$$U = \frac{(\text{stress})^2}{2Y} = \frac{P^2}{Y}$$

So the correct choice is (b).

24. As the weight of wire acts at centre of gravity.

$\therefore$ Only half the length of wire gets extended.

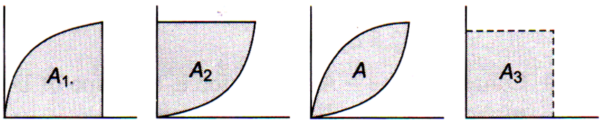
Now $Y = \frac{F}{A} \cdot \frac{(L/2)}{\Delta l} = \frac{Mg(L/2)}{A\Delta l}$

$\Rightarrow \quad \Delta l \frac{MgL}{2AY} \Rightarrow \Delta l \frac{AL\rho gL}{2AY}$

$\therefore \quad \Delta l = \frac{PL^2 g}{2Y}$

So the correct choice is (b)

25. Hysteresis loss corresponding to elasticity per unit volume of a substance is given by the area of hysteresis loop, i.e., stress-strain curve corresponding to one complete loading and deloading.




Area of an ellipse = $\pi \times$ semi-major axis $\times$ semi-minor axis

$$A_1 = \frac{1}{4}(\pi \times 8 \times 4 \times 10^2) \text{ and } A_2 = \frac{1}{4}(\pi \times 8 \times 4 \times 10^2)$$

Also, $A_3 = 8 \times 4 \times 10^2$

Area of hysteresis loop is $A = A_1 + A_2 - A_3$

$$A = 2\left[\frac{\pi}{4} \times 8 \times 4 \times 10^2\right] - [8 \times 4 \times 10^2]$$

= work done per cycle

= energy lost per cycle per unit volume

26. Gravitational potential energy of mass $m$ at earth's surface

$$U_e = -\frac{GMm}{R}$$

Gravitational potential energy of same mass at a height $nR$ from the earth's surface

$$U_h = -\frac{GMm}{(R+nR)} = -\frac{GMm}{R(n+1)}$$

Thus, magnitude of the change in gravitational potential energy

$$\Delta U = U_h - U_e$$

$$= \frac{GMm}{R}\left\{1 - \frac{1}{(n+1)}\right\}$$

$$= \left(\frac{n}{n+1}\right)\frac{GMm}{R}$$

$$= \left(\frac{n}{n+1}\right) mgR \qquad (\because\ GM = gR^2)$$

27. Binding energy of satellite in the first case is $= \frac{GMm}{2r}$

where $r$ is the radius of orbit.

In second case $BE = \frac{GMm}{2 \times \frac{3r}{2}}$

$$\therefore \qquad \Delta E = \frac{GMm}{r}\left(\frac{1}{2} - \frac{1}{3}\right) = \frac{GMm}{6r}$$

% increase in energy of a satellite

$$= \frac{\frac{GMm}{6r}}{\frac{GMm}{2r}} \times 100$$

$$= \frac{2}{6} \times 100 = 33.33\%$$

28. Acceleration due to gravity on the surface of the planet is

$$g_p = \frac{GM_p}{R_p^2}$$

Given, $M_p = \frac{M_e}{2}$ and $R_p = \frac{R_e}{2}$

$$\therefore \qquad g_p = \frac{G(M_e/2)}{(R_e/2)^2} = \frac{2\,GM_e}{R_e} = 2g_e$$

29. On earth, $mg = 10$ or $1 \times g = 10 \Rightarrow g = 10\ \text{ms}^{-2}$

Now, $g' = g\frac{R^2}{r^2} = 10 \times \frac{R^2}{(3R/2)^2} = \frac{40}{9}$

Pull on satellite $= m'g'$

$$= 200 \times \frac{40}{9} = 889\ \text{N}$$

30. The ratio

$$\frac{g'}{g} = \frac{R^2}{(R+h)^2} = \frac{1}{2}$$

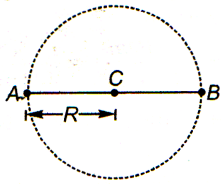
or $R + h = \sqrt{2}R$

or $h = (\sqrt{2} - 1)\,R$

or $h = (0.414) \times 6400$

$\Rightarrow$ $h = 2650\ \text{km}$

31. Two particles $A$ and $B$ each of mass $m$ move in a circular path of radius $R$.
Then gravitational force between them provides the necessary centripetal force,




