Energy & the Environment
Homework #5

80 pts total

Chs 13 & 14 13: 32, 33, 36, 38
14: 1, 3, 5, 7, 9, 10, 32, 43, 44

(13.32) $P_e = 1000$ MW, 35% efficient
Given $Q = 30\ m^3/s$, $\rho = 1000\ kg/m^3$

Find ΔT

Total power input = Waste heat out + Electric power out

$P_T = P_w + P_e$, $\frac{P_e}{P_T} = E$

$P_w = P_T - P_e$

$= \left(\frac{1}{E} - 1\right) P_e$

$P_w = \left(\frac{1}{.35} - 1\right) 1000\ MW = 1.86(1000\ MW)$

$P_w = 1860\ MW$

$P_w = Q h_{cp} \rho \Delta T$

$\frac{P_w}{Q h_{cp} \rho} = \Delta T$

h_{cp} = specific heat $= 4186 \frac{J}{kg^\circ C}$

$\frac{1.86 \times 10^9 \frac{J}{s}}{\left(30 \frac{m^3}{s}\right) 4186 \left(\frac{J}{kg^\circ C}\right) 1000 \left(\frac{kg}{m^3}\right)} = \Delta T(^\circ C)$

$\Delta T = 14.81\ ^\circ C$

→

NC

Given | Find

13.33 $E_{max} = 0.66$ | ΔT

$P_e = 1000\ mw$

$\rho = 1000\ kg/m^3$, $Q = 20\ m^3/s$

$h_{cp} = 4186\ J/kg/°C$

$$E_{max} = \frac{T_{high} - T_{low}}{T_{high}} = 0.66$$

$$P_w = \left(\frac{1}{E} - 1\right) P_e = 0.52(1000\ mw)$$

$$P_w = 520\ mw = 5.2 \times 10^8\ \frac{J}{s}$$

$$\Delta T = \frac{P_w}{Q h_{cp} \rho} = \frac{5.2 \times 10^8\ J/s}{(20\ \frac{m^3}{s})(4186\ J/kg/°C)\ 1000(kg/m^3)}$$

$$\boxed{\Delta T = 6.21°C}$$

13.36 $P = 80\ \frac{cm}{yr}$, $ET = 68\ \frac{cm}{yr}$

$A = 3.5 \times 10^4\ km^2$

$= 3.5 \times 10^{10}\ m^2$

Assume Runoff = Precip − Evapotranspiration

$$Q = A(P - ET)$$

$$= (3.5 \times 10^{10}\ m^2)(80 - 68 \times 10^{-2}\ \frac{m}{yr})$$

$$\boxed{Q = 4.2 \times 10^9\ \frac{m^3}{yr} = 133\ \frac{m^3}{s} = 4.2 \times 10^{12}\ \frac{kg}{yr}}$$

-1/2

13.38 $P_e = 1000$ mw
lifetime = 40 yr
(Given) capacity factor = 96%

lifetime $\frac{Out}{In} = 16$ Find Energy to construct

(kWhr) (J) lifetime power out $= P_e * \text{Capacity factor} * \text{lifetime (hr)}$

$= 10^6 \text{ kW} * .96 * (40 \times 365 \times 24 \text{ hr})$

lifetime power out $= 3.36 \times 10^{11}$ kWh

$= (3.36 \times 10^{11} \text{ kWh})\left(\frac{1000 \text{ J/s}}{\text{kW}}\right)\left(3600 \frac{\text{s}}{\text{hr}}\right)$

Energy Out $= 1.21 \times 10^{18}$ J

$= 3.36 \times 10^{11}$ kWh

Energy In $= \frac{1}{16}$ Energy Out $= 7.57 \times 10^{16}$ J

2.10×10^{10} kWh

Chapter 14

1 (a)
3 (a)
5 Tab 14.5 (b)
7 (e)
9 (not sure a, e)

14.32 $pH = -\log_{10}[H^+]] = 4.6$ 5/4

Given

14.36 CO tolerance $= 40{,}000\ \mu g/m^3$

NOx tolerance $= 500\ \mu g/m^3$

$$\text{relative toxicity} = \frac{\text{CO tolerance}}{\text{NOx tolerance}} = \frac{40{,}000}{500}$$

relative toxicity = 80

14.43 1 ton coal part. $\rightarrow 100\ \frac{\mu g}{m^3}$ exposure

a) $$\frac{1000\text{ tons}}{d}\left(\frac{100\ \mu g/m^3}{\text{ton}}\right) = 100{,}000\ \frac{\mu g}{m^3/d}$$

b) From book P. 277 $0.02 - 0.6 \times 10^{-4}\ \frac{\text{cancers}}{\mu g/m^3}$

use 0.4

$$\left(10^5\ \frac{\mu g/m^3}{d}\right)\left(0.4\times10^{-4}\ \frac{\text{cancers}}{\mu g/m^3}\right) = 4\ \frac{\text{cancers}}{\text{day}}$$

c) $$\left(10^5\ \mu g/m^3\right)(.55)\left(.16\%\ ^{1}/_{\mu g/m^3}\right) = 880\%$$ increase

14.44 CO : $40{,}000\ \mu g/m^3$

HC : $19{,}300\ \mu g/m^3$

SO_2 : $1430\ \mu g/m^3$

NO_x : $514\ \mu g/m^3$

Part. : $375\ \mu g/m^3$

All given @ tolerance levels

Assume CO @ $40{,}000\ \mu g/m^3$

This question is not clear