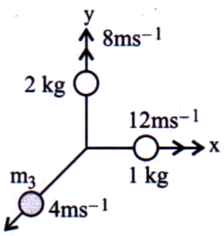
WEEKLY TEST MEDICAL PLUS -01 TEST - 14 Balliwala SOLUTION Date 18-08-2019

[PHYSICS]

1.

The situation of the problem is as shown in the figure. According to law of conservation of linear momentum



$$\vec{p}_1 + \vec{p}_2 + \vec{p}_3 = 0$$

$$\therefore \quad \vec{p}_3 = -(\vec{p}_1 + \vec{p}_2)$$

Here,

$$\vec{p}_1 = (1\text{kg})\,(12\text{ ms}^{-1})\hat{i} = 12\,\hat{i}\text{ kg ms}^{-1}$$

$$\vec{p}_2 = (2\text{ kg})\,(8\text{ ms}^{-1})\,\hat{j}$$

$$= 16\hat{j}\text{ kg ms}^{-1}$$

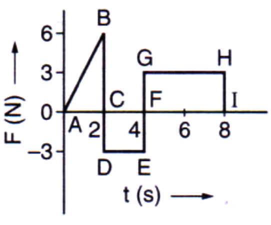
$$\therefore \quad \vec{p}_3 = -(12\,\hat{i} + 16\hat{j})\text{ kg ms}^{-1}$$

The magnitude of $\vec{p}_3$ is :

$$p_3 = \sqrt{(12)^2 + (16)^2} = 20\text{ kg ms}^{-1}$$

$$\therefore \quad m_3 = \frac{p_3}{v_3} = \frac{20\text{ kg ms}^{-1}}{4\text{ ms}^{-1}} = 5\text{kg}$$

2.



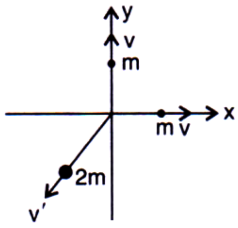
Change in momentum = Area under F-t graph in that interval

= Area of ΔABC – Area of rectangle $CDEF$ + Area of rectangle $FGHI$

$$= \frac{1}{2}\times 2\times 6 - 3\times 2 + 4\times 3 = 12\text{ N s}$$

3.

Let $\vec{v'}$ be velocity of third piece of mass $2m$. Initial momentum, $\vec{P_i} = 0$ (As the body is at rest). Final momentum,



$\vec{P_f} = mv\hat{i} + mv\hat{j} + 2m\vec{v'}$

According to law of conservation of momentum

$\vec{p_i} = \vec{p_f}$

$0 = mv\hat{i} + mv\hat{j} + 2m\vec{v'}$

$\vec{v'} = -\frac{v}{2}\hat{i} - \frac{v}{2}\hat{j}$

The magnitude of $\vec{v'}$ is

$v' = \sqrt{\left(-\frac{v}{2}\right)^2 + \left(-\frac{v}{2}\right)^2} = \frac{v}{\sqrt{2}}$

Total kinetic energy generated due to explosion

$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)v'^2$

$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)\left(\frac{v}{\sqrt{2}}\right)^2 = mv^2 + \frac{mv^2}{2}$

$= \frac{3}{2}mv^2$

4.

Given that,

$\vec{F} = (2t\hat{i} + 3t^2\hat{j})$ and $\vec{a} = 2t\hat{i} + 3t^2\hat{j}$

Hence, $v = \int_0^t a\,dt = t^2\hat{i} + t^3\hat{j}$

$\therefore \quad P = \vec{F}\cdot\vec{v} = 2t\cdot t^2 + 3t^2\cdot t^3 = 2t^3 + 3t^5$

5.

Power delivered in time T is,

$P = F\cdot V = MaV$

or $\quad P = MV\frac{dV}{dT}$

or $\quad PdT = MVdV$

or $\quad PT = \frac{MV^2}{2}$

or $\quad P = \frac{1}{2}\frac{MV^2}{T}$.

