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Assignment-2

Ans 1:- Total energy supplied by fossil fuels in 2013 $= 300 \times 10^{15}$ KJ

(a) $\because$ Combustion equation of C_3H_5

$$2C_3H_5 + 17O_2 \rightarrow 6CO_2 + 5H_2O$$

$\because$ average energy content of $C_3H_5 = 40\,000$ KJ/Kg

Now, let say x Kgs of C_3H_5 is used to supply energy

$$\therefore x \times 40000 = 300 \times 10^{15}$$

$$\Rightarrow x = 7.5 \times 10^{12} \text{ Kgs}$$

$\therefore$ moles of C_3H_5 used $= \frac{7.5}{41} \times 10^{12}$

moles of CO_2 produced $= \frac{6}{2} \times \frac{7.5}{41} \times 10^{12}$

$\therefore$ weight of CO_2 produced $= 44 \times \frac{6}{2} \times \frac{7.5}{41} \times 10^{12}$

$$= 24.15 \times 10^{12} \text{ Kg}$$

$\therefore$ CO_2 released into atmosphere $= 2.415 \times 10^{13}$ Kg.

(b) $\therefore$ Increase in atmospheric $CO_2 = 2.415 \times 10^{13}$ Kg

& weight of air $= 5 \times 10^{18}$ Kg

also, molecular weight of air $= 29$ g/mol

Let d_{CO_2} be the density of CO_2

and d_{air} be the density of air.

$\therefore$ Increase in CO_2 ppm (by weight) $= \frac{2.415 \times 10^{13} \times 10^{6}}{5 \times 10^{18}}$

$= 4.83$ ppm by weight

$\therefore$ Increase in CO_2 (ppm) by volume

$= 4.83 \times \frac{d_{air}}{d_{CO_2}}$

Now, consider the system in ideal condition,

$PV = nRT$

$\Rightarrow PV = \frac{m}{M} RT$

M: molar mass

m: mass

$\Rightarrow M = \left(\frac{m}{V}\right)\left(\frac{RT}{P}\right)$

$\Rightarrow M \propto \frac{m}{V} \Rightarrow M \propto$ density

$\therefore$ Increase in CO_2 ppm by volume

$= 4.83 \frac{d_{air}}{d_{CO_2}} = \frac{4.83 \times (\text{Molecular weight})_{air}}{(\text{Molecular weight})_{CO_2}}$

$= 4.83 \times \frac{29}{44} = 3.18$

$\Rightarrow$ Increase in CO_2 ppm by volume $= 3.18$ ul/l.

Ans 2:-

$\because \quad \Delta Q = \Delta F - \lambda \Delta T \quad , \Delta F = 5.35 \ln\left(\frac{c}{280}\right)$

$\Delta Q = k \, \Delta T$

where, $k = 0.6 \ W/m^2K \quad \& \ \lambda = 1.4 \ W/m^2K$

(i) $\because \Delta T = 2^\circ C = 2K$

$\Rightarrow \Delta Q = \Delta F - \lambda \Delta T = k \Delta T$

$\Rightarrow \Delta F = (\lambda + k) \Delta T = (1.4 + 0.6) \Delta T$

$= 2 \times 2 = 4$

$\Rightarrow 5.35 \ln\left(\frac{c}{280}\right) = 4$

$\Rightarrow \frac{c}{280} = e^{0.747} = 2.112$

$\Rightarrow c = 591.37 \ ppm$

(ii) $\therefore$ change in concentration $= 591.37 - 280$

$= 311.37 \ ppm$

$\because$ Gt C corresponding to 1 ppm increase

$= 2.1 \ Gt\,C \times 2$

Gt C corresponding to 311.37 ppm increase

$= 2.1 \times 311.37 \times 2$

$= 1307.754 \ Gt\,C$

$\therefore$ Emissions in Gt C $= 1307.754$ Gt C.

(iii) $\because$ 2.1×2 Gt C emissions $\rightarrow$ 1 ppm increase

$\therefore$ 540 Gt C emissions $\rightarrow$ 128.57 ppm increase

Now, $\Delta F = (k + \lambda)\Delta T$

$\Rightarrow 5.35 \ln\left(\frac{C}{280}\right) = (0.6 + 1.4)\Delta T$

ΔT due to non CO_2 emissions $= 0.5°C$

ΔT due to CO_2 forcing $= 2°C - 0.5°C$

$= 1.5°C$

$\therefore 5.35 \ln\left(\frac{C}{280}\right) = 2 \times 1.5$

$\Rightarrow \ln\left(\frac{C}{280}\right) = \frac{3}{5.35} = 0.56$

$\Rightarrow C = 280 \times 1.7519 = 490.55$ ppm

Now, 280 ppm (pre industrial value)

& 128.57 ppm (already emitted)

gives 408.57 ppm already in atmosphere

So, remaining emissions lead to 490.55 − 408.57 ppm CO_2

= 82 ppm

To increase 82 ppm, 82×4.2 Gt C emissions will be required

$\therefore$ Ans = 344.4 Gt C emissions

(ie, Remaining Carbon budget)

(iv) $\because k + \lambda = 1.8\ W/m^2 K$

$\therefore \Delta T = 1.5$

$\therefore 5.35 \ln\left(\frac{C}{280}\right) = 1.8 \times 1.5$

$$\ln\left(\frac{C}{280}\right) = \frac{2.7}{5.35} = 0.5046$$

$\Rightarrow C = 463.8$ ppm

$\therefore \Delta C = (463.8 - 280)$ ppm

$= 183.8$ ppm

ie, total estimate after pre-industrial to increase temp. by 1.5°C

$= 183.8$ corresponds to 183.8×4.2 Gt C emissions

≈ 772 Gt C.

Now, already emitted carbon $= 540$ Gt C

& new carbon budget $= 772 - 540$

$= 232$ Gt C

$\therefore$ Global emission rate $= 10$ Gt C/year

Now, lets x be the years to take emit 232 Gt C more

$\therefore 10x = 232$

$\Rightarrow x = 23.2$ years