i.e., $$\frac{mv^2}{R} = \frac{GMm}{(2R)^2}$$

$\Rightarrow$ $$v = \frac{1}{2}\sqrt{\left(\frac{GM}{R}\right)}$$

32. On earth $v_e = \sqrt{\frac{2GM}{R}} = 11 \text{ km/s}$

On moon $v_m = \sqrt{\frac{2GM \times 4}{81 \times R}}$

$$= \frac{2}{9}\sqrt{\frac{2GM}{R}}$$

$$= \frac{2}{9} \times 11.2 = 2.5 \text{ kms}^{-1}$$

33. On moon, $g_m = \frac{4}{3}\pi G\left(\frac{R}{4}\right)\left(\frac{2\rho}{3}\right)$

$$= \frac{1}{6}\left(\frac{4}{3}\pi GR\rho\right) = \frac{1}{6}g$$

Work done in jumping $= m \times g_m \times 0.5$

$$= m \times \left(\frac{g}{6}\right) h_1$$

$$h_1 = 0.5 \times 6 = 3.0 \text{ m}$$

34. . A satellite which revalues around the earth in its equatorial plane with the same angular speed and in the same direction as the earth rotates about its own axis is called a geostationary or synchronous satellite.
The height of a satellite above the earth's surface is given by

$$h = \left(\frac{T^2R^2g}{4\pi^2}\right)^{1/3} - R$$

But $T = 24 \text{ h} = 86400 \text{ s}$

$R =$ radius of earth $= 6400$ km

$g = 9.8 \text{ ms}^{-2} = 0.0098 \text{ kms}^{-2}$

$\therefore$ $$h = \left(\frac{(86400)^2 \times (6400)^2 \times 0.0098}{4 \times 9.87}\right)^{1/3}$$

$$d = 42330 - 6400 = 35930 \text{ km}$$

$$\approx 36000 \text{ km}$$

35. From Kepler's law

$$T^2 \propto R^3$$

or $$T \propto R^{3/2}$$

$$\frac{T'}{T} = \left(\frac{R'}{R}\right)^{3/2}$$

or $$\frac{T'}{T} = \left(\frac{4R}{R}\right)^{3/2}$$

$$= (4)^{3/2} = (2^2)^{3/2}$$

$$= 2^3 = 8$$

$\therefore$ $$T' = 8T = 8 \times 90$$

$$= 720 \text{ min}$$

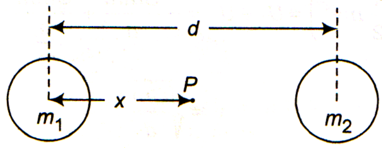
36.

$$g = \frac{GM}{R^2} = \frac{G\left(\frac{4}{3}\pi R^3\right)\rho}{R^2}$$

$\therefore$ $$\rho = \frac{g}{G \cdot 4\pi \frac{R}{3}} = \frac{3g}{4\pi GR}$$

37. Total mechanical energy is conserved, not the kinetic energy..

38. Force will be zero at the point of zero intensity




$$x = \frac{\sqrt{m_1}}{\sqrt{m_1} + \sqrt{m_2}} d$$

$$= \frac{\sqrt{81M}}{\sqrt{81M} + \sqrt{M}} D = \frac{9}{10} D$$

39. At equator $g' = g - R\omega^2 = 0$

$\therefore$ $$\omega = \sqrt{\frac{g}{R}}$$

$$\frac{2\pi}{T} = \sqrt{\frac{g}{R}}$$

$\therefore$ $$T = 2\pi\sqrt{\frac{R}{g}}$$

40. On surface of earth $U = -\frac{GMm}{R}$

At height $h (<< R)$, increase in potential energy is $mgh$

$\therefore$ $$U_h = -\frac{GMm}{R} + mgh$$

41.
$$T = 2\pi\sqrt{\frac{l}{g}} \propto \frac{1}{\sqrt{g}}$$

$$\therefore \quad \frac{T_2}{T_1} = \sqrt{\frac{g_1}{g_2}} = \sqrt{\frac{g}{\frac{g}{\left(1+\frac{h}{R}\right)^2}}} = 2 \text{ (at } h = R)$$