6.

Here, $m_1 = m$, $m_2 = 2m$

$u_1 = 2$ m/s , $u_2 = 0$

Coefficient of restitution, $e = 0.5$

Let v_1 and v_2 be their respective velocities after collision.

Applying the law of conservation of linear momentum, we get,

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$\therefore$ $$m \times 2 + 2m \times 0 = m \times v_1 + 2m \times v_2$$

or $$2m = mv_1 + 2mv_2$$

or $$2 = (v_1 + 2v_2) \quad \ldots(i)$$

By definition of coefficient of restitution,

$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

or $$e(u_1 - u_2) = (v_2 - v_1)$$

$$0.5(2 - 0) = (v_2 - v_1)$$

$$1 = v_2 - v_1 \quad \ldots(ii)$$

Solving equations (i) and (ii), we get,

$$v_1 = 0 \text{ m/s}, v_2 = 1 \text{ m/s}$$

7.

According to conservation of momentum

$$m_1v_1 + m_2v_2 = (m_1 + m_2)v,$$

where v is common velocity of the two bodies.

$m_1 = 0.1$ kg, $m_2 = 0.4$ kg

$v_1 = 1$ m/s, $v_2 = -0.1$ m/s

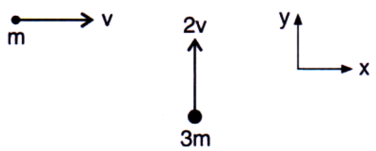
$\therefore$ $0.1 \times 1 + 0.4 \times (-0.1) = (0.1 + 0.4)v$

or $0.1 - 0.04 = 0.5v$,

$$v = \frac{0.06}{0.5} = 0.12 \text{ m/s.}$$

Hence, distance covered = $0.12 \times 10 = 1.2$ m

8.



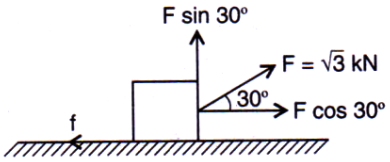
According to conservation of momentum, we get

$$mv\hat{i} + (3m)2v\hat{j} = (m + 3m)v'$$

where v' is the final velocity after collision

$$v' = \frac{1}{4}v\hat{i} + \frac{6}{4}v\hat{j} = \frac{1}{4}v\hat{i} + \frac{3}{2}v\hat{j}.$$

9.



The component of applied force F in the direction of motion is $F\cos 30°$.
The work done by the applied force is,

$$W = (F\cos 30°)S = \sqrt{3}\times 10^3 \times \frac{\sqrt{3}}{2}\times 10\,\text{J}$$
$$= 15\times 10^3\ \text{J} = 15\ \text{kJ}.$$

10.

Mass of water falling/second = 15 kg, $h = 60$ m
$g = 10\,\text{m/s}^2$, loss =10% , *i.e.*,90% is used
Power generated $= 15\times 10\times 60\times 0.9 = 8100$ W $= 8.1$ kW

11.

$$mv = Mv' \quad \text{or} \quad v' = \left(\frac{m}{M}\right)v$$

Total KE of the bullet and the gun $= \frac{1}{2}mv^2 + \frac{1}{2}Mv'^2$

$$\text{Total KE} = \frac{1}{2}mv^2 + \frac{1}{2}M\cdot\frac{m^2}{M^2}v^2$$
$$\text{Total KE} = \frac{1}{2}mv^2\left[1+\frac{m}{M}\right]$$

or $$1.05\times 1000\ \text{J} = \left[\frac{1}{2}\times 0.2\right]\left[1+\frac{0.2}{4}\right]v^2$$

or $$v^2 = \frac{4\times 1.05\times 1000}{0.1\times 4.2} = (100)^2;$$

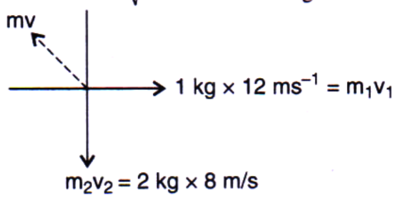
$\therefore$ $$v = 100\ \text{ms}^{-1}$$

12.

