

Problems:

1) Two bodies have a mass ratio of 3:4. The force applied on the bigger mass produces an acceleration of 12ms^{-2} . What could be the acceleration of the other body, if the same force acts on it.

Mass of the first body $m_1 = 3\text{kg}$, Mass of the second body $m_2 = 4\text{kg}$

Acceleration of the second body $a_2 = 12\text{ms}^{-2}$

According to Newton's second law of motion | Acceleration of the first body $a_1 = ?$

$$F = ma$$

$$F_1 = m_1 a_1$$

$$F_1 = 3a_1$$

$$F_2 = m_2 a_2$$

$$F_2 = 4 \times 12 = 48\text{N}$$

$$F_1 = F_2$$

$$\therefore 3a_1 = 48$$

$$a_1 = \frac{48}{3} = 16\text{ms}^{-2}$$

$\therefore$ Acceleration of the first body $a_1 = 16\text{ms}^{-2}$

2.) A ball of mass 1kg moving with a speed of 10ms^{-1} rebounds after a perfect elastic collision with the floor. Calculate the change in linear momentum of the ball.

Mass $m = 1\text{kg}$ Initial velocity $u = 10\text{ms}^{-1}$, Final velocity $v = -10\text{ms}^{-1}$

Change in linear momentum = ?

Momentum before collision $= mu = 1 \times 10 = 10\text{kgms}^{-1}$

Momentum after collision $= mv = -(1 \times 10) = -10\text{kgms}^{-1}$

Change in momentum $= mv - mu$

$$= -10 - 10 = -20\text{kgms}^{-1}$$

3.) A mechanic unscrew a nut by applying a force of 140N with a spanner of length 40cm . What should be the length of the spanner if a force of 40N is applied to unscrew the same nut?

Force $F_1 = 140\text{N}$

Length $l_1 = 40\text{cm}$

$$= 40 \times 10^{-2}\text{m}$$

Force $F_2 = 40\text{N}$

Length $l_2 = ?$

$$F_1 l_1 = F_2 l_2$$

$$\text{Length of the spanner } l_2 = \frac{F_1 \times l_1}{F_2} = \frac{140 \times 40 \times 10^{-2}}{40} = 140 \times 10^{-2}$$

$$\therefore \text{length } l_2 = 1.4\text{m}$$

4) The ratio of masses of two planets is 2:3 and the ratio of their radii is 4:7. Find the ratio of their accelerations due to gravity.

The ratio of masses of two bodies is $m_1:m_2 = 2:3$

Mass of the smaller body $m_1 = 2\text{kg}$; Mass of the bigger body $m_2 = 3\text{kg}$

Radius of the smaller body $R_1 = 4\text{km}$ Radius of the bigger body $R_2 = 7\text{km}$

$$r_1:r_2 = 4:7$$

$$g_1:g_2 = ?$$

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

$$g_1 = \frac{GM_1}{R_1^2}$$

$$g_2 = \frac{GM_2}{R_2^2}$$

$$\frac{g_1}{g_2} = \frac{\frac{GM_1}{R_1^2}}{\frac{GM_2}{R_2^2}} = \frac{M_1}{M_2} \times \frac{R_2^2}{R_1^2}$$

$$\frac{g_1}{g_2} = \left(\frac{M_1}{M_2}\right) \left(\frac{R_2}{R_1}\right)^2 = \frac{2}{3} \left(\frac{7}{4}\right)^2 \Rightarrow \frac{g_1}{g_2} = \frac{2 \times 7 \times 7}{3 \times 4 \times 4} = \frac{49}{24}$$

$$\therefore g_1:g_2 = 49:24$$

L-2 : Optics: Book Back Problems:

1) An object is placed at a distance 20cm from a convex lens of focal length of 10cm. Find the image distance and nature of the image.

Object distance $u = -20\text{cm}$ Focal length of convex lens $f = 10\text{cm}$

Image distance $v = ?$ Nature of the image = ?

Object is placed from the lens so 'u' becomes negative

$$\text{Lens formula } \frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} + \frac{1}{(-20)} = \frac{1}{10} - \frac{1}{20} = \frac{1}{20}$$

$\therefore$ Distance of the image $v = 20\text{cm}$

Enlarged and inverted image at a distance of 20cm on the right side of the lens. $m = \frac{v}{u} = \frac{20}{-20} = -1$ (-ve indicates inverted image)

$\therefore$ Nature of the image = Enlarged and inverted image

2) An object of height 3cm is placed at 10cm from a concave lens of focal length 15cm. Find the size of the image

Object distance $u = -10\text{cm}$ focal length $f = -15\text{cm}$ ($\because$ concave lens, so it is (-)ve)