42. Decrease in kinetic energy = increase in PE

$$\therefore \quad \frac{1}{2}m\left(\frac{v_e}{\sqrt{2}}\right)^2 = \frac{mgh}{1+\frac{h}{R}}$$

or
$$\frac{v_e^2}{4} = \frac{gh}{1+\frac{h}{R}}$$

or
$$\frac{2gR}{4} = \frac{gh}{1+\frac{h}{R}} \text{ or } \frac{R}{2} = \frac{h}{1+\frac{h}{R}}$$

Solving this equation, we get $h = R$

**Note** Kinetic energy is half the value required to escape.

Therefore speed is $\frac{1}{\sqrt{2}}$ times the value required to escape.

43.
$$F = \frac{k}{r}$$

$$\therefore \quad \frac{mv^2}{r} = \frac{k}{r}$$

or
$$v \propto r^0$$

44. Actually gravitational force provides the centripetal force.

45. $g = \frac{GM}{R^2}$ or $\frac{G}{g} = \frac{R^2}{m}$

$\therefore$ $\frac{G}{g}$ will have the units $\frac{m^2}{kg}$

## [CHEMISTRY]

46.
$$W = q_V = -nC_V(T_2 - T_1)$$
$$3000 = -1 \times 20 \times (T_2 - 300) \quad \Rightarrow \quad T_2 = \mathbf{150\ K}$$

47.

System is closed and insulated, $Q = 0$ (heat change between system and surrounding). $\Delta E = W + Q = W$ (Since $Q = 0$)

48.
$$q_P = nC_P\Delta T$$
$$\Delta T = \frac{1000}{\left(\frac{100}{18}\right) \times 75} = \mathbf{2.4\ K}$$

49.

Mixture of monoatomic gases will still have monoatomic gases. \

50.

51.

During adiabatic process, no heat is exchanged with surrounding. Hence, $q = 0$.

From $\Delta E = q + W$ (Work done on the system)

$\Delta E = W$ (Since, $q = 0$)

52.

1 Litre-atm = 24.2 calorie

1 calorie = 4.1868 Joule

1 Joule = $10^7$ erg

53.

More negative the enthalpy of formation, more is the stability.

54.

$q = 300$ calorie

$W = -P\Delta V = -1 \times 10$ litre-atm $= -10 \times 24.2$ cal $= -242$ cal

$\Delta E = q + W = 300 - 242 = $ **58 cal**

55.

$\Delta H$ for isothermal free expansion is zero.

56.

57.

$$\frac{V_2}{V_1} = \frac{1}{10}$$

$$W \text{ (on the system)} = -2.303 nRT \log \frac{V_2}{V_1}$$

$$= -2.303 \times 1 \times 2 \times 500 \log \frac{1}{10} \text{ cal}$$

$$= +\frac{2.303 \times 2 \times 500}{1000} \text{ kcal} = \mathbf{+2.303\ kcal}$$

58.

In cyclic system, $\Delta E = 0$, $\Delta H = 0$.

Work done by the system = − 550 kJ.

$\Delta E = q + W$

$\Rightarrow \quad 0 = q - 550 \quad \Rightarrow \quad$ $\mathbf{q = 550\ kJ}$

59.

$$W = -2.303 nRT \log \frac{V_2}{V_1}$$

$$= -2.303 \times 2 \times 8.314 \times 300 \times \log \frac{50}{5} \text{ joule}$$

$$= -11488.285\text{J} \simeq \mathbf{-11.5\ kJ}$$

60.

$q = +200$J

$W = -P\Delta V = -1 \times (20 - 10) = -10$ atm L

$= -10 \times 101.3$ J $= -1013$ J

$\Delta E = q + W = (200 - 1013)$J $=$ **−813 J**

61.

