AVIRAL
JEE | NEET | FOUNDATIONS

WEEKLY TEST RANKER'S BATCH-02 TEST - 02 Balliwala SOLUTION Date 15-09-2019

[PHYSICS]

1. From the law of conservation of angular momentum

$$mr_1v_1 = mr_2v_2$$
$$r_1v_1 = r_2v_2$$
$$\frac{v_1}{v_2} = \frac{r_2}{r_1}$$

2. We have

$$P = \mathbf{F}\cdot\mathbf{v} = Fv\cos\theta$$

So just before hitting θ is zero and both F and v are maximum.

3.
$$\frac{9h}{25} = \frac{g}{2}(2t-1)$$
$$\frac{1}{2}gt^2 = h$$
$$h = 122.5 \text{ m}$$

4. The acceleration due to gravity at depth d below the earth's surface is given by $g_d = g\left(1-\frac{d}{R}\right)$

5. The potential energy on the surface of earth would be equal to mgR.
So, the change in potential energy would be equal to

$$\Delta \text{PE} = \frac{mgh}{1+\frac{h}{R}} = \frac{mgR}{1+\frac{R}{R}} = \frac{mgR}{2}$$

6. Option (c) shows the graph of variation of acceleration due to gravity g with depth h from the surface of the earth.

7. Given, $g' = \frac{g}{4}$

We know that is acceleration due to gravity at height h from the surface of the earth

$$g' = g\left[\frac{R}{R+h}\right]^2$$

Hence $$\frac{g}{4} = g\left[\frac{R}{R+h}\right]^2 \qquad \left(\because g' = \frac{g}{4}\right)$$

$$\frac{R}{R+h} = \frac{1}{2}$$
$$R+h = 2R$$
$$h = R$$

8. The escape speed of a body from the surface of earth (radius of earth = R_E) is $\sqrt{2gR_E}$.

9. Escape velocity, $v_e = \sqrt{\frac{2GM}{R}}$

$$= \sqrt{\frac{2G \times 2M}{R/2}} = 2\sqrt{\frac{2GM}{I}}$$

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

$$= 22.4 \text{ km s}^{-1}$$

10. Time period $T = \frac{2\pi r}{v_o}$

$$T = \frac{2\pi R}{\sqrt{\frac{GM_m}{R}}} \qquad \left(\because v_o = \sqrt{\frac{GM}{R}}\right)$$

$$T^2 = \frac{4\pi^2 R^3}{GM_m}$$

11. When a satellite revolves around planet in its orbit, it possesses both potential energy and kinetic energy.

Potential energy, $U = -\frac{GMm}{r}$

and kinetic energy, $K = \frac{GMm}{2r}$

12. Time period does not depends on mass.

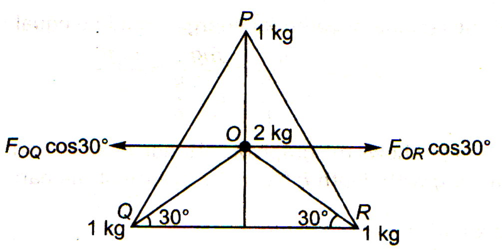
13. Force, $F = G\frac{M_E m}{R_E^2}$

$$mg = G\frac{M_E m}{R_E^2}$$

$$g = \frac{GM_E}{R_E^2}$$

or $M_E = \frac{gR_E^2}{G}$

14. Given, $OP = OQ = OR = \sqrt{2}$ m



The gravitational force on mass 2 kg due to mass 1 kg at P.