When an explosion breaks a rock, by the law of conservation of momentum, initial momentum which is zero, is equal to total momentum of three pieces.

Total momentum of the two pieces 1 kg and 2 kg

$$= \sqrt{12^2 + 16^2} = 20 \text{ kg m s}^{-1}$$



The third piece has the same momentum and in the direction opposite to the resultant of these two momenta.

$\therefore$ Momentum of the third piece $= 20 \text{ kg ms}^{-1}$;

Velocity $= 4 \text{ ms}^{-1}$

$\therefore$Mass of the 3rd piece $= \frac{mv}{v} = \frac{20}{4} = 5$ kg.

13.
14.
15.
16.
17.

Velocity of total mass $(u) = 0$ (because it is stationary). According to law of conservation of momentum

$$(m_1 + m_2)u = m_1v_1 + m_2(-v_2)$$

or $$(m_1 + m_2) \times 0 = m_1v_1 - m_2v_2$$

or $$m_1v_1 = m_2v_2$$

or $$\frac{v_1}{v_2} = \frac{m_2}{m_1}$$

We also know that;

Kinetic energy, $(E) = \frac{1}{2}mv^2 \propto mv^2$

$\therefore$ $$\frac{E_1}{E_2} = \left(\frac{m_1}{m_2}\right) \times \left(\frac{v_1}{v_2}\right)^2$$

$$= \frac{m_1}{m_2} \times \left(\frac{m_2}{m_1}\right)^2 = \frac{m_2}{m_1}.$$

18.

When the mass attached to a spring fixed at the other end is allowed to fall suddenly, it extends the spring by x. Potential energy lost by the mass is gained by the spring,

$$Mgx = \frac{1}{2}kx^2$$

or $$x = \frac{2Mg}{k}.$$

19.

Work done = area under $F-x$ curve

= area of trapezium

$$= \frac{1}{2} \times (6+3) \times 3 = 13.5 \text{ J.}$$

20.
21.
22.

Given that $\frac{dW}{dt} = P = K$

or, $W = Pt = \frac{1}{2}mv^2$

or, $\sqrt{\frac{2Pt}{m}} = v$

Hence, $a = \frac{dv}{dt} = \sqrt{\frac{2P}{m}} \frac{1}{2\sqrt{t}}$

Hence, force $= ma = \sqrt{\frac{2Pm^2}{m}} \frac{1}{2\sqrt{t}}$

$$= \left[\sqrt{\frac{mK}{2}}\right] t^{-1/2} \quad (\because P = K)$$

23.

Because the collision is perfectly inelastic, hence the two blocks stick together. By conservation of linear momentum, $2mV = mv$ or $V = v/2$

By conservation of energy,

$$mgh = \frac{1}{2} mV^2 = \frac{1}{2} m \cdot \frac{v^2}{4} \quad \text{or} \quad h = \frac{v^2}{8g}.$$

24.

$$u_1 = \sqrt{2gh_1}, \quad v_1 = \sqrt{2gh_2}$$

$$e = \frac{v_1 - v_2}{u_2 - u_1}$$

Since, $u_2 = v_2 = 0$,

$$\therefore \quad e = -\frac{v_1}{u_1} = \sqrt{\frac{h_2}{h_1}}.$$

25.

Loss in potential energy $= mgh$

$= 2 \times 10 \times 10 = 200$ J

Gain in kinetic energy = Work done = 300 J

$\therefore$ Work done against friction $= 300 - 200 = 100$ J.

26.
27.