Image distance $v = ?$

Height of the object $h = 3\text{cm}$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{-15} + \frac{1}{-10} = \frac{-10-15}{150} = \frac{-25}{150}$$

$$\therefore v = \frac{150}{-25} = -6\text{cm} \quad \text{Magnification } m = \frac{v}{u} = \frac{6}{10} = 0.6$$

$$m = \frac{\text{height of the image}}{\text{height of the object}} = \frac{h'}{h} \Rightarrow m = \frac{h'}{3} \quad h' = 0.6 \times 3 = 1.8\text{cm}$$

$$\therefore h' = 1.8\text{cm}$$

L-3 Thermal physics

1.) Find the final temperature of a copper rod whose area of cross section changes from 10m^2 to 11m^2 due to heating. The copper rod is initially kept at 90K . (coefficient of superficial expansion is $0.0021/\text{K}$)

Area of copper rod (A_1) = 10m^2

After expansion area (A_2) = 11m^2

Initial temperature $T_1 = 90\text{K}$

Co-efficient of superficial expansion = $0.0021/\text{K}$

Final temperature $T_2 = ?$

$$\frac{\Delta A}{A} = \alpha \Delta T$$

$$\frac{A_2 - A_1}{A} = \alpha (T_2 - T_1)$$

$$\frac{11 - 10}{10} = 0.0021 (T_2 - 90)$$

$$\frac{1}{10 \times 0.0021} = T_2 - 90$$

$$\frac{1}{0.021} + 90 = T_2 \Rightarrow \frac{1 + 90(0.021)}{0.021}$$

Final temperature $T_2 = 137.6\text{K}$

2.) Calculate the coefficient of cubical expansion of a zinc bar whose volume is increased 0.25m^3 from 0.3m^3 due to the change in its temperature of 50K .

Volume of the zinc bar $V = 0.3\text{m}^3$

change in volume $\Delta V = 0.25\text{m}^3$

change in temperature $\Delta T = 50\text{K}$

coefficient of cubical expansion $\alpha_v = ?$

$$\frac{\Delta V}{V} = \alpha_v \Delta T \Rightarrow \alpha_v = \frac{\Delta V}{V \cdot \Delta T}$$

$$\alpha_v = \frac{0.25}{0.3 \times 50} = \frac{0.25}{15} = 0.0166\text{K}^{-1}$$

$\therefore$ Co-efficient of cubical expansion $\alpha_v = 0.0166\text{K}^{-1}$

L-4 Electricity

An electric iron consumes energy at the rate of 420W when heating is at the maximum rate and 180W when heating is at the minimum rate. The applied voltage is 220V what is the current in each case

In the first case the power consumed by the electric iron (P) = 420W

Applied voltage i.e., potential difference

current in each case } $I = ?$ | $V = 220\text{V}$

$$P = VI \Rightarrow I = \frac{P}{V} = \frac{420}{220} = \frac{21}{11}$$

$\therefore$ when heating is at maximum rate $I = \frac{21}{11} = 1.909\text{A}$

In the second case when heating

is at minimum $P = 180\text{W}$

Applied voltage $V = 220\text{V}$

$$P = VI \Rightarrow I = \frac{P}{V} = \frac{180}{220} = \frac{9}{11}$$

$\therefore$ when heating is at minimum rate $I = \frac{9}{11} = 0.818\text{A}$

② A 100 watt electric bulb is used for 5 hours daily and four 60 watt bulbs are used for 5 hours daily. Calculate the energy consumed (in kWh) in the month of January.

Time $t = 5\text{hr}$ For month of January = 31 days

Number of 60w bulbs = 4

60w used for a time = 5hr

Energy consumed by 100w bulb = ?

$$\text{Energy} = P \times t$$

Energy consumed by 100w bulb = Power $\times$ time

$$= 100 \times 31 \times 5 = 15500$$

$$= 15.5\text{ kWh}$$

Energy consumed by 60w bulb

$$= 4 \times 60 \times 5 \times 31 = 37200\text{Wh}$$



3) A person who is sitting at a distance of 400m from a source of sound is listening to a sound of 600Hz. Find the time period between successive compressions from the source?

Frequency $\gamma = 600 \text{ Hz}$ (or) $n = 60 \text{ Hz}$
 $T = ?$ $T = \frac{1}{n} = \frac{1}{600} = 1.7 \times 10^{-3}$

$\therefore$ Time period $[T = 0.00073]$

4) An ultrasonic wave is sent from a ship towards the bottom of the sea. It is found that the time interval between the transmission and reception of the wave is 1.6 sec. What is the depth of the sea, if the velocity of sound in the sea water is 1400 ms^{-1} ?