$$F_{OP} = G\frac{2 \times 1}{(\sqrt{2})^2}$$

$= G$ along OP

Similarly,

$$F_{OQ} = G\frac{2\times 1}{(\sqrt{2})^2} = G \text{ along } OQ$$

and $$F_{OR} = G\frac{2\times 1}{(\sqrt{2})^2} = G \text{ along } OR$$

$F_{OQ}\cos 30°$ and $F_{OR}\cos 30°$ are equal and acting in opposite directions, then cancel out each other. Then the resultant force on the mass 2 kg at O

$$F = F_{OP} - (F_{OQ}\sin 30° + F_{OR}\sin 30°)$$

$$F = G - \left(\frac{G}{2} + \frac{G}{2}\right)$$

$$F = 0 \text{ (zero)}$$

15. Acceleration due to gravity at the surface of the earth

$$g = \frac{GM}{R^2} = \frac{4}{3}\pi\rho GR \quad \text{...(i)}$$

Acceleration due to gravity at depth d from the surface of earth

$$g' = \frac{4}{3}\pi\rho G(R-d) \quad \text{...(ii)}$$

From Eqs. (i) and (ii)

$$g' = g\left[1 - \frac{d}{R}\right]$$

16. The acceleration due to gravity varies with height as

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

$$\Rightarrow \quad \frac{g}{100} = \frac{g}{\left(1+\frac{h}{R}\right)^2}$$

$$\Rightarrow \quad \left(1+\frac{h}{R}\right)^2 = 100$$

$$\Rightarrow \quad h = 9R$$

17. Gravitational pull depends upon acceleration due to gravity on that planet.

$$M_m = \frac{1}{81}M_e,\ g_m = \frac{1}{6}g_e$$

$$g = \frac{GM}{R^2}$$

$$\Rightarrow \quad \frac{R_e}{R_m} = \left[\frac{M_e}{M_m}\times\frac{g_m}{g_e}\right]^{1/2} = \left[81\times\frac{1}{6}\right]^{1/2}$$

$$\therefore \quad R_e = \frac{9}{\sqrt{6}}R_m$$

18. Acceleration due to gravity at earth's surface is given by

$$g = \frac{GM}{R^2} \quad \ldots(i)$$

Since, earth is assumed to be spherical in shape, its mass is

$$M = \text{volume} \times \text{density} = \frac{4}{3}\pi R^3 \rho$$

Given, $\rho_e = \rho_p = \rho,\ G_p = 2G_e$

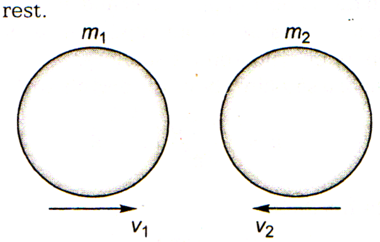
$$\therefore \quad \frac{g_e}{g_p} = \frac{G_e\left(\frac{4}{3}\pi R_e^3\right)\rho \times R_p^2}{R_e^2 \times G_p\left(\frac{4}{3}\pi R_p^3\right)\rho}$$

$$1 = \frac{G_e R_e^3 \times R_p^2}{R_e^2 \times R_p^3 \times 2G_e} \quad (\because G_p = 2G_e)$$

$$1 = \frac{R_e}{2R_p}$$

$$\Rightarrow \quad \frac{R_p}{R_e} = \frac{1}{2}$$

19. According to Newton's law of universal gravitation, every point mass attracts every other point mass by a force directed along the line connecting the two. The gravitational force is an internal force. Since, the two particles are initially at rest their centre of mass is also initially at rest under the effect of internal forces, so the centre of mass remains in the state of rest.



20. Ratio of acceleration due to gravity

$$\frac{g'}{g} = \frac{978}{980} = 1 - \frac{d}{R}$$

or $$\frac{d}{R} = 1 - \frac{978}{980} = \frac{2}{980} \text{ or } d = \frac{2R}{980}$$

$$= \frac{2 \times 6300}{980}$$

$$= 12.86 \text{ km}$$

21. Escape velocity from earth's surface,

$$v_e = \sqrt{2gR}$$

where g = acceleration due to gravity

and R = radius of earth.