As the force is internal, $\vec{p}_{Th} + \vec{p}_{\alpha} = 0$

(as initially system was at rest)

$$(\vec{p}_{Th})^2 = (-\vec{p}_{\alpha})^2 \quad \text{or} \quad p_{Th}^2 = p_{\alpha}^2$$

or $K_{Th} m_{Th} = K_{\alpha} m_{\alpha}$ or $K_{Th} = \frac{4}{234} \times 4.1$

$= 0.07008$ MeV.

28.

Applying the law of conservation of momentum we get; $mv_0 + 0 = 2m \times v$ or $v = \frac{v_0}{2}$

$$KE = \frac{1}{2}(2m)v^2 = \frac{1}{2} \times 2m \times \left(\frac{v_0}{2}\right)^2 = \frac{mv_0^2}{4}$$

Let the system reach a height h.

Potential energy of the system = $2mgh$

Hence, $\frac{mv_0^2}{4} = 2mgh$ or $h = \frac{v_0^2}{8g}$.

29.

After collision if bullet gets embedded in the block and block rises to a height h, then initial velocity of bullet,

$v = \frac{(M+m)}{m} \cdot \sqrt{2gh}$ (Refer to question 104)

$\therefore$ $v = \sqrt{2 \times 980 \times 2.5}\left(\frac{5010}{10}\right) = 350.7$ m/sec.

30.

Power $P = Fv = \frac{K}{v} \cdot v = K =$ constant

$\therefore$ $W = Pt = Kt$.

31.

32.

As $F_{ext.} = 0$

hence according to law of conservation of momentum,

$\vec{p}_s = \vec{p}_1 + \vec{p}_2 =$ constant

However, initially both the blocks were at rest so,

$$\vec{p}_1 + \vec{p}_2 = 0, \quad i.e., \quad \vec{p}_2 = -\vec{p}_1$$

i.e., at any instant, the two blocks will have momentum equal in magnitude but opposite in direction (though they have different values of momentum in different positions).

33.

According to law of conservation of momentum

$$0 = m_1v_1 + m_2v_2 \quad \ldots(i)$$

$$K_2 = \frac{1}{2}m_2v_2^2 = \frac{1}{2}\frac{m_2^2v_2^2}{m_2} = \frac{m_1^2v_1^2}{2m_2}$$

$$= \frac{(3)^2 \times (16)^2}{2 \times 6} = 192 \text{ J.}$$

34.

35.

$$\text{Stopping distance} = \frac{\frac{1}{2}mv^2}{\mu mg}$$

$$= \frac{\frac{1}{2m} \times m^2v^2}{\mu mg} = \frac{p^2}{2\mu m^2 g}.$$

36.

$$dU = -dW$$

dU = Change in potential energy

dW = Work done by conservative forces

Hence, work done by conservative forces on a system is equal to the negative of the change in potential energy.

37.

$\frac{3}{4}$th energy is lost, *i.e.*, $\frac{1}{4}$th kinetic energy is left.

Hence, its velocity becomes $\frac{v_0}{2}$ under a retardation of μg in time t_0.

$\therefore \quad \frac{v_0}{2} = v_0 - \mu g t_0$

$\therefore \quad \mu g t_0 = \frac{v_0}{2} \quad$ or $\quad \mu = \frac{v_0}{2gt_0}$.

38.

39.

$$P = Fv = M\frac{dv}{dt}v$$

Hence, $\quad v\,dv = \frac{P}{M}dt$

On integration, we find

$$v \propto \sqrt{t}$$

40.

$$P = \frac{dW}{dt} = p\frac{dV}{dt}$$

Here, $\quad P = hdg$

$= 10 \times 13.6 \times 980 = 1.3328 \times 10^5$ dyne/cm^2

and $\quad \frac{dV}{dt}$ = pulse frequency

$\times$ blood discharged per pulse

$\therefore \quad \frac{dV}{dt} = \frac{72}{60} \times 75 = 90$ cc/sec

$\therefore \quad$ Power of heart $= 1.3328 \times 10^5 \times 90$ erg/sec

$= 1.19$ W

41.

$$P = Fv = m\frac{dv}{dt}v$$

or $\quad v\frac{dv}{dt} = \frac{P}{m} \quad$ or $\quad v \cdot \frac{dv}{dx} \cdot \frac{dx}{dt} = \frac{P}{m}$

or $\quad v^2\frac{dv}{dx} = \frac{P}{m} \quad$ or $\quad v^2\,dv = \frac{P}{m}dx$

On integration, we get;

$$\frac{v^3}{3} = \frac{Px}{m} \quad \text{or} \quad v = \left(\frac{3xP}{m}\right)^{1/3}.$$

42.