Time interval (t) = 1.6 s
 Velocity $c = 1400 \text{ ms}^{-1}$
 Depth $d = \frac{ct}{2} = \frac{1400 \times 1.6}{2}$
 $= \frac{2240}{2} = 1120 \text{ m}$

$\therefore d = 1120 \text{ m}$

5. A man is standing between two vertical walls 680m apart. He claps his hands and hears two distinct echoes after 0.9 seconds and 1.1 sec respectively. What is the speed of sound in the air?

Time of first echo $t_1 = 0.9 \text{ s}$

Time of second echo $t_2 = 1.1 \text{ s}$

Distance between man & wall $d = 680 \text{ m}$

speed $c = ?$

$d = \frac{ct}{2}$ $c = \frac{2d}{t}$ $t = t_1 + t_2$

$\therefore c = \frac{2 \times 680}{0.9 + 1.1} = \frac{2 \times 680}{2.0} = 680 \text{ m/s}$

6) Two observers are stationed in two boats 4.5 km apart. A sound signal sent by one, under water reaches the other after 3 seconds. What is the speed of sound in the water?

$d = 4.5 \text{ km} = 4.5 \times 10^3 \text{ m}$

$t = 3 \text{ s}$ $c = ?$

$c = \frac{d}{t}$ (speed of sound in water $c = \frac{d}{t}$)

$\therefore c = \frac{4.5 \times 10^3}{3} = 1.5 \times 10^3 = 1500 \text{ m/s}$

7) A strong sound signal is sent from a ship towards the bottom of the sea. It is received back after 1 s. What is the depth of the sea given that the speed of sound in water is 1450 ms^{-1} ?

Time taken by the signal to reach the bottom of the sea = $\frac{1}{2} \text{ s}$
 speed of sound in water $c = 1450 \text{ m/s}$