22. Energy required = Total energy (final) − Total energy (initial)

$$= -\frac{GMm}{2(3R)}\left(-\frac{GMm}{2(2R)}\right)$$

$$= \frac{GMm}{4R} - \frac{GMm}{6R}$$

$$= \frac{GMm}{12R}$$

23. Escape velocity is given by

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

$$= \sqrt{\frac{2G}{R} \times \frac{4}{3}\pi R^3 \rho}$$

$\Rightarrow$ $$v_e = R\sqrt{\frac{8}{3}\pi G\rho}$$

$\therefore$ $$\frac{v_A}{v_B} = \frac{R_A}{R_B} = 2$$

24. Using law of conservation of energy

$$\frac{1}{2}mv^2 = \frac{1}{2}m[(20)^2 - v_e^2]$$

Here escape velocity $v_e = 8\sqrt{2}$ kmh^{-1}

$\therefore$ $$v^2 = (20)^2 - (8\sqrt{2})^2$$

$$= 400 - 128$$

$$= 272$$

So, $v = 16.5$ kmh^{-1}

25. . Escape velocity of a body from the surface of earth is given by

$$v_e = \sqrt{\frac{2GM_e}{R_e}}$$

So, from the question,

$$M_p = \frac{M_e}{2},\ R_p = \frac{R_e}{4}$$

We have $$v_e' = \sqrt{\frac{2G \times M_e \times 4}{2R_e}} = \sqrt{2}v_e$$

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

Pull on satellite $= m'g'$

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

30. The ratio

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

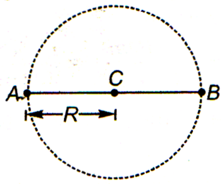
or $$R + h = \sqrt{2}R$$

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

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

But $T = 24$ h $= 86400$ s

R = radius of earth = 6400 km

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

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

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

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

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

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

$$= 2^3 = 8$$

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

$$= 720\ \text{min}$$

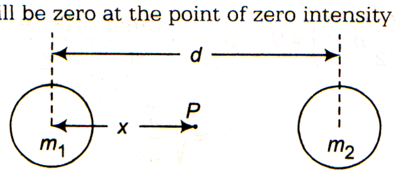
36.

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

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

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

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

42. Decrease in kinetic energy = increase in PE

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

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

or $\frac{2gR}{4} = \frac{gh}{1+\frac{h}{R}}$ 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. $F = \frac{k}{r}$

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

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

$\Delta E = q + W = 300 - 242 = \mathbf{58\ cal}$

55.

ΔH for isothermal free expansion is zero.

56.

57.

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

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

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

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

58.

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

Work done by the system = − 550 kJ.

$\Delta E = q + W$

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

59.

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

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

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

60.

$q = +200\text{J}$

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

$= -10 \times 101.3 \text{ J} = -1013 \text{ J}$

$\Delta E = q + W = (200 - 1013)\text{J} = \mathbf{-813\ J}$

61.

ΔH 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

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

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

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

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

70

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

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

$= -2.303 \times 8.314 \times 300 \times 0.3010 = -1729$ 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 $dw = P_B(V_D - V_A)$

$= 8\times10^4(5\times10^{-3} - 2\times10^{-3})$

$= 8\times10^4\times3\times10^{-3}\text{ J} = 240\text{ J}$

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

$W = -2.303\times1\times0.082\times300\text{lof}\frac{1}{10}$

$W = -1381.9\text{ cal}$

75.

76.

$$W_{\text{expansion}} = -P\Delta V$$
$$= -(1\times10^5\text{Nm}^{-2})[(1\times10^{-2} - 1\times10^{-3})\text{m}^3]$$
$$= -10^5\times(10\times10^{-3} - 1\times10^{-3})\text{ Nm}$$
$$= -10^5\times9\times10^{-3}\text{ J} = -9\times10^2\text{ J} = \mathbf{-900\ J}$$

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.

$$W = -P\Delta V = -3\text{ atm}\times(6-4)\text{ dm}^3 = -6\text{ atm L} = -6\times101.325\text{J} = \mathbf{-608\ J}$$

90