Centripetal force $= \frac{mv^2}{r} = \frac{K}{r^2}$ (in magnitude)

$KE = \frac{1}{2}mv^2 = \frac{K}{2r}$ (since KE is always positive)

$PE = -\int_{\infty}^{r} F\,dr = -\int_{\infty}^{r} -\frac{K}{r^2}\,dr = -\frac{K}{r}$

$TE = PE + KE = -\frac{K}{r} + \frac{K}{2r} = -\frac{K}{2r}$.

43.

Work done against gravitational force $= mgh$

$= 1000 \times 9.8 \times 20 = 196 \times 10^3$ J

Work done to impart velocity to the body $= \frac{1}{2}mV^2$

$= \frac{1}{2} \times 10^3 \times 16 = 8 \times 10^3$ J

Work done against frictional force $= 500 \times 20 = 10 \times 10^3$ J

Total work done $= 214 \times 10^3$ J.

44.

Work done by man in one hour = power × time

$= 9.8 \times 1 \times 60 \times 60$ J

Work done by man in raising one brick

$= mgh = 2.5 \times 9.8 \times 3.6$ J

Number of bricks, $N = \frac{9.8 \times 1 \times 60 \times 60}{2.5 \times 9.8 \times 3.6} = 400$.

45.

$$\text{Power} = \left(\frac{mgh + \frac{1}{2}mV^2}{t}\right)$$

$$= \frac{1000 \times 10 \times 10 + \frac{1}{2} \times 1000 \times 10 \times 10}{60}$$

$= \frac{15,000}{6}$ watt

But 1 watt $= \frac{1}{746}$ HP

$\therefore$ Power $= \frac{15000}{6 \times 746} = 3.33$ HP

[CHEMISTR]

46.

47. (d) When a real gas is forced through a porous plug into a region of low pressure, it is found that due to expansion, the gas on the side of low pressure gets cooled.

The phenomenon of producing lowering of temperature when a gas is made to expand adiabatically from a region of high pressure into a region of low pressure is known as Joule-Thomson effect.

48. (d) In isothermal reversible process ideal gas has constant volume and so $\Delta E = 0$ and $\Delta H = \Delta E = 0$.

49. (a) The compressor has to run for longer time releasing more heat to the surroundings.

50. (b) $dV = 0$ for an isochoric process.

51. (a) For isochoric process $\Delta V = 0$ so $q_v = \Delta E$ i.e. heat given to a system under constant volume is used up in increasing ΔE.

52. (b) The less energy of a system and more is its stability.

53. (b) The functions whose value depends only on the state of a system are known as state functions.

54. (d) For adiabatic process $q = 0$.

55. (b) The intensive property is mass/volume.

56. (c) Volume is not an intensive property.

57. (c) An isolated system neither shows exchange of heat nor matter with surroundings.

58. (d) ΔQ is not a state function.

59. (c) For adiabatic process $\Delta Q = 0$.

60. (c) Work is not a state function as during a process its value depends on the path followed. The value of enthalpy, internal energy and entropy depends on the state and not on the path followed to get that state, hence these are state functions.

61. (c) Surface tension is an intensive property which do not depend upon the quantity of matter present in the system.

62. (d) First low of thermodynamics is also known as Law of conservation of mass and energy.