Depth of the sea = speed $\times$ time
 $= c \times t$

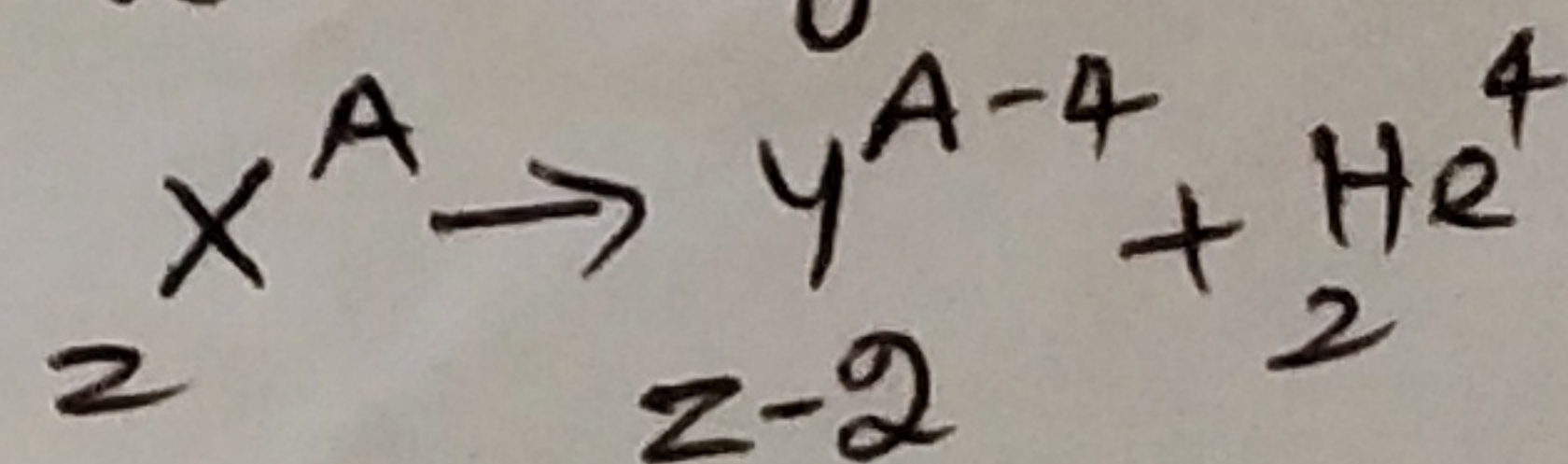
$d = 1450 \times \frac{1}{2}$

Depth of the sea $[d = 725 \text{ m}]$

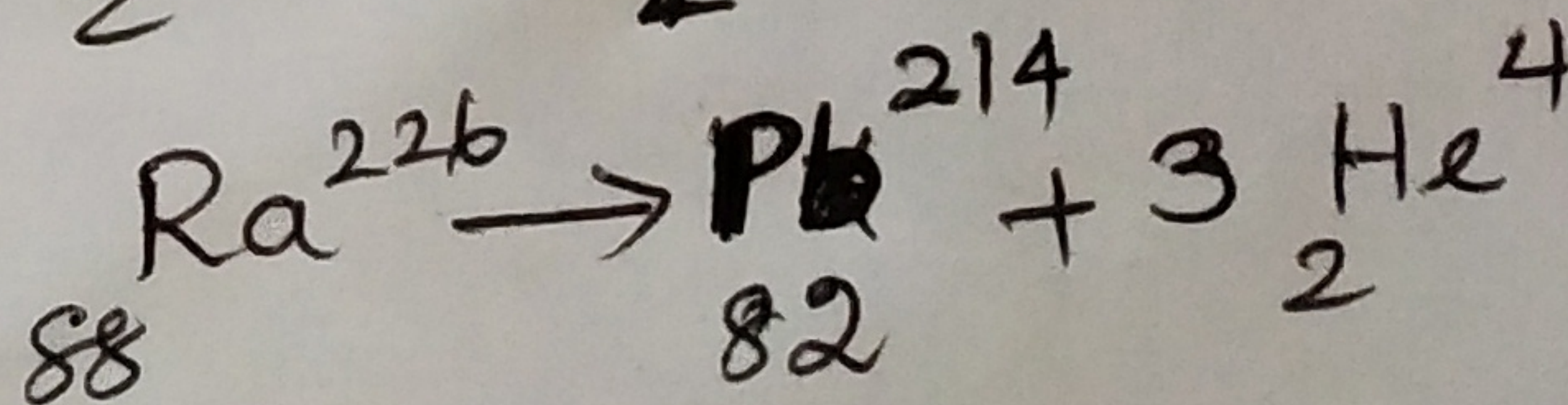
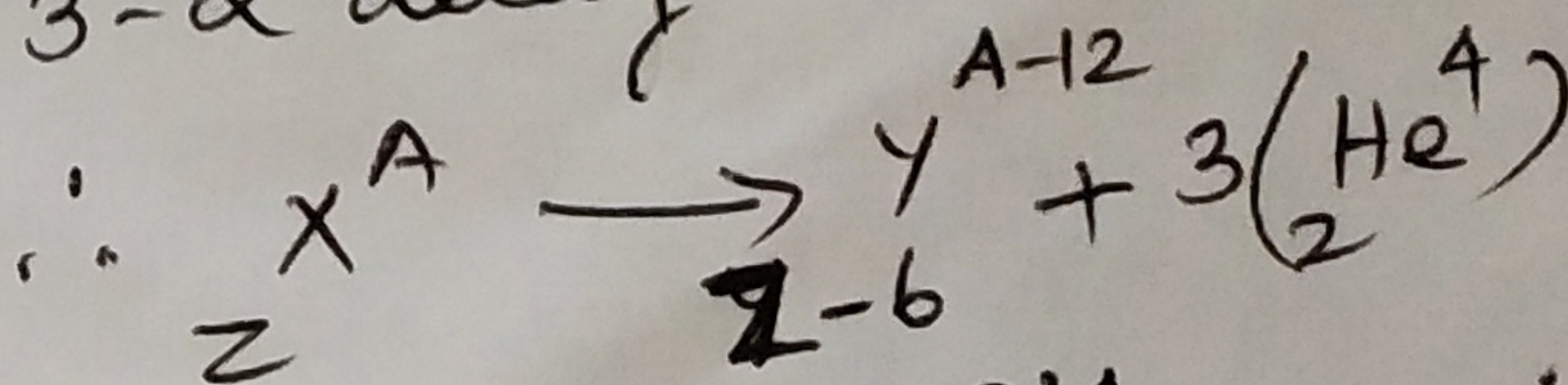
L-7 Nuclear Physics:

1) Ra^{226}_{88} experiences three α -decay. Find the number of neutrons in the daughter element.

α -decay: formula



3- α decay



2.) A cobalt specimen emits induced radiation of 75.6 millicurie per second. Convert this disintegration into becquerel
 (One curie = 3.7×10^{10} Becquerel)
 1 curie = 3.7×10^{10}
 $75.6 \text{ millicurie} = 75.6 \times 10^{-3} \times 1 \text{ Curie}$
 $\therefore 75.6 \text{ millicurie} = 75.6 \times 10^{-3} \times 3.7 \times 10^{10}$
 $= 279.7 \times 10^7$
 $\therefore \text{Ans} = 279.7 \times 10^7 \text{ Becquerel}.$

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