Joule’s Heating:

Whenever heat is converted into mechanical work or mechanical work is converted into heat, then the ratio of work done to heat produced always remains constant. i.e.

$$W \propto Q \quad \text{or} \quad WQ=J$$

This is Joule's law and J is called mechanical equivalent of heat.

(1) From W = JQ if Q = 1 then J = W. Hence the amount of work done necessary to produce unit amount of heat is defined as the mechanical equivalent of heat.

(2) J is neither a constant, nor a physical quantity rather it is a conversion factor which used to convert Joule or erg into calorie or kilo calories vice-versa.

(3) Value of

$$J=4.2 Joulecal=4.2\times10^{7} ergcal$$

$$=4.2\times10^{3} Joulekcal$$

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(4) When water in a stream falls from height h, then its potential energy is converted into heat and temperature of water rises slightly.

From

$$W=JQ$$

$\Rightarrow$ $mgh = J\ (mc\ \Delta\theta)$

[where m = Mass of water, c = Specific heat of water,

$$\Delta\theta = \text{temperature rise]}$$

$\Rightarrow$ Rise in temperature $\Delta\theta=ghJc{\circ}C$

(5) The kinetic energy of a bullet fired from a gun gets converted into heat on striking the target. By this heat the temperature of bullet increases by $\Delta\theta$.

From W = JQ

$\Rightarrow$ $12mv^{2}=J(ms\Delta\theta)$

[where m = Mass of the bullet, v = Velocity of the bullet, c = Specific heat of the bullet]

$\Rightarrow$ Rise in temperature,

$$\Delta t=v^{2}2Jc{\circ}C$$

If the temperature of bullet rises upto the melting point of the bullet and bullet melts then.

From

$$W = J(Q_{\text{Temperature change}} + Q_{\text{Phase change}})$$

$\Rightarrow \frac{1}{2}mv^2 = J(mc\Delta\theta + mL)$

; L = Latent heat of bullet

$\Rightarrow$ Rise in temperature,

$$\Delta\theta = \left[\frac{\left(\frac{v^2}{2J} - L\right)}{c}\right]^\circ C$$

(6) If m kg ice-block falls down through some height (h) and melts partially (m' kg) then its potential energy gets converted into heat of melting.

From W = JQ

$\Rightarrow \quad mgh = Jm'L$

$\Rightarrow \quad h = \frac{m'}{m}\left(\frac{JL}{g}\right)$

If ice-block melts completely then

$$m' = m \Rightarrow h = \frac{JL}{g} \text{meter}$$