63. (b) Formation of CO_2 from CO is an exothermic reaction; heat is evolved from the system, *i.e.*, energy is lowered. Thus, exothermic reactions occur spontaneously on account of decrease in enthapy of system. Thus, $\Delta E > \Delta H$.

64. A

65. (b) $\Delta H = \Delta E + P\Delta V$.

66. (a) Bomb calorimeter is commonly used to find the heat of combustion of organic substances which consists of a sealed combustion chamber, called a bomb. If a process is run in a sealed container then no expansion or compression is allowed, so $w = 0$ and $\Delta U = q$.
$\Delta U < 0, w = 0$

67. C

68. (d) If $\Delta n = -ve$ than $\Delta H < \Delta E$.

69. C

70. (c) During isothermal expansion of ideal gas, $\Delta T = 0$
$\Delta H = \Delta E + P\Delta V = \Delta E + nR\Delta T = 0 + 0 = 0$.

71. (b) $W = 2.303\ nRT \log \frac{V_2}{V_1}$

$= 2.303 \times 1 \times 8.314 \times 10^7 \times 298 \log \frac{20}{10}$

$= 298 \times 10^7 \times 8.314 \times 2.303 \log 2$.

72. C

73. (a) The enthalpies of all elements in their standard state at $25^o C$ or $298K$ are zero.

74. (c) $\Delta E_v = E_P - E_R$.

75. (c) $\Delta E = q + w$.

76. (a) $\Delta E = 0$ for reversible isothermal process.

77. (a) At constant T and P internal energy of ideal gas remains unaffected.

78. (a) ΔE increases with temperature.

79. (a) $\Delta H = \Delta E + W$ or $\Delta H = \Delta E + P\Delta V$

80. (c) $-W = +2.303\, nRT \log \frac{p_1}{p_2}$

$-W = 2.303 \times 1 \times 2 \times 300 \log \frac{10}{1} = 1381.8\, cal.$

81. (b) Joule-Thomson expansion is isoenthalpic.

82. (b) $q = \Delta E - W$ if $q = 0$ for adiabatic process, than $\Delta E = W$.

83. (c) As the system is closed and insulated no heat enter or leave the system, *i.e.* $q = 0$; $\therefore \Delta E = Q + W = W$.

84. (d) $W = 0$ is not true.

85. (a) $W = 2.303 nRT \log \frac{P_2}{P_1}$

$= 2.303 \times 1 \times 2 \times 300 \log \frac{10}{2} = 965.84$

at constant temperature, $\Delta E = 0$.

$\Delta E = q + w$; $q = -w = -965.84\, cal$.

86. (c) $q = 40\, J$

$w = -8\, J$ (work done by the system)

$\Delta E = q + w = 40 - 8 = 32\, J$.

87. (a) We know that $\Delta E = Q + W = 600 + (-300) = 300\, J$

$W = 300$, because the work done by the system.

88. (c) Given that

$P_1 = 10\, atm$, $P_2 = 1\, atm$, $T = 300K$, $n = 1$

$R = 8.314\, J/K/mol$

Now, by using

$W = 2.303 nRT \log_{10} \frac{P_2}{P_1}$

$= 2.303 \times 1 \times 8.314 \times 300 \log_{10} \frac{1}{10}$

$W = 5744.1\, Joule$

89. (b) Given number of moles $=1$

Initial temperature $= 27^\circ C = 300K$

Work done by the system $= 3\,KJ = 3000K$

It will be $(-)$ because work is done by the system.

Heat capacity at constant volume $(Cv) = 20\,J/k$

We know that work done

$W = -nC_V\,(T_2 - T_1)$; $3000 = -1 \times 20\,(T_2 - 300)$

$3000 = -20T_2 + 6000$

$20T_2 = 3000$; $T_2 = \frac{3000}{20} = 150K$

90. (c) $W = -P\Delta V = -1 \times 10^5\,(1 \times 10^{-2} - 1 \times 10^{-3})$

$= -1 \times 10^5 \times 9 \times 10^{-3} = -900J$