$\Delta H$ for isothermal free expansion is zero.

62.

Volume occupied by molecules of a gas can never be zero.

63.

64\.

Leakage of a gas from balloon is related with its expansion by taking energy from attractive forces of molecules. This decreases the temperature.

65\. In an adiabatic change, no heat is exchanged between the system and the surroundings.

66\. : State function

67\. Based on the first law of thermodynamics,

$\Delta U = q + w$

Change in internal energy for a cyclic process is zero, *i.e.* $\Delta U = 0$.

$\therefore \quad q = -w$

68\. As it absorbs heat, $q = +208$ J

$$w_{rev} = -2.303 nRT \log_{10}\left(\frac{V_2}{V_1}\right)$$

$$w_{rev} = -2.303 \times (0.04) \times 8.314 \times 310 \log_{10}\left(\frac{375}{50}\right)$$

$$\therefore \quad w_{rev} = -207.76 \approx -208 \text{ J}$$

69\. $T_3 < T_1$ because cooling takes place on adibatic expansion. Hence, (b) is incorrect.

70

$$W = -2.303 nRT \log\frac{V_2}{V_1}$$

$$= -2.303 \times 1 \times 8.314 \times 300 \times \log\frac{20}{10}$$

$= -2.303 \times 8.314 \times 300 \times 0.3010 = -1729$ joules

Work done $= -1729$ joules

71\. Volume depends on the mass of the system.

72\.

73\. No work is done along the path AB because this process is isochoric (for isochoric process V = 0

$\therefore$ work done $= PdV = 0$ ).

Thus, the work done $dw = P_B(V_D - V_A)$

$$= 8 \times 10^4 (5 \times 10^{-3} - 2 \times 10^{-3})$$

$$= 8 \times 10^4 \times 3 \times 10^{-3} \text{ J} = 240 \text{ J}$$

The energy absorbed by the system

$$= (dq)_{AB} + (dq)_{BC} = 600 + 200 = 800 \text{ J}$$

The change in internal energy $dE = dq - dw$

$$dE = 800 - 240 = 560 \text{ J}$$

74\. $W = -\Delta 2.303\ \Delta nRT\ \log\frac{P_1}{P_2}$

$$W = -2.303 \times 1 \times 0.082 \times 300 \text{lof} \frac{1}{10}$$

$W = -1381.9$ cal

75\.

76\.

$$W_{\text{expansion}} = -P\Delta V$$
$$= -(1\times 10^{5}\,\text{Nm}^{-2})[(1\times 10^{-2} - 1\times 10^{-3})\,\text{m}^{3}]$$
$$= -10^{5} \times (10\times 10^{-3} - 1\times 10^{-3})\,\text{Nm}$$
$$= -10^{5} \times 9\times 10^{-3}\,\text{J} = -9\times 10^{2}\,\text{J} = \mathbf{-900\ J}$$

77.

78.

$W_{\text{rev}} > W_{\text{irrev}}$; Thus, there will be more cooling in reversible process.

79.

80.

$$q = +40.65\,\text{kJ mol}^{-1}$$
$$W_{\text{exp.}} = -3.1\,\text{kJ}$$
$$\Delta E = q + W$$
$$= 40.65 - 3.1 = \mathbf{37.55\ kJ}$$

81.

As the system starts from $A$ and reaches to $A$ again, whatever the stages may be net energy change is **zero**.

82.

83

84

85. (c) During isothermal expansion of an ideal gas against vacuum is zero because expansion is isothermal. The reason, that volume occupied by the molecules of an ideal gas is zero, is false.

86. (a) it is fact that absolute values of internal energy of substances can not be determined. It is also true that to determine exact values of constituent energies of the substance is impossible.

87. (b) Mass and volume are extensive properties. mass/volume is also an extensive parameter. Here, both assertion and reason are true.

88.

89.

$$W = -P\Delta V = -3\,\text{atm} \times (6-4)\,\text{dm}^{3} = -6\,\text{atm L} = -6\times 101.325\,\text{J} = \mathbf{-608\ J}$